Sept. 29, 1953 O. E. DEMPSEY ET AL 2,653,545

WELL INSTALLATION FOR SUBSURFACE HYDRAULIC PUMPS

Filed April 7, 1951 3 Sheets-Sheet 1

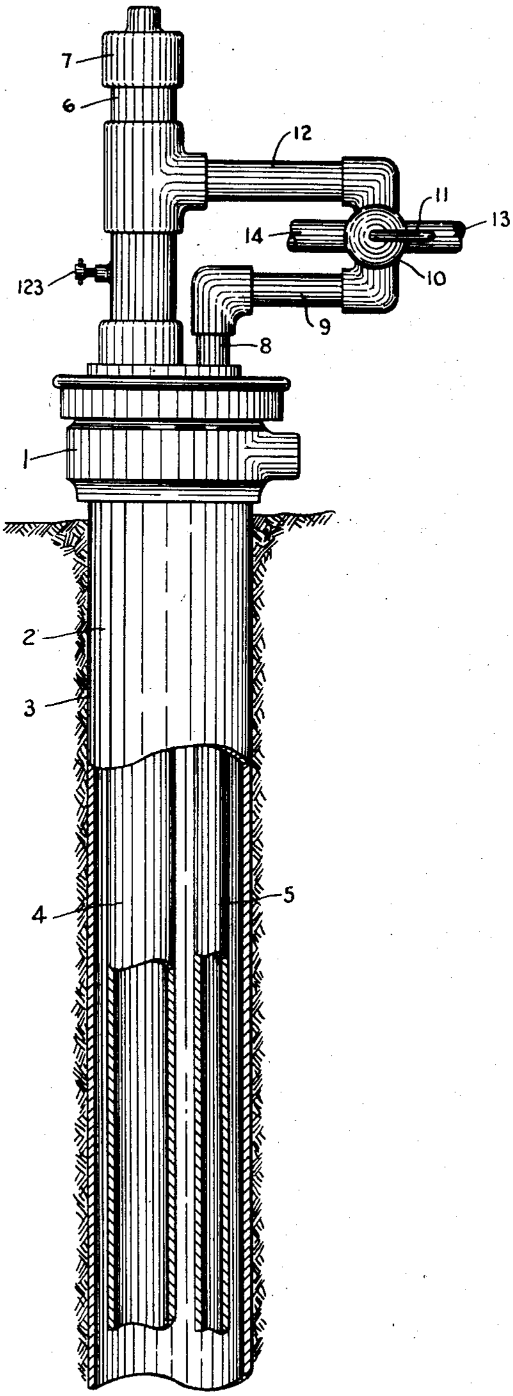


FIG. 1

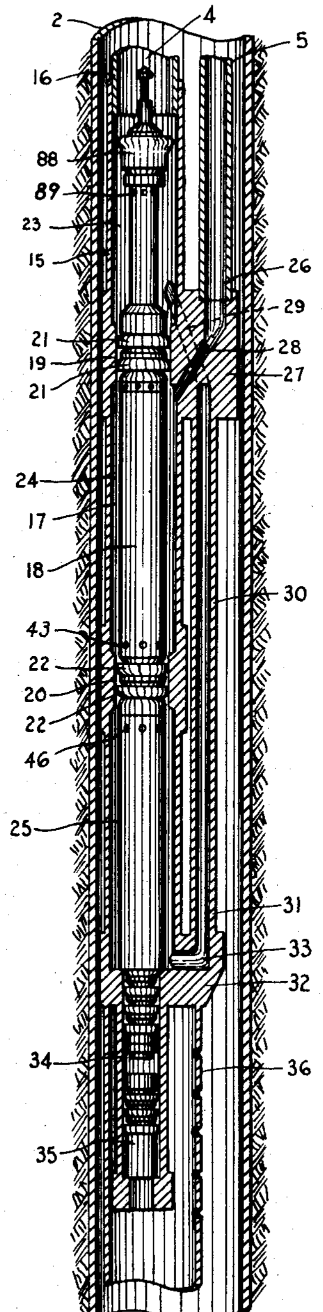


FIG. 2

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# WELL INSTALLATION FOR SUBSURFACE HYDRAULIC PUMPS

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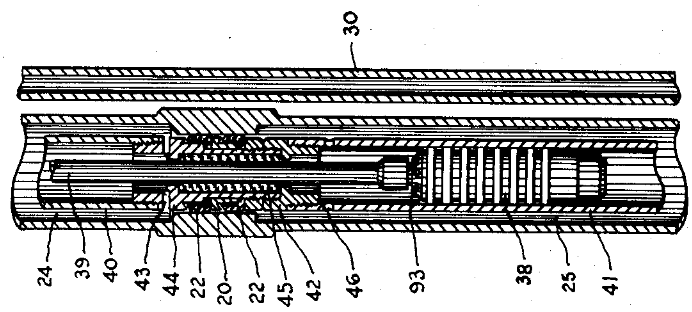

FIG. 5

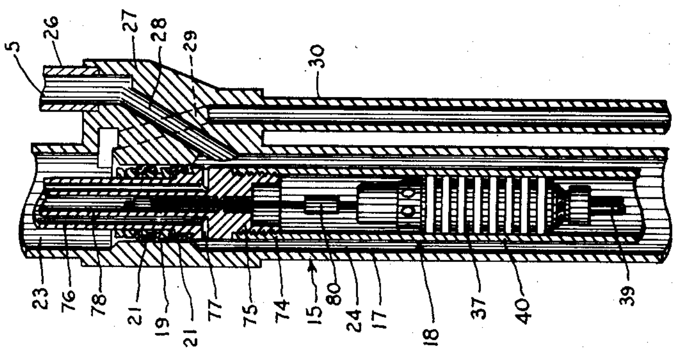

FIG. 4

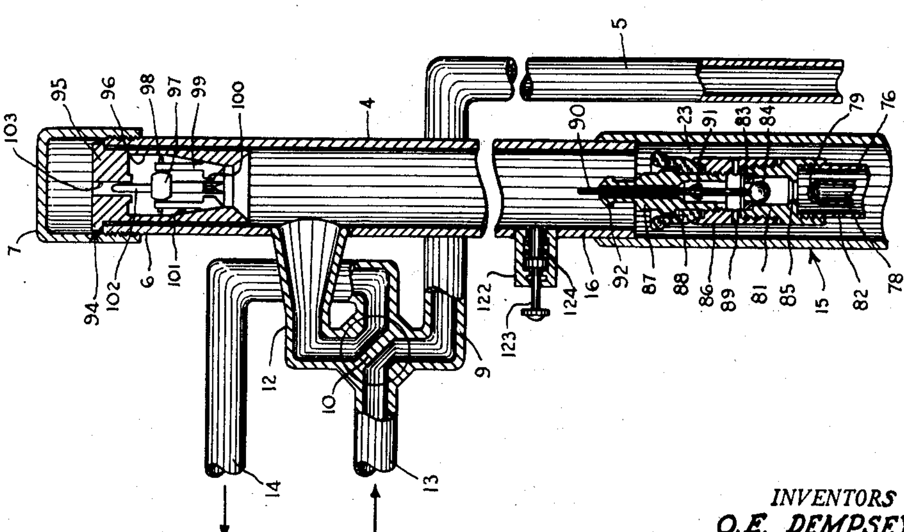

FIG. 3

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WELL INSTALLATION FOR SUBSURFACE HYDRAULIC PUMPS

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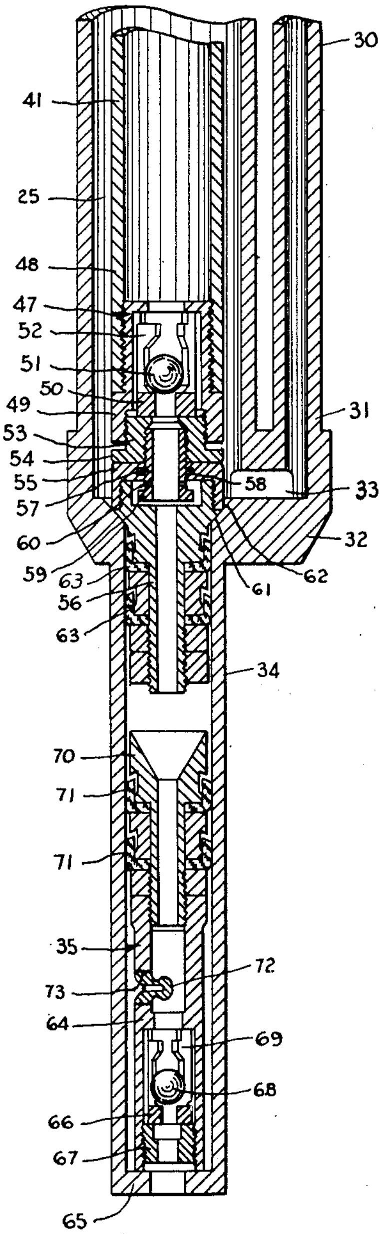


FIG. 6

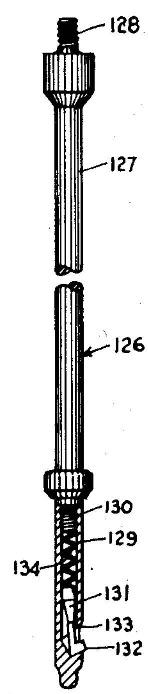


FIG. 8

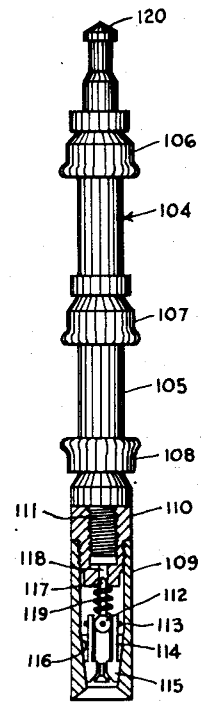


FIG. 7

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# UNITED STATES PATENT OFFICE

2,653,545

## WELL INSTALLATION FOR SUBSURFACE HYDRAULIC PUMPS

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Application April 7, 1951, Serial No. 219,848

19 Claims. (Cl. 103—46)

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This invention relates to improvements in oil well pumping apparatus, and more particularly, but not by way of limitation, to a subsurface hydraulic pump installation for an oil well, and means for removing and installing the pump in an oil well.

As it is well known, subsurface hydraulic pumps have been used in oil wells for several years. The prevalent method of installing a hydraulic pump in a well has been to secure the pump on the end of a small string of tubing, commonly called the "macaroni" string, and inserting the pump and the macaroni string in a larger string of well tubing. The well tubing is in turn disposed in the well casing and extends downwardly in the well casing into communication with the well fluid. The pump is seated in fluid tight engagement with lower portion of the well tubing to provide an annular producing passageway between the macaroni string and the well tubing for the well fluid and the exhausted or spent power fluid utilized to operate the hydraulic pump.

In operation, high pressure power fluid is usually forced downwardly in the macaroni string to operate the hydraulic pump. The well pump in turn pumps the well fluid upwardly through the annular production passageway to the surface of the well. The power fluid, after passing through the engine end of the pump, is usually combined with the well fluid in the production column. As a general rule, for every unit volume of high pressure power fluid forced down the macaroni string, one unit volume of well fluid is drawn into the system by the pump, thus two unit volumes of fluid are recovered at the surface of the well.

It is also well known that most well fluids carry variable amounts of sand, shale, and abrasive oxides from the formation, which, together with pipe scale and other foreign substances contaminating the power oil system, are very destructive to the pumping mechanism. Therefore, the pump must be periodically removed from the well for repair and replacement of parts. In the method of pump installation previously described, the complete macaroni string must be pulled from the well to remove the pump unit. To pull the macaroni string requires the service of several workmen for several hours (depending upon the depth of the well), as well as a portable pulling unit which is ordinarily not present at the well and must be transported from a distant location. It is readily seen, therefore, that not only is the removal and reinstallation of a pump unit in this manner relatively expensive, but the well must also be shut down for a considerable period of time, resulting in loss of production.

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In addition to sand being present in the well fluid, there may also be paraffin therein which gradually accumulates and solidifies in the producing column and must be periodically removed therefrom. It will be readily appreciated that an abundant accumulation of paraffin in an annular shaped production column would be very difficult to remove. The subsurface pump is usually raised part way out of the well bore to break loose the paraffin, resulting in a loss of production time and involving the services of several workmen and auxiliary equipment.

Another known method of installing a subsurface hydraulic pump in an oil well is by providing two parallel strings of tubing in the well casing communicating at their lower ends. One string of the tubing is of comparatively large diameter and the other is of comparatively small diameter, for example, two inches and one inch respectively. The pumping unit is telescopically disposed in the lower end of the large tubing and is seated therein with the lower or pumping end of the unit in communication with the fluid in the well. In operation, high pressure power fluid is forced down the large tubing by suitable surface equipment to operate the subsurface pump, and the pump in turn pumps well fluid and the exhausted or spent power fluid upwardly through the small tubing to the surface of the well.

The greatest advantage obtained by use of this type of pump installation is the ease of removal and installation of the pump in a well bore. For removal, it is simply necessary to reverse the flow of fluid in the parallel tubing strings, whereupon the pumping unit will be pumped upwardly through the large tubing to the surface of the well. However, each time the flow in the parallel tubing strings is reversed, as when a soluble plug is forced down the small tubing to remove paraffin therefrom, the pumping unit is removed from its seat, or pumping position, and must be reseated before production of the well can be resumed. Furthermore, a portion of the dirty well fluid invariably enters the engine end of the pumping unit each time the flow in the parallel tubing strings is reversed to damage the intricate hydraulic valve and plunger mechanism therein. Another disadvantage of this type of installation is the resistance to flow of the fluid being pumped. As previously set forth, the volume of fluid forced to the surface of the well is usually twice the amount forced downwardly to the pump. It is readily seen, therefore, that since the largest volume of fluid must be pumped through the small tubing, the frictional resistance to flow of the pumped well fluid, and exhausted power fluid will be imposed directly on the subsurface pumping unit to materially impair the effectiveness of the unit.

The present invention contemplates a novel subsurface hydraulic pump installation utilizing a large and small string of tubing installed in parallel relation in the casing of an oil well. A hydraulic pumping unit is disposed in a housing at the lower end of the large tubing in communication with the well fluid in such a manner that high pressure power fluid forced down the small tubing operates the pump, and the pump in turn pumps well fluid and exhausted power fluid upwardly through the large tubing to the surface of the well.

A novel extension is provided on the upper end of the pumping unit to receive a retrieving device when it is desired to retrieve the subsurface unit. The retrieving device is adapted to be pumped down the large tubing by a reversal of fluid flow in the parallel strings of tubing. After the retrieving device is in engagement with the pump extension, and the normal direction of flow is resumed through the parallel strings of tubing, high pressure fluid acts on the lower side of the retrieving device to force the pumping unit upwardly through the large tubing to the surface of the well. The direction of flow in the parallel strings of tubing may be periodically reversed, as when cleaning paraffin from the large tubing, without affecting the seating of the pump, and without forcing dirty well fluid through the engine end of the pump. Furthermore, all valves for controlling the flow of fluid at the lower end of the well are retrievable without pulling the well tubing.

An important object of this invention is to provide for the minimum frictional resistance to flow of fluid being pumped by a subsurface hydraulic pump from an oil well in order to increase the overall pumping efficiency.

Another object of this invention is to provide a subsurface hydraulic pump installation utilizing two parallel strings of tubing whereby the direction of flow in the tubing strings may be reversed without affecting the seating of the pumping unit disposed at the end of one string of tubing.

It is another object of this invention to provide a subsurface hydraulic pump installation in such a manner that paraffin may be easily and efficiently removed from the production column without affecting the seating position of the pump.

A further object of this invention is to preclude the introduction of paraffin into the pumping unit.

A still further object of this invention is to prevent the forcing of dirty well fluid into the engine end of a subsurface fluid actuated pumping unit, when flow of fluid is reversed, or when the pump is being removed from the well.

Another object of this invention is to provide a hydraulic pump installation utilizing a large and a small string of tubing wherein the smaller volume of power fluid flows through the smaller tubing and the greater volume of fluid, consisting of spent power fluid and displaced well fluid, flows through the larger tubing.

Another object of this invention is to provide a hydraulic pump installation for an oil well utilizing a housing secured to the lower ends of two variable sized parallel strings of tubing, wherein the pump is removed and inserted in the well through the larger of the two parallel strings of tubing, but is completely disposed in the housing below the larger string of tubing when in operating position.

A further object of this invention is to provide a hydraulic pump installation utilizing two parallel strings of tubing and a pump housing communicating with the lower ends of each of the tubings having a greater internal diameter than either of the tubings.

Another object of this invention is to provide a subsurface hydraulic pump installation wherein all valves disposed in the well are removable without pulling the well tubing.

An additional object of this invention is to provide a housing for a subsurface hydraulic pump so constructed and arranged that high pressure power fluid introduced into the housing for operating the pump cannot develop sufficient axial thrust to force the pump out of the housing. Also, to provide such a housing and pump whereby the pump may be removed from the housing only by the connection of a proper tool to the pump, whereupon the high pressure power fluid being introduced into the housing in the same manner as for operating the pump coacts with the tool to remove the pump from the housing.

Other objects and advantages of the invention will be evident from the following detailed description, read in conjunction with the accompanying drawings, which illustrate our invention.

In the drawings:

Figure 1 is an elevational view, partially in section, of the upper portion of a subsurface hydraulic pump installation constructed in accordance with this invention.

Figure 2 is a continuation of Fig. 1 and illustrates the lower portion of the installation and discloses a novel pump chamber having a subsurface hydraulic pump disposed therein.

Figure 3 is a sectional view of the upper portion of the hydraulic pump installation, partially diagrammatically shown for clarity.

Figure 4 is a continuation of Figure 3 and illustrates the upper portion of the hydraulic pump.

Figure 5 is a continuation of Figure 4 and illustrates the lower portion of the hydraulic pump.

Figure 6 is a continuation of Figure 5 and illustrates the standing valves at the lower end of the pump installation.

Figure 7 is an elevational view, partially in section, of a novel retrieving device for removing the subsurface pump unit.

Figure 8 is an elevational view, partially in section, of a wire line grappling member.

Referring to the drawings in detail, and particularly Fig. 1, reference character **1** designates the usual casing head provided at the upper end of the well casing **2**. The well casing **2** extends downwardly in the well bore **3** to the producing sands (not shown). A pair of tubing strings **4** and **5** are secured in the casing head **1** and extend downwardly in the casing **2** in parallel relationship. The upper end **6** of the larger tubing string **4** is enclosed by a cap **7** for purposes as will be hereinafter set forth. The upper end **8** of the smaller tubing string **5** is interconnected by a conduit **9** to a suitable four-way valve **10** having the usual handle **11**. The opposite side of the valve **10** is connected by a conduit **12** to an intermediate portion of the tubing string **4** above the casing head **1**.

A supply conduit **13**, and a discharge conduit **14** are also connected to the valve **10**. The conduit **13** communicates with a suitable hydraulic surface pump (not shown) utilized to supply clean power fluid, preferably oil, to the valve **10**. The conduit **14** communicates with a suitable storage tank or the like (not shown) for receiving the fluid displaced from the well bore **3**. It will be understood that the valve **10** may be manually operated by turning the handle **11** to place the conduit **13** into communication with either conduit **9**, or **12**, and simultaneously placing conduit **14** into communication with either conduit **12** or **9**.

The tubing string **4** forms the production column for the installation and extends downwardly into proximity with the lower end (not shown) of the casing **2**, and has a novel housing **15** (Fig. 2) suspended from the lower end **16** thereof. An essentially cylindrical pump cavity **17** is provided in the housing **15** to receive a subsurface hydraulic pump **18**. The diameter of the cavity **17** is larger than the internal diameter of the tubing **4** for purposes as will be hereinafter set forth. Vertically spaced circumferential shoulders **19** and **20** extend into the pump cavity **17** to engage sealing rings **21** and **22**, respectively, carried by the pump unit **18**. Therefore, when the pump **18** is installed in the cavity **17** as shown in Figure 2, the cavity **17** is divided into three chambers **23**, **24** and **25**.

The lower end **26** of the small tubing string **5** is connected to an intermediate header **27** of the housing **15** disposed below the lower end **16** of the tubing string **4**. A passageway **28** is provided in the header **27** providing communication between the lower end **26** of the tubing **5** and the centrally disposed chamber **24** of the pump cavity **17**. Another passageway **29** in the header **27** provides communication between the upper chamber **23** and a conduit **30** also connected to the header **27**. The lower end **31** of the conduit **30** is connected to a lower header **32** of the housing **15**, and communicates through a passageway **33** with the lower pump cavity chamber **25**. Communication is therefore constantly provided between the large tubing string **4**, the upper chamber **23** and the lower chamber **25**, as well as between the small tubing string **5** and the central or intermediate chamber **24**.

A conduit **34** extends from the lower header **32** of the housing **15** in aligned relationship with the lower chamber **25** to provide a seating nipple for the pump unit **18**. A bleeder type standing valve unit **35** is provided in the seating nipple **34** below the pump unit **18**, as will be more fully hereinafter set forth. A conduit **36** of larger diameter is also suspended from the lower end **32** of the housing **15**, and is perforated as clearly shown in Figure 2 to provide passageways for well fluid (not shown) to flow from the casing **2** into the conduit **34**.

It will be understood that the housing **15** may may be constructed in one unit as shown, or may be formed from a plurality of elements (not shown) according to the dictates of the manufacturer. The housing **15** is illustrated as one unit merely for simplicity.

As clearly shown in Figures 4 and 5, the pump unit **18** comprises an engine piston **37** and a pumping piston **38** interconnected by a hollow rod **39**. The engine piston **37**, pump piston **38** and hollow rod **39** are preferably similar to those elements as shown in applicant's copending application, Serial No. 90,953, entitled "Hydraulic Pump," filed May 2, 1949, now Patent No. 2,631,541. The elements provided in the engine piston **37** and the pump piston **38** are therefore not shown in detail herein. A main valve (not shown) and a pilot valve (not shown) are carried in the engine piston **37** to control the application of high pressure power fluid to the engine piston and hence the operation of the pump **18**. The usual traveling valve (not shown) is carried in the pump piston **38** to preclude flow of fluid downwardly through the piston but permit flow of fluid upwardly through the piston.

The engine piston **37** reciprocates in a tubular engine cylinder **40** and the pump piston **38** reciprocates in a pump cylinder **41**. The cylinders **40** and **41** are interconnected by an apertured middle plug **42** (Fig. 5) through which extends the hollow rod **39**. The sealing rings **22** are carried by the middle plug **42**, and are adapted to engage the seating shoulder **20** as previously set forth. A plurality of circumferentially spaced apertures **43** are provided transversely in the upper end **44** of the middle plug **42** and establish communication between the central pump cavity chamber **24** and the lower end of the engine cylinder **40**. Suitable packing **45** is provided in the apertured middle plug **42** around the rod **39** in the usual manner. A plurality of transverse apertures **46** are also provided in the upper end of the pump cylinder **41** to establish communication between the upper portion of the pump cylinder **41** and the lower pump cavity chamber **25**.

A standing valve unit **47** (Fig. 6) is threadedly secured on the lower end **48** of the pump cylinder **41** and comprises a valve body **49** having a valve seat **50** therein. A ball type valve **51** cooperates with the valve seat **50** to preclude flow of fluid downwardly through the valve unit **47**. A valve cage **52** is provided in the body **49** above the ball valve **51** to limit the upward movement of the ball valve **51** when fluid flows upwardly through the valve unit **47**.

The valve seat **50** is secured in the body **49** by a threaded sleeve **53** having an outwardly projecting annular flange **54** on the lower end thereof. The flange **54** normally rests on an apertured cap-shaped member **55** secured to the upper end of a tubular mandrel **56**. A smaller sized sleeve **57** is secured in the sleeve **53** and extends downwardly through the apertured cap **55**. A suitable sealing ring **58** provides a fluid tight seal between the sleeve **57** and the apertured cap **55**. The sleeve **57** may be moved relative to the cap **55**, as will be hereinafter set forth. A circumferential flange **59** is provided on the lower end of sleeve **57** to limit its relative upward movement. A plurality of circumferentially spaced apertures **60** are provided in the sleeve **57** to provide communication between the lower pump cavity chamber **25** and internal bore of the tubular mandrel **56** when the sleeve **57** is in its uppermost position (not shown). When the sleeve **57** is in its normal operating position as shown in Figure 6, the apertures **60** are disposed below the sealing ring **58**, thereby precluding communication between the chamber **25** and the mandrel **56**.

A conical seating surface **61** is provided on the outer periphery of the tubular mandrel **56** and cooperates with a conical shaped seat **62** provided in the lower end **32** of the housing **15** to position the pump unit **18** in the pump cavity **17**. A plurality of sealing cups **63** are secured on the outer periphery of the mandrel 56 in the usual manner to cooperate with the nipple 34 and anchor the pump unit 18 in the cavity 17.

As previously set forth, a standing valve unit 35 is also provided in the downwardly extending nipple 34. The valve unit 35 comprises a valve body 64 adapted to rest on an inwardly projecting circumferential flange 65 provided in the lower portion of the nipple 34. A valve seat 66 is secured in the lower end of the valve body 64 by a threaded sleeve 67. A ball type valve 68 cooperates with the valve seat 66 to preclude flow of fluid downwardly through the body 64. The ball 68 moves upward when a suction is created in the nipple 34 by action of the pump unit 18 to permit flow of fluid upwardly through the valve body 64. The upward movement of the ball 68 is limited by a valve cage 69 secured in the body 64.

A tubular mandrel 70 is threadedly secured to the upper end of the valve body 64 and has a plurality of sealing cups 71 secured on the outer periphery thereof in the usual manner to anchor the valve unit 35 in the seating nipple 34. An inwardly projecting hollow knockout plug or pin 72 is threadedly secured in an aperture 73 provided in the central portion of the valve body 64. The plug 72 may be broken off upon the insertion of a tool in the valve unit 35 as will be more fully hereinafter set forth to permit removal of the valve unit 35 from the well.

The upper end 74 (Fig. 4) of the engine cylinder 40 is enclosed by an apertured plug member 75 having an upwardly extending tubular portion 76. The sealing rings 21 are secured on the tube 76 and cooperate with the shoulder 19 to separate the upper pump cavity chamber 23 from the intermediate chamber 24 as previously set forth. A plurality of circumferentially spaced apertures 77 are provided in the plug 75 to establish communication between the chamber 24 and the tube 76 for purposes as will be hereinafter set forth. A smaller sized tube 78 extends upwardly from the plug 75 within the tube 76 and is enclosed at its upper end 79 (Fig. 3). The pilot valve rod 80 (Fig. 4) of the engine piston 37 extends upwardly through the apertured plug 75 into the tube 78 and is actuated in the same manner as in said previously mentioned copending application.

A valve housing 81 (Fig. 3) is threadedly secured to the upper end 82 of the tube 76. A valve seat 83 is secured in the valve body 81 to receive a ball type valve 84. A circumferential shoulder 85 is provided in the lower portion of the valve body 81 to limit the downward movement of the ball 84. A sleeve 86 is secured to the valve body 81 and extends upwardly therefrom for connection with a tubular element 87. The sleeve 86 is also utilized to secure an upturned sealing cup 88 on the member 87. A plurality of circumferentially spaced apertures 89 are provided in the sleeve 86 to establish communication between the valve body 81 above the valve seat 83 and the upper pump cavity chamber 23. A rod 90 is reciprocally disposed in the tubular member 87 and is adapted to retain the ball valve 84 off of the seat 83 in one position thereof as will be hereinafter set forth. The rod 90 is precluded from being forced upwardly out of the member 87 by a head 91 provided in the central portion thereof. A conical shaped head 92 is provided on the upper end of the tubular member 87.

### *Operation*

Assuming the pump unit 18 is seated in the cavity 17 as shown in Figures 2 to 6 and the valve 10 is set as shown in Figure 3, high pressure power fluid being pumped through the conduit 13, in the direction of the arrow, will be directed through the conduits 9, power tubing 5, and passageway 28 (Fig. 4) into the central chamber 24 of the pump cavity 17. From the chamber 24, the power fluid flows in two directions. Firstly, the power fluid flows through the apertures 77 and the tube 76 into the valve body 81 (Fig. 3) to retain the ball 84 upwardly against the seat 83. The power fluid in chamber 24 also flows through the apertures 43 (Fig. 5) into the lower end of the engine cylinder 40 to operate the hydraulic pump 18. The pump 18 operates in the same manner as in the above-mentioned copending application, and the power fluid, after acting on the engine piston 37, is exhausted downwardly through the hollow middle rod 39 and thence upwardly through the pump piston 38 into the upper portion of the pump cylinder 41.

During the upstroke of the pump plunger 38, a suction is created in the lower end of pump cylinder 41 (Fig. 6) and the seating nipple 34, causing a flow of well fluid from the well bore 3 upwardly through the standing valve unit 35 and the valve body 47 into the lower portion of the pump cylinder 41. On the downstroke of the pump plunger 38 (Fig. 5), well fluid previously drawn into the lower end of the pump cylinder 41 is forced through the pump plunger 38 and out through the apertures 93 into the upper portion of the pump cylinder 41 to mix with the exhausted or spent power fluid from the engine 37 previously discharged through the hollow rod 39, and apertures 93. It will be noted that the ball valves 51 and 68 (Fig. 6) are seated on their respective seats 50 and 66 during the downstroke of the pump plunger 38 to preclude a retrograde flow of the well fluid downwardly through the seating nipple 34.

On the subsequent upstroke of the pump plunger 38, the travelling valve (not shown) carried thereby will close, and the plunger 38 will displace the combined well fluid and exhausting power fluid out of the cylinder 41 through the apertures 46 into the lower pump cavity chamber 25 (Fig. 5). From the chamber 25 the fluid will be forced through the passageway 33 (Fig. 6), conduit 30 and passageway 29 (Fig. 4) into the upper pump cavity chamber 23. The pumped fluid will then flow upwardly through the large production tubing 4 (Fig. 3), conduit 12, valve 10 and conduit 14 to a desired storage (not shown).

From the foregoing it is apparent that during the normal operation of the pump unit 18 (Fig. 2), the smaller volume of high pressure power fluid will flow through the smaller power tubing 5, and the larger volume of production fluid, being a combination of pumped well fluid and exhausted or spent power fluid, will flow through the larger production tubing 4. The frictional resistance to flow of the production fluid will therefore be maintained at a minimum, thereby imposing a minimum load on the subsurface pump unit 18 and providing a more efficient well pumping installation. Furthermore, the weight of the column of fluid in the production tubing 4 will continuously press downward on the pump unit 18 to retain the pump in its seated position during operation thereof, as shown in Fig. 2.

### *Pump removal*

To facilitate the removal of the pump unit 18, a suitable pump catcher 94 (Fig. 3) is disposed in the upper end 6 of the large tubing string 4, and is retained therein by the cap 7. The pump catcher 94 comprises a cylindrical body portion 95 having a slip chamber 96 therein. A head 97 is disposed in the chamber 96 and is provided with a plurality of pins 98 extending radially therefrom. A slip 99, having an inwardly projecting head 100 on the lower end thereof, is loosely secured on each pin 98 to catch the pump unit 18 as will be hereinafter set forth. The slips 99 are forced inwardly by the tapering walls 101 of the chamber 96 when in a down position as shown in Fig. 3. A rod 102 extends upwardly from the head 97 into a bore 103 to retain the slips 99 in alignment with the chamber 96.

A retrieving device 104 (Fig. 7) is provided for removing the pump unit 18. The retriever 104 comprises a cylindrical mandrel 105 having three (but not limited thereto) sealing cups 106, 107 and 108 suitably secured on the outer periphery thereof. The upper two cups 106 and 107 are turned downwardly, and the lower cup 108 is turned upwardly for purposes as will be hereinafter set forth. A housing 109 is threadedly secured, through the medium of a sleeve 110, to the lower end 111 of the mandrel 105. A head 112 is disposed in the housing 109 and has a plurality of pine 113 extending outwardly therefrom. A slip member 114, having an inwardly projecting head 115 on the lower end thereof, is loosely secured on each pin 113. The slips 114 are retained in contact with each other by the tapered inner walls 116 of the housing 109 when the slips 114 are in a down position as shown in Figure 7. A rod 117 projects upwardly from the head 112 and is reciprocally disposed in a bore 118 of the sleeve 110 to retain the slips 114 in alignment in the housing 109 during movement thereof. A helical spring 119 is disposed on the rod 117 and co-acts with the sleeve 110 to yieldably retain the slips 114 in a down position as shown. A conical shaped head 120 is provided on the upper end of the mandrel 105 for purposes as will be hereinafter set forth.

When it is desired to remove the pump unit 18, the cap 7 and pump catcher 94 (Fig. 3) are removed to permit insertion of the retriever 104 into the upper end 6 of the tubing 4. The retriever 104 is inserted in the tubing 4 in an upright position as shown in Figure 7, and forced manually downward below the interconnection of the conduit 12 and tubing 4. The pump catcher 94 and cap 7 may then be replaced without interference with the retriever 104. The valve 10 is then turned to direct the high pressure fluid from the conduit 13 into the conduit 12 and hence into the upper portion of the tubing 4. The high pressure fluid will act on the upturned cup 108 of the retriever 104 and force the retriever downwardly in the large tubing 4, it being understood that the cup 108 is forced outwardly into sealing relationship with the tubing 4.

The combined well fluid and exhausted power fluid standing in the tubing 4 will be forced downwardly through the tubing 4 by the retriever 104 and flow inwardly through the apertures 89 (Fig. 3) into the sleeve 86 above the valve body 81. The ball valve 84 will thereby be forced downwardly into unseating position, permitting the downwardly moving fluid to flow through the valve seat 83, valve body 81, tube 76 and apertures 77 (Fig. 4) into the central pump cavity chamber 24. Since the lower chamber 25 also communicates with the tubing 4 through passageway 33 (Fig. 6), conduit 30 and passageway 29 (Fig. 4), the fluid pressure on both sides of the pump is equalized. Therefore, operation of the pump unit 18 will be stopped. In this condition, the clean power fluid stagnant in the central chamber 24 will not discharge through the engine piston 37, but is displaced by the downwardly moving dirty fluid through the passageway 28 and tube 5, since the tubing 5 is then at low pressure by virtue of the position of the four way valve 10. In like manner, the previously pumped dirty fluid in tubing 4 being forced downwardly by the retriever 104 will not enter the engine piston 37, but will be forced through the central chamber 24, thence through the passageway 28 (Fig. 4), tubing 5, conduit 9 (Fig. 3), valve 10 and conduit 14 to storage.



As the retriever 104 reaches the pump unit 18, the housing 109 of the retriever 104 moves over the conical shaped head 92 (Fig. 3). The head 92 will thereby become engaged by the slips 114, and the head 112 of the retriever 104 will move the rod 90 downwardly to hold the ball 84 off of the seat 83. The valve 10 is then turned back to the position shown in Figure 3 to again direct the high pressure power fluid through conduit 9, tubing 5, and passageway 28 into the central chamber 24 (Fig. 4). Since the ball 84 (Fig. 3) is then retained off of the seat 83 by the rod 90, the high pressure fluid will flow from the chamber 24 (Fig. 4) through the apertures 77, tube 76, valve housing 81, apertures 89, and chamber 23 into the lower end 16 of tubing 4. The high pressure fluid will then act on the downturned cups 106 and 107 of the retriever 104, forcing the retriever in an upward direction to unseat the pump unit 18. The pressure of the power fluid will be sufficiently high that the force exerted on the exposed annular area of the inverted cups 106 and 107 will overcome the weight of the column of fluid in the tubing 4 and initially raise the retriever 104 and the pump unit 18.

It will be noted that the chamber 23 communicates with the lower chamber 25 through the passageway 29, conduit 30 and passageway 33. Therefore, the pressure of the power fluid will be exerted in the lower chamber 25 and act downwardly on the sealing cups 63 (Fig. 6). Furthermore, the pressure in the seating nipple 34 below the seating cups 63 will be equal to the well pressure and therefore relatively low as compared to the pressure of the power fluid. It will therefore be apparent that upward movement of the mandrel 56 will be retarded. However, the sleeve 57, being rigidly connected to the pump cylinder 41, will be moved upward through the cap 55 during the initial upward movement of the pump unit 18. When the lower flanged end 59 of the sleeve 57 contacts the cap 55, the high pressure fluid will flow from the chamber 25 through the apertures 60 and mandrel 56 into the seating nipple 34 to equalize the pressure above and below the cups 63 and facilitate removal of the mandrel 56. The lower standing valve unit 35 will prevent flow of the fluid downwardly out of the nipple 34. When the mandrel 56 has been moved upwardly into the chamber 25, the high pressure fluid will act on the entire cross sectional area of the pump unit 18 as well as the exposed area of the cups 106 and 107 (Fig.

7) to provide a speedy upward movement of the pump unit 18 through the tubing 4.

As the pump unit 18 and retriever 104 approach the upper end 6 of the tubing 4, the conical shaped head 120 enters the pump catcher 94 (Fig. 3) and is engaged by the slips 99. To remove the pump unit 18 it is then simply necessary to remove cap 7 and lift the pump catcher 94, retriever 104 and pump unit 18 out of the tubing 4.

A boss 122 is provided on the tubing 4 adjacent the upper end 6 thereof. A plunger rod 123 is reciprocally disposed in the boss 122 and may be pushed partially into the tubing 4, except when the pump unit 18 is disposed in the upper portion of the tubing 4. Suitable packing (not shown) is provided in the boss 122 around the rod 123 to prevent a leakage of fluid from the tubing 4. A helical spring 124 is also provided in the boss 122 around the rod 123 to normally retain the rod 123 in a retracted position from the tubing 4 as shown in Figure 3. By manual operation of the rod 123 the presence or absence of the pump unit 18 in the upper portion of the tubing 4 can be ascertained.

From the foregoing it is apparent that when the flow of fluids in the parallel tubing strings 4 and 5 is reversed for any reason, thereby obtaining a higher fluid pressure in the lower end 16 of the tubing 4 than in the lower end 26 of the tubing 5, the pump unit 18 remains in its seated position in the pump cavity 17 and the dirty well fluid is not forced through the engine piston 37 to damage the delicate valve mechanism (not shown) therein. The pump 18 can only become unseated and removed from the well when the retriever device is disposed in tube 4 in connection with the element 92 and the normal fluid flow through tubes 5 and 4 is resumed. It is also apparent that upon flow reversal a soluble plug (not shown) may be pumped down the large tubing 4 to remove paraffin by liquefication due to change in temperature and pressure, without affecting the seating position of the pump unit 18.

When it is desired to install the pump unit 18, the pump is inserted in the upper end 6 of the tubing 4 in an upright position as shown in Figure 2 and the pump catcher 94 and cap 7 are replaced. The valve 10 is then turned to direct high pressure power fluid from the conduit 13 through the conduit 12 into the tubing 4. The high pressure fluid will then act on the upturned cup 88 (Fig. 3) to force the cup 88 outwardly into sealing contact with the inner periphery of the tubing 4, and force the pump unit 18 downwardly in the tubing 4. As previously set forth, the diameter of the pump cavity 17 is greater than the internal diameter of the tubing 4, therefore as the cup 88 enters the upper chamber 23, the pressure on opposite sides of the cup 88 will be equalized to render the cup 88 inoperative for assisting the movement of the pump unit 18 downwardly. However, when the cup 88 enters the chamber 23, at least one of the cups 21 (Fig. 4) will have contacted the shoulder 19, also one of the cups 22 (Fig. 5) will have contacted the shoulder 20 and one of the cups 63 (Fig. 6) will have entered the seating nipple 34. The pump cavity 17 will therefore be divided into the three chambers 23, 24 and 25, the same as when the pump unit 18 is fully seated.

The valve 10 is then again turned to the position shown in Fig. 3 to direct the high pressure power fluid through the small tubing 5 and into



the central chamber 24 to operate the pump unit 18 in the usual manner. During the first upstroke of the pump plunger 38, a suction will be created in the seating nipple 34. The weight of the column of oil standing in the tubing 4 and acting on the pump unit 18 will then force the pump unit 18 downwardly to the fully seated position as shown in Figs. 2 and 6. It will be readily seen that during downward movement of the pump unit 18, the cap 55 will be retained in contact with the flange 54 due to fluid standing in the cavity 17 and resisting movement of the pump unit 18. Therefore, when the pump unit 18 is partially seated, the sealing ring 58 is disposed above the apertures 60, to preclude flow from the chamber 25 through the ports 60 during the first upstroke of the pump plunger 38 and assure the creation of a suction in the seating nipple 34 to assist the final seating of the pump unit 18.

It is sometimes necessary to remove the lower standing valve unit 35. A suitable grappling member 126 is illustrated in Fig. 8 and is utilized for this purpose. The grappling member 126 comprises a rod 127 threaded at its upper end 128 for connection with a wire line connector (not shown). A sleeve 129 is threadedly secured to the lower end 130 of the rod 127 and has a dog 131 provided therein. A head 132 is provided on the lower end of the dog 131 and normally extends outwardly through an aperture 133. The dog 131 is yieldably retained in a down position as shown in Figure 8 by a suitable spring 134.

Assuming the pump unit 18 has been removed from the well and it is desired to remove the standing valve unit 35, the grappling member 126 is lowered through the tubing 4 by use of a suitable wire line or the like (not shown). As the sleeve 129 moves through the mandrel 70, the lower end of the sleeve 129 contacts and breaks off the knockout plug 72 to expose the aperture 73. The column of fluid standing in the large tubing 4 and the small tubing 5 is then drained through the mandrel 70, aperture 73 and around the lower portion of the valve housing 64 out of the lower end of the seating nipple 34 into the well casing 2. As the dog 131 is moved downwardly through the mandrel 70, the dog is retracted against the action of the spring 134 to move the head 132 into the sleeve 129. When the dog head 132 has moved below the mandrel 70, the spring 134 moves the head 132 outwardly for engagement with the lower end of the mandrel 70 upon a subsequent upward movement of the grappling member 126. After the tubings 4 and 5 have been drained, the standing valve unit 35 may be freely removed through the tubing 4.

From the foregoing it is apparent that the present invention provides a novel subsurface hydraulic pump installation wherein the minimum frictional resistance to flow is generated by the fluid being pumped from the well to reduce the load imposed on the subsurface pump to a minimum and increase the overall pumping efficiency. Two strings of tubing are provided in the well bore and are interconnected in such a manner that the flow through the tubings can be reversed, as when sending a retrieving device down the well to recover the subsurface hydraulic pump unit, or a soluble plug is passed downwardly through the production column to remove paraffin therefrom, without affecting the seating position of the pumping unit. Furthermore, the dirty production or well fluid will not be forced through the pump unit to damage the intricate valve mechanism therein, when the flow of fluid in the parallel strings of tubing is reversed. When the retrieving device is passed downwardly through the production column, paraffin which may be present therein is forced downwardly to a depth where the paraffin will become liquefied. Therefore, when the subsurface pump unit is subsequently raised through the production column, solidified paraffin is not forced from the production column into the various piping connections at the surface of the well to impair the flow of fluid therethrough. It is also apparent that the present invention provides a novel pump installation wherein all valves provided in the well bore are removable.

Changes may be made in the combination and arrangement of parts as heretofore set forth in the specification and shown in the drawings, it being understood that any modification in the precise embodiment of the invention may be made within the scope of the following claims without departing from the spirit of the invention.

We claim:

1. In a well installation for a subsurface hydraulic pump, comprising a large tubing and a small tubing extending downwardly in the well, a housing secured to the lower end of the large tubing for the reception of the subsurface pump constructed and arranged to provide communication between the power inlet of the subsurface pump and the small tubing and between the outlet of the subsurface pump and the large tubing, whereby power fluid flowing down the small tubing will operate the subsurface pump and the fluid pumped by the subsurface pump will flow up the large tubing, a passageway in the subsurface pump providing a by-pass passageway for fluid upon a reversal of flow in the large and small tubings, a check valve in the passageway to preclude flow of fluid from the small tubing through the passageway into the large tubing, and a retrieving device adapted to engage the upper end of the subsurface pump and open said check valve, whereby fluid will flow from the small tubing through the passageway to act on the retrieving device and raise the subsurface pump through the large tubing.

2. In a well installation for a subsurface hydraulic pump, comprising a large tubing and a small tubing extending downwardly in the well, a housing secured to the lower end of the large tubing for the reception of the subsurface pump constructed and arranged to provide communication between the power inlet of the subsurface pump and the small tubing and between the outlet of the subsurface pump and the large tubing, whereby power fluid flowing down the small tubing will operate the subsurface pump and the fluid pumped by the subsurface pump will flow up the large tubing, a passageway in the subsurface pump providing a by-pass passageway for fluid upon a reversal of flow in the large and small tubings, a check valve in the passageway to preclude flow of fluid from the small tubing through the passageway into the large tubing, a retrieving device adapted to move in the large tubing and adapted to engage the upper end of the subsurface pump, sealing rings carried by the retrieving device in sealing contact with the large turbing, means for opening the check valve upon engagement of the retrieving device with the pump, whereby fluid may flow from the small tubing through the passageway underneath the sealing rings and raise the subsurface pump through the large tubing.

3. In a well installation for a subsurface hydraulic pump, comprising a large tubing and a small tubing extending downwardly in the well, a housing secured to the lower end of the large tubing for the reception of the subsurface pump constructed and arranged to provide communication between the power inlet of the subsurface pump and the small tubing and between the outlet of the subsurface pump and the large tubing, whereby power fluid flowing down the small tubing will operate the subsurface pump and the fluid pumped by the subsurface pump will flow up the large tubing, a passageway in the subsurface pump providing a by-pass passageway for fluid upon a reversal of flow in the large and small tubings, a check valve in the passageway to preclude flow of fluid from the small tubing through the passageway into the large tubing, a rod carried by the subsurface pump and adapted to open the check valve in one position thereof, a retrieving device adapted to engage the upper end of the subsurface pump and retain said rod in said one position, whereby fluid from the small tubing will flow through said passageway into the large tubing upon engagement of the retrieving device, and a sealing cup on the retrieving device disposed in sealing contact with the large tubing when fluid is flowing from the small tubing through the passageway to raise the subsurface pump in the large tubing.

4. In a well installation for a subsurface hydraulic pump comprising a large tubing and a small tubing extending downwardly in the well from the surface thereof, a pump cavity communicating with the lower end of the large tubing, a seating nipple communicating with the lower end of the pump cavity for seating a subsurface pump in the pump cavity, a pair of vertically spaced shoulders in the pump cavity, sealing cups carried by the subsurface pump and adapted to contact the shoulders to divide the pump cavity into two chambers, one of said chambers being in communication with the power inlet of the subsurface pump, the other of said chambers being in communication with the outlet of the subsurface pump, a passageway between the first mentioned chamber and the small tubing to transfer power fluid from the small tubing to the power inlet of the subsurface pump, and a passageway between the second mentioned chamber and the large tubing whereby fluid pumped by the subsurface pump will be pumped through the large tubing to the surface of the well, an extension on the upper end of the subsurface pump, a passageway in said extension providing a by-pass passageway for fluid from the large tubing into the first mentioned chamber upon a reversal of flow in the large and small tubings, a check valve in said last mentioned passageway to preclude flow of fluid therethrough from the first mentioned chamber into the large tubing, a retrieving device adapted to engage the upper end of said extension, and a rod carried in said extension adapted to open the check valve upon engagement of the retrieving device with the extension to provide a flow of fluid from said first mentioned chamber through said last mentioned passageway to act on said retriever and raise the subsurface pump through the large tubing.

5. A well pump installation comprising first and second tubings extending downwardly within the well in parallel relation; a fluid-actuated

pump unit of a size to pass through said first tubing and having a power fluid inlet, a pump inlet and a pump outlet; a housing secured to the lower ends of said tubings and defining a pump-receiving cavity aligned with said first tubing whereby said pump unit may be lowered through said first tubing and into operative position in said cavity; cooperating sealing means on said pump unit and said housing dividing said cavity into a power fluid chamber communicating with said power fluid inlet and a pump chamber communicating with said pump outlet; said housing having first passage means providing communication between said pump chamber and said first tubing, and having second passage means providing communication between said second tubing and said power fluid chamber.

6. A well pump installation comprising first and second tubings extending downwardly within the well in side-by-side relation; a fluid-actuated pump unit of a size to pass through said first tubing and having a power fluid inlet, a pump inlet and a pump outlet; a housing secured to the lower ends of said tubings and defining a pump-receiving cavity aligned with said first tubing, whereby said pump unit may be lowered through said first tubing and into operative position in said cavity; first cooperating sealing means on said pump unit and said housing dividing said cavity into an upper chamber communicating with said power fluid inlet and a lower chamber communicating with said pump outlet; second cooperating sealing means on said pump unit and said housing isolating said upper chamber from said first tubing; said housing having first passage means providing communication between said second tubing and said upper chamber, said housing having second passage means providing communication between said lower chamber and said first tubing.

7. A well pump installation comprising first and second tubings extending downwardly within the well in side-by-side relation; a fluid-actuated pump unit of a size to pass through said first tubing and having a power fluid inlet, a pump inlet and a pump outlet; a housing secured to the lower ends of said tubings and defining a pump-receiving cavity aligned with said first tubing, whereby said pump unit may be lowered through said first tubing and into operative position in said cavity; first cooperating sealing means on said pump unit and said housing dividing said cavity into an upper chamber communicating with said power fluid inlet and a lower chamber communicating with said pump outlet; second cooperating sealing means on said pump unit and said housing isolating said upper chamber from said first tubing; third cooperating sealing means on said pump unit and said housing isolating said lower chamber from said pump inlet; said housing having first passage means providing communication between said second tubing and said upper chamber, said housing having second passage means providing communication between said lower chamber and said first tubing.

8. An installation as set forth in claim 6, wherein said second passage means includes a conduit communicating at its lower end with the lower portion of said lower chamber and extending upwardly past said lower chamber and said upper chamber, and communicating at its upper end with said first tubing at a point above said second sealing means.

9. An installation as set forth in claim 6, wherein said second passage means includes a third tubing disposed in substantial alignment with said second tubing, said third tubing communicating at its lower end with the lower portion of said lower chamber and extending upwardly alongside said housing, the upper end of said third tubing communicating with said first tubing at a point above said second sealing means.

10. A well pump installation comprising a first tubing and a second tubing extending downwardly within the well; a housing secured to the lower end of said first tubing and defining a pump-receiving cavity in alignment with said first tubing; a fluid-actuated pump unit of a size to pass through said first tubing and adapted to seat in said cavity, said pump unit including a reciprocating fluid motor having a power fluid inlet and valve-means for causing reciprocation of the motor in both directions by power fluid introduced through said inlet, said pump unit including a pump actuated by said motor and having an inlet and an outlet; said housing having first passage means providing communication between said pump outlet and said first tubing; said housing having second passage means providing communication between said second tubing and said motor inlet.

11. A well pump installation as set forth in claim 10, and including sealing means on said pump unit and on said housing cooperating, upon seating of said pump unit in said cavity, to isolate said first and second passages from each other.

12. A well pump installation as set forth in claim 10, and including sealing means on said pump unit and on said housing cooperating, upon seating of said pump unit in said cavity, to isolate said second passage means from said first tubing.

13. A well pump installation as set forth in claim 10, and including sealing means on said pump unit and on said housing cooperating, upon seating of said pump unit in said cavity, to isolate said first and second passages from each other, and including sealing means on said pump unit and on said housing cooperating, upon seating of said pump unit in said cavity, to isolate said second passage means from said first tubing.

14. A well pump installation as set forth in claim 10, and including sealing means on said pump unit and on said housing cooperating, upon seating of said pump unit in said cavity, to isolate said first and second passages from each other, and including sealing means on said pump unit and on said housing cooperating, upon seating of said pump unit in said cavity, to isolate said second passage means from said first tubing, and including sealing means on said pump unit and on said housing cooperating, upon seating of said pump in said cavity, to isolate said pump inlet from said first and second passages.

15. A well pump installation comprising a first tubing and a second tubing extending downwardly within the well; a housing secured to the lower end of said first tubing and defining a pump-receiving cavity aligned with said first tubing; a fluid-actuated pump unit seated in said cavity and including a fluid-actuated motor having an inlet and an outlet for power fluid, and a pump operatively connected to said motor and having an inlet and an outlet for pump fluid; first passage means in said housing providing communication between said second tubing and

said motor inlet whereby power fluid pumped down said second tubing will actuate said motor; second passage means in said housing providing communication between said motor and pump outlets and said first tubing whereby pump fluid discharged by said pump and spent power fluid exhausted from said motor are discharged upwardly through said first tubing; said pump unit having a by-pass passage therein and a check valve in said passage, said by-pass passage and said check valve providing unidirectional flow of fluid from said first tubing to said second tubing and by-passing said motor and pump, said check valve being normally operative to prevent by-pass flow of fluid from said second tubing to said first tubing through said by-pass passage.

16. A well pump installation comprising a first tubing and a second tubing extending downwardly in the well; a housing secured to the lower end of said first tubing and defining a pump-receiving cavity aligned with said first tubing; a fluid-actuated pump unit adapted to be lowered through said first tubing and seat in said cavity, said pump unit comprising a fluid-actuated motor having an inlet and an outlet for power fluid, and a pump operatively connected to said motor and having an inlet and an outlet for pump fluid; sealing means on said pump unit and on said housing cooperating, upon seating of said pump in said cavity, to divide said cavity into a motor chamber communicating with said motor inlet but isolated from said first tubing and a pump chamber communicating with said pump outlet but isolated from said second tubing; first passage means in said housing providing communication between said pump chamber and said first tubing; second passage means in said housing providing communication between said motor chamber and said second tubing; and a check valve controlled by-pass passage in said pump unit providing unidirectional flow from said first tubing to said motor chamber, said check valve normally preventing flow from said motor chamber through said by-pass passage to said first tubing.

17. A well pump installation comprising a first tubing and a second tubing extending downwardly within the well; a housing secured to the lower end of said first tubing and defining a pump-receiving cavity aligned with said first tubing; a fluid-actuated pump unit seated in said cavity and including a fluid-actuated motor having an inlet and an outlet for power fluid, and a pump operatively connected to said motor and having an inlet and an outlet for pump fluid; first passage means in said housing providing communication between said second tubing and said motor inlet whereby power fluid pumped down said second tubing will actuate said motor; second passage means in said housing providing communication between said motor and pump outlets and said first tubing whereby pump fluid discharged by said pump and spent power fluid exhausted from said motor are discharged upwardly through said first tubing; said pump unit having a by-pass passage therein and a check valve in said passage, said by-pass passage and said check valve providing unidirectional flow of fluid from said first tubing to said second tubing and by-passing said motor and pump, said check valve being normally operative to prevent by-pass flow of fluid from said second tubing to said first tubing through said by-pass passage, and means for rendering said check valve inoperative, to thereby permit fluid flow from said second tubing through said by-pass passage to said first tubing.



18. A housing for a fluid-actuated well pump, comprising a hollow body defining a pump receiving cavity; a head member secured to the upper end of said body, said head member having means for securing a first tubing thereto in alignment with said cavity and for securing a second tubing thereto in laterally offset relation to said cavity; a foot member secured to the lower end of said body; a by-pass conduit extending from said head member to said foot member; a first passage in said head member providing communication between said second tubing and said cavity, and a second passage in said head member providing communication between the upper end of said by-pass conduit and said cavity at a point spaced above the point of communication of said first passage with said cavity; a third passage in said foot member providing communication between the lower end of said by-pass conduit and the lower portion of said cavity; and a sealing surface in said cavity between said points of communication of said first and second passages with said cavity and adapted to cooperate with seal means on a pump unit, upon seating of said pump unit in said cavity, to isolate said first and second passages from each other.

19. A housing for a fluid-actuated well pump, comprising a hollow body defining a pump receiving cavity; a head member secured to the upper end of said body, said head member having means for securing a first tubing thereto in alignment with said cavity and for securing a second tubing thereto in laterally offset relation to said cavity; a foot member secured to the lower end of said body; a by-pass conduit extending from said head member to said foot member; a first passage in said head member providing communication between said second tubing and said cavity, and a second passage in said head member providing communication between the upper end of said by-pass conduit and said cavity at a point spaced above the point of communication of said first passage with said cavity; a third passage in said foot member providing communication between the lower end of said by-pass conduit and the lower portion of said cavity; a sealing surface in said cavity between said points of communication of said first and second passages with said cavity and adapted to cooperate with seal means on a pump unit, upon seating of said pump unit in said cavity, to isolate said first and second passages from each other; and a second sealing surface in said cavity between the points of communication of said first and third passages with said cavity and adapted to cooperate with seal means on said pump unit to isolate said first and third passages from each other.

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