July 16, 1957 C. H. KANGAS 2,799,226

HYDRAULIC PUMP

Filed Oct. 15, 1954 2 Sheets-Sheet 1

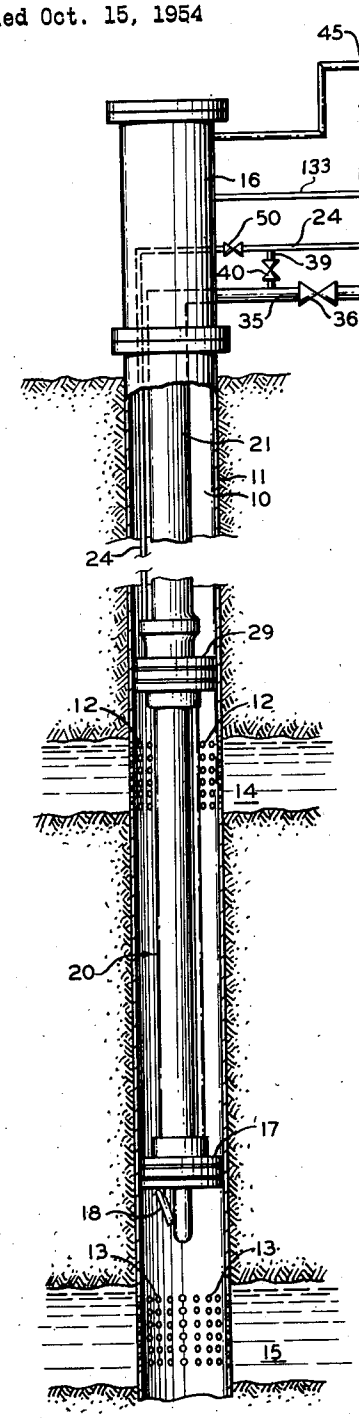

FIG. 1

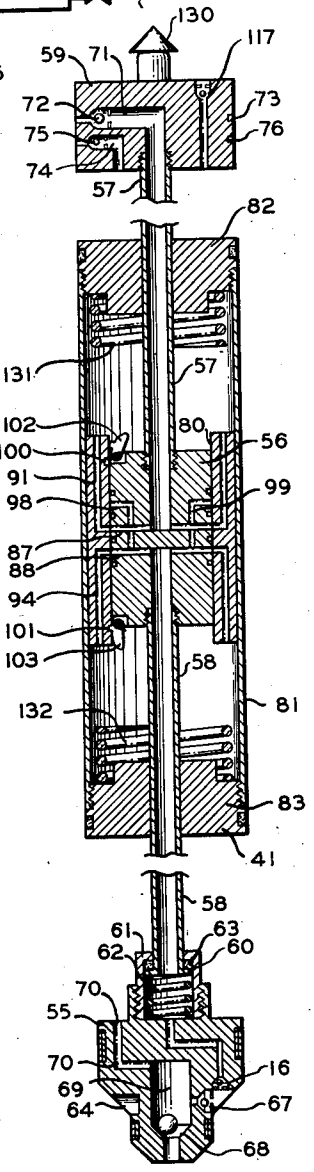

FIG. 3

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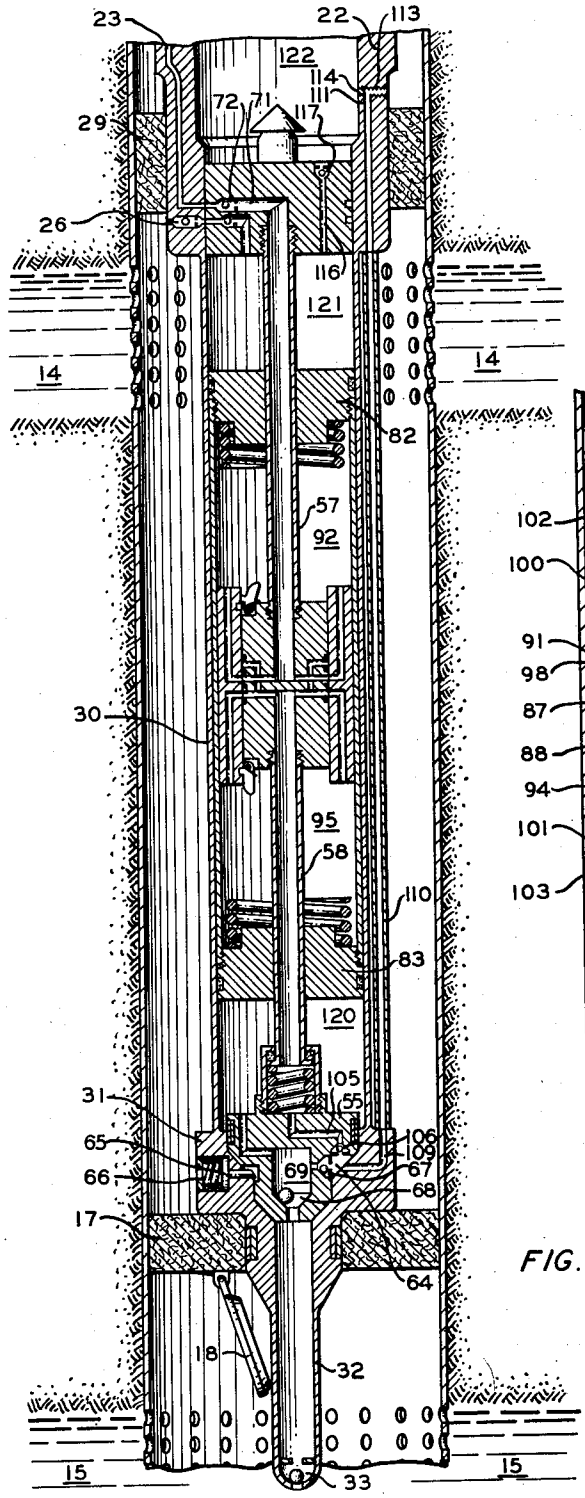

FIG. 2

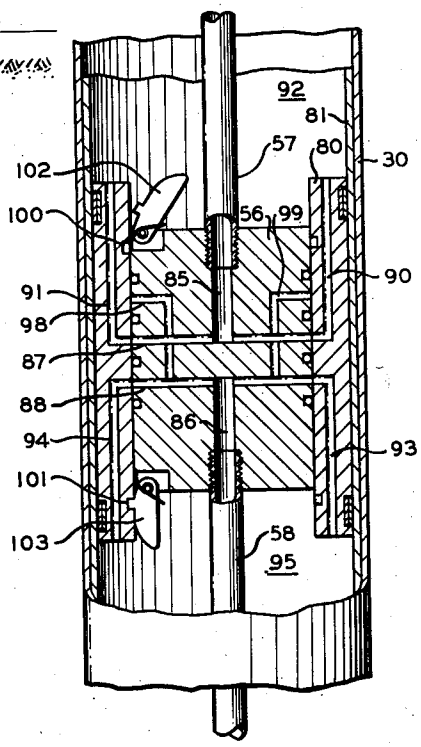

FIG. 4

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HYDRAULIC PUMP

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Application October 15, 1954, Serial No. 462,478

11 Claims. (Cl. 103—46)

This invention relates to a bottom hole hydraulic pump for use in dual zone producing wells. In another aspect, it relates to a single zone double acting hydraulic pump.

Oil wells often intersect several independent strata from which oil may be produced. In pumping wells of this nature, it is often desirable or necessary that the oil produced from the separate zones be removed as independent streams. This can be accomplished either by employing a plurality of pumps in different bore holes in the same field or by separating the inlets of a plurality of pumps in a single bore hole in such a manner that the oil in the two zones is removed through separate conduits. Various types of dual zone deep well pump assemblies are known in the art for pumping such wells. However, the known pumping structures have not been entirely satisfactory because of the relative complexity of the devices. It is desired that the pump structure be of such configuration that it can readily be removed from the well for servicing operations without removing the entire well tubing and hydraulic fluid lines. Furthermore, it is desired that the pump structure be relatively simple and employ a minimum number of moving parts. Another desirable feature is that such a pumping structure is readily convertible from dual zone to single zone producing operations.

Accordingly, it is an object of this invention to provide an improved hydraulic pump adapted to remove fluid simultaneously from two spaced well formations without admixing the pumped fluids.

Another object is to provide a hydraulic actuated well pump of such configuration that the moving parts of the structure can readily be removed from the well without withdrawing the tubing string from which the pump is suspended.

A further object is to provide a pumping structure for use in either single or dual zone producing wells.

Other objects, advantages and features of this invention should become apparent from the following detailed description taken in conjunction with the accompanying drawing in which:

Figure 1 is an elevation view, shown partially in section, of a dual zone producing well having the pumping structure of this invention inserted therein;

Figure 2 is a detailed sectional view of the pump assembly of this invention;

Figure 3 is a sectional view of the moving pump assembly which is inserted in the tubing string; and

Figure 4 is a detailed view of the center section of the pump assembly of Figure 3.

Referring now to the drawing in detail and to Figure 1 in particular, there is shown a bore hole **10** having a casing string **11** therein. Casing string **11** is provided with spaced perforations **12** and **13** adjacent respective oil producing formations **14** and **15**. A casing head **16** is attached to the upper end of casing string **11**. When it is desired to produce oil from formations **14** and **15** independently of one another, a first packer **17** is set in casing string **11** between the two formations. As shown in greater detail in Figure 2, packer **17** is provided with a central opening which can be closed by a hinged check valve **18**, if desired. After packer **17** is set in the casing string, a pump assembly housing **20** is lowered into the well on the lower end of a tubing string **21**.

With reference to Figure 2, the lower end of tubing string **21** terminates in an upper valve housing **22**. Housing **22** is provided with a passage **23** which communicates at its upper end with a hydraulic fluid supplying conduit **24**, Figure 1, which extends upwardly through casing string **11** to the surface of the well. Conduit **24** extends out of casing head **16** at the surface and through a valve **50** to the outlet of a hydraulic pump **25**. The lower end of passage **23** communicates with the interior region of valve housing **22**. A check valve **26** in housing **22** defines a passage between the exterior and interior of valve housing **22** in a manner which permits fluid flow from formation **14** into the interior of housing **22** but prevents flow in the reverse direction. An expandable packer **29** is carried by housing **22** above the passage formed by check valve **26**. The lower end of housing **22** forms an elongated pump barrel **30**, and the lower end of pump barrel **30** forms a second housing **31** which rests upon packer **17**. The lower end of housing **31** forms an elongated conduit **32** which extends through the central opening in packer **17** by displacing valve **18** downwardly. The lower end of conduit **32** is provided with a check valve **33** which permits the flow of oil from formation **15** into the interior of conduit **32** but prevents flow in the reverse direction. Once the tubing string is lowered into the well such that housing **31** rests upon packer **17**, expandable packer **29** is set to seal the region between housing **22** and casing string **11**. Well packers are, of course, well known in the art and, for this reason, are not described in detail herein.

The pump assembly illustrated in Figure 3 is then positioned within tubing string **21** at the surface of the well. Casing head **16** is attached to casing string **11** such that a conduit **35** having a valve **36** therein communicates with the top of tubing string **21**. An oil reservoir **37** is connected to the inlet port of pump **25** by a conduit **38**. Conduits **24** and **35** are connected by a conduit **39** having a valve **40** therein. Conduits **41** and **42**, having respective valves **43** and **44** therein, also communicate with oil reservoir **37**. The second end of conduit **42** is connected to a conduit **45** which communicates at one end with the interior of casing head **16** and at the other end with a valve **47** in a conduit **46**. After the pump assembly of Figure 3 is positioned within tubing string **21**, valves **36** and **50** are closed and valve **40** is opened so that pump **25** forces hydraulic fluid from reservoir **37** into the top of tubing string **21**. This forces the pump assembly of Figure 3 downwardly through tubing string **21** until the lower end of the assembly engages housing **31**, as illustrated in Figure 2.

The pump assembly of Figure 3 comprises a center plug **56** which forms a valve body having respective pipes **57** and **58** extending upwardly and downwardly therefrom. A plug **59** is attached to the upper end of pipe **57** and a plug **55** is secured to the lower end of pipe **58**. The lower end of pipe **58** is provided with an outwardly extending flange **60** which is disposed within an inverted cup-shaped sleeve **61**. Sleeve **61** is threaded to plug **55**. A compression spring **62** is disposed within sleeve **61** to force flange **60** upwardly in sleeve **61** in engagement with packing material **63**. This arrangement provides a flexible attachment between pipe **58** and plug **55** and prevents compression forces being exerted on pipe **58**.

The lower portion of plug **55** is provided with an annular recess **64** which is engaged by a plunger **65** in housing **31**, see Figure 2. Plunger **65** is forced into recess **64** by a compression spring **66** to lock the pump assembly of Figure 3 in barrel **30**. A check valve **67** forms a passage

between recess 64 and a central passage 69 in plug 55. Passage 69 communicates at its lower end with the interior of conduit 32 through a check valve 68 which permits fluid flow upwardly into passage 69 but prevents flow in the reverse direction. The upper end of passage 69 communicates with the region above plug 55 through a passage 70.

The interior of pipe 57 communicates with passage 23 of Figure 2 through a passage 71 in plug 59. Passage 71 contains a check valve 72 which permits fluid flow from passage 23 into passage 71 but prevents flow in the reverse direction. An annular recess 73 is provided in plug 59 adjacent the inlet of check valve 72 to ensure communication with passage 23 irrespective of the rotational alignment of the pump assembly within housing 22. A passage 74, having a check valve 75 therein, is formed in plug 59 between the passage formed by check valve 26 of Figure 2 and the region of the pump assembly below plug 59. Check valve 75 permits the flow of fluid from formation 14 into the region below plug 59 but prevents flow in the reverse direction. An annular recess 76 is provided in plug 59 adjacent the inlet of check valve 75 to ensure engagement with the passage formed by check valve 26.

As illustrated in greater detail in Figure 4, center plug 56 of the pump assembly is surrounded by a sleeve 80 which makes slidable engagement therewith. An elongated sleeve 81 encloses sleeve 80 in slidable contact. The upper end of sleeve 81 is connected to a first piston 82, see Figure 3, which encloses pipe 57, and the lower end of sleeve 81 is connected to a second piston 83 which encloses pipe 58.

Plug 56 is provided with longitudinal passages 85 and 86 which communicate with respective pipes 57 and 58. Passages 85 and 86 in turn communicate with respective radial passages 87 and 88 which terminate at their outer ends adjacent sleeve 80. The outer ends of passage 87 communicate with respective longitudinal passages 90 and 91 in sleeve 80. The upper ends of passages 90 and 91 are in communication with the region 92 above plug 56. The outer ends of passage 88 are in communication with respective passages 93 and 94 which extend longitudinally of sleeve 80 and which communicate at their lower ends with a region 95 below plug 56. Passages 98 and 99 in plug 56 communicate at their respective first ends with passage 88 and at their respective second ends with regions exterior of plug 56 adjacent sleeve 80. Annular recesses 100 and 101 are formed in sleeve 80 adjacent the respective upper and lower ends thereof. Spring biased locks 102 and 103 are mounted on the respective upper and lower ends of plug 56 to engage respective recesses 100 and 101. As illustrated in Figure 4, lock 103 is in engagement with recess 101, whereas lock 102 is out of engagement with recess 100.

As illustrated in Figure 2, pipe 58 is in communication with annular recess 64 in housing 31 through a passage 105 which has a check valve 106 therein. Check valve 106 allows the passage of fluid from pipe 58 to recess 64 but prevents flow in the reverse direction. A passage 109 is formed in housing 31 in communication with recess 64 at one end. The second end of passage 109 communicates with a conduit 110 which extends longitudinally of pump barrel 30. The upper end of conduit 110 communicates with a passage 111 which extends longitudinally through housing 22. The upper end of passage 111 is in communication with a threaded passage 113 which extends between the interior and exterior of housing 22. A plug 114 is positioned within passage 113 to block communication between passage 111 and the interior of housing 22 above plug 59. A passage 116, having a check valve 117 therein, extends through plug 59. Check valve 117 permits fluid flow from the region 121 above piston 82 to the region 122 above plug 59 but prevents flow in the reverse direction.

When the pump assembly is located in position within barrel 30, valve 40 is closed and valves 50 and 36 are opened, see Figure 1. Hydraulic fluid from reservoir 37 is then directed by pump 25 through conduit 24, passage 23, check valve 72, passage 71, pipe 57, passage 87 and passages 90 and 91 into region 92 below piston 82. The fluid pressure in region 92 moves piston 82 upwardly to displace any oil previously in region 121 through passage 116 and check valve 117 into tubing string 21. This oil is removed at the surface through conduit 35 and valve 36. Piston 83 is attached rigidly to piston 82 by sleeve 81 and moves upwardly therewith. Oil then flows from formation 15 into region 120 below piston 83 through check valve 33, conduit 32, check valve 68, passage 69 and passage 70. At approximately the end of the upward stroke, the center portion of piston 83 disengages lock 103 from recess 101. The periphery of piston 83 then engages sleeve 80 and forces it upwardly until lock 102 engages recess 100. At this latter position, passage 87 is in communication with passages 93 and 94 whereas passages 98 and 99 are in communication with respective passages 91 and 90.

The hydraulic fluid from conduit 24 is then directed through passages 93 and 94 into region 95 to displace the piston assembly downwardly. Oil in region 120 from formation 15 is forced through passages 70 and 69, check valve 67, passage 109, conduit 110 and passages 111 and 113 into the annular space surrounding tubing string 21. This oil is removed at the surface through conduit 45 and can be directed through conduit 46 or returned to reservoir 37 as needed. The downward movement of piston 82 forces hydraulic fluid from region 92 through passages 90, 91, 88 and 86 into pipe 58. From pipe 58 the fluid is directed through passage 105 and check valve 106 into exhaust passage 109. Thus, the fluid removed at the surface through conduit 45 is a mixture of the produced oil from zone 15 and the hydraulic fluid supplied by pump 25 from reservoir 37. The downward movement of piston 82 results in the flow of oil from zone 14 into region 121 through check valves 26 and 75 and passage 74. As previously mentioned, this oil from zone 14 is removed on the upstroke of piston 84 through tubing string 21. At the end of the downstroke of the piston assembly, lock 102 is disengaged from recess 100 by piston 82 and sleeve 80 is displaced downwardly until lock 103 again engages recess 101. On the following upstroke of the piston assembly, the hydraulic fluid in region 95 is displaced through passages 93, 94, 88 and 86 into pipe 58. From pipe 58 the fluid is directed through passage 105 and check valve 106 into outlet passage 109. Thus, the hydraulic fluid supplied to the well from pump 25 is removed at all times through the annular space surrounding tubing string 21. The oil pumped from zone 15 is likewise removed from this annular space. The oil from upper zone 14, however, is removed from the interior of tubing string 21. In this manner, the production from the two zones is removed in separate streams. Springs 131 and 132 serve as shock absorbers.

When it is desired to remove the pumping assembly from barrel 30, hydraulic fluid is forced by pump 25 through line 133 into the annular space surrounding tubing string 21 by opening valve 134 and closing valves 39 and 50. Valve 134 is open only when the pumping assembly is removed. This fluid is directed through passages 113 and 111, conduit 110 and passage 109 into the annular space 64. The fluid pressure in this region displaces piston 65 against the force of spring 66 to disengage the pump assembly from the barrel. The fluid pressure in region 64 also exerts an upward force on the pump assembly which forces the assembly upwardly through tubing string 21. The pump assembly can thus readily be removed without disturbing the tubing string or the fluid supply conduit 24.

When it is desired to employ the pumping apparatus of this invention in a single zone producing well, plug 114 is positioned in the right-hand side of passage 113 such that passage 111 is in communication with the in-

terior of tubing string **21** rather than with the annular space surrounding the tubing string. Packer **17** is not needed in such an operation because the oil from the single zone is permitted to enter the pump assembly through both check valve **33** and check valve **26**. The operation of the pump is substantially the same as previously described except that all of the oil removed is from a common zone. For this reason, it is not necessary to separate the product streams and all of the oil as well as the hydraulic fluid can be removed through tubing string **21**.

The outer ends of passages **87**, **88**, **98** and **99** or the inner ends of passages **90**, **91**, **93** and **94** terminate in annular recesses to provide communication with the adjacent passages irrespective of the relative positions of plug **56** and sleeve **80**. A latching member **130** is provided on plug **59** to enable the pump assembly to be "fished" out of the well if necessary. In order to simplify the drawing, the various check valves have been shown schematically. Also, the apparatus is not necessarily drawn to scale, and it should be apparent that the relative dimensions of the parts can be varied as desired.

While the invention has been described in conjunction with a present preferred embodiment, it should be apparent that the invention is not limited thereto.

What is claimed is:

1. A hydraulic fluid actuated pumping unit comprising, in combination, a housing defining a piston chamber, said housing having an inlet opening and an outlet opening at each end thereof, a check valve in each of said inlet openings to prevent fluid from flowing from the interior of said housing to the exterior thereof, a check valve in each of said outlet openings to prevent fluid from flowing from the exterior of said housing to the interior thereof, first and second pistons positioned within said housing, said pistons being connected together in spaced relationship, inlet conduit means communicating between a region exterior of said housing and a region within said housing between said pistons, outlet conduit means communicating between a region exterior of said housing and a region within said housing between said pistons, a valve body having first and second inlet ports communicating with the ends of said inlet and outlet conduit means between said pistons, respectively, said valve body having first and second outlet ports communicating with said first and second inlet ports, respectively, and a member in slidable engagement with said valve body, said member and said valve body dividing the region between said pistons into first and second fluid chambers, said member having first and second passages therein, first ends of said passages communicating with said first and second fluid chambers, respectively, and second ends of said passages being adjacent said valve body, said member being movable relative to said valve body by said pistons whereby said first outlet port is in communication with said first passage and said second outlet port is in communication with said second passage in a first position and said first outlet port is in communication with said second passage and said second outlet port is in communication with said first passage in a second position.

2. The combination in accordance with claim 1 wherein said member is moved to said first position by said first piston and to said second position by said second piston, and further comprising latching means to retain said member in said positions until moved by one of said pistons.

3. A hydraulic fluid actuated pumping unit comprising, in combination, a housing defining a piston chamber, said housing having an inlet opening and an outlet opening at each end thereof, a check valve in each of said inlet openings to prevent fluid from flowing from the interior of said housing to the exterior thereof, a check valve in each of said outlet openings to prevent fluid from flowing from the exterior of said housing to the

interior thereof, first and second pistons positioned within said housing, a hollow cylinder extending between said first and second pistons to retain said pistons in spaced relationship, a cylindrical valve body positioned within said cylinder, a hydraulic fluid inlet supply conduit extending from a region exterior of said housing to a first inlet port in said valve body, a hydraulic fluid outlet conduit extending from a region exterior of said housing to a second inlet port in said valve body, said valve body having first and second outlet ports in the side wall thereof communicating through said valve body with said first and second inlet ports, respectively, an annular member enclosing said valve body in slidable engagement, said member and said valve body dividing the region between said pistons into first and second fluid chambers, said member having first and second passages therein, first ends of said passages communicating with said first and second fluid chambers, respectively, and second ends of said passages being adjacent said valve body, said member being movable relative to said valve body by said pistons whereby said first outlet port is in communication with said first passage and said second outlet port is in communication with said second passage in a first position and said first outlet port is in communication with said second passage and said second outlet port is in communication with said first passage in a second position, and latching means to retain said member and said valve body in said positions until moved by one of said pistons.

4. A hydraulic fluid actuated pumping unit adapted to be positioned in a well tubing comprising, in combination, first and second pistons adapted to be positioned in a well tubing for slidable movement therein, said pistons being connected together in spaced relationship, inlet conduit means having one end thereof positioned between said pistons, outlet conduit means having one end thereof positioned between said pistons, a valve body having first and second inlet ports communicating with the ends of said inlet and outlet conduit means between said pistons, respectively, said valve body having first and second outlet ports communicating with said first and second inlet ports, respectively, and a member in slidable engagement with said valve body, said member and said valve body dividing the region between said pistons into first and second fluid chambers, said member having first and second passages therein, first ends of said passages communicating with said first and second fluid chambers, respectively, and second ends of said passages being adjacent said valve body, said member being movable relative to said valve body by said pistons whereby said first outlet port is in communication with said first passage and said second outlet port is in communication with said second passage in a first position and said first outlet port is in communication with said second passage and said second outlet port is in communication with said first passage in a second position.

5. A hydraulic fluid actuated well pumping unit comprising, in combination, an elongated housing defining a piston chamber, said housing being adapted to be positioned in a well on the end of a tubing, said housing having a first inlet opening at the lower end thereof, a check valve in said first inlet opening to prevent fluid flow from within said housing to the region exterior thereof, said housing having a first outlet opening at the lower end thereof, a check valve in said first outlet opening to prevent fluid flow from the region exterior of said housing to the interior thereof, said housing having second and third inlet openings at the upper end thereof, said second inlet opening being adapted to be connected to a source of operating hydraulic fluid under pressure, said housing having a second outlet opening in the upper end thereof to communicate with the interior of the tubing when said housing is positioned in a well, a check valve in said second outlet opening to prevent fluid

flow from a region exterior of said housing to the interior thereof, a check valve in said third inlet opening to prevent fluid flow from within said housing to the region exterior thereof, first and second pistons positioned within said housing, a hollow cylinder extending between said first and second pistons to retain said pistons in spaced relationship, a cylindrical valve body positioned within said cylinder, means connecting said second inlet opening to a first inlet port in said valve body, a hydraulic fluid outlet conduit extending from a region exterior of said housing to a second inlet port in said valve body, said valve body having first and second outlet ports in the side wall thereof communicating through said valve body with said first and second inlet ports, respectively, an annular member enclosing said valve body in slidable engagement, said member and said valve body dividing the region between said pistons into first and second fluid chambers, said member having first and second passages therein, first ends of said passages communicating with said first and second fluid chambers, respectively, and second ends of said passages being adjacent said valve body, said member being movable relative to said valve body by said pistons whereby said first outlet port is in communication with said first passage and said second outlet port is in commnication with said second passage in a first position and said first outlet port is in communication with said second passage and said second outlet port is in communication with said first passage in a second position.

6. The combination in accordance with claim 5 further comprising a tubing suspending said housing in a well, a source of hydraulic fluid under pressure at the surface of the well, and a conduit extending between said source of hydraulic fluid and said second inlet opening, said second outlet opening being in communication with the interior of said tubing.

7. The combination in accordance with claim 6 further comprising conduit means extending between said first outlet opening and the interior of said tubing.

8. The combination in accordance with claim 6 further comprising a well packer extending outwardly from said housing at a region between said first and third inlet openings to engage the wall of the well.

9. The combination in acordance with claim 8 further comprising a second well packer extending outwardly from the assembly of said tubing and said housing at a region above said third inlet opening to engage the wall of the well.

10. The combination in accordance with claim 9 wherein said latching means comprises first and second spring biased arms to secure said plug and said sleeve member together when they occupy first locations, said first and second arms being removed from said first locations when engaged by respective ends of said first and second pistons.

11. A hydraulic fluid actuated pumping unit comprising, in combination, a housing defining a piston chamber, said housing having an inlet opening and an outlet opening at each end thereof, a check valve in each of said inlet openings to prevent fluid from flowing from the interior of said housing to the exterior thereof, a check valve in each of said outlet openings to prevent fluid from flowing from the exterior of said housing to the interior thereof, first and second pistons positioned within said housing, a hollow cylinder extending between said first and second pistons to retain said pistons in spaced relationship, a sleeve member positioned within said cylinder in slidable engagement therewith, a cylindrical plug positioned within said sleeve member in slidable engagement therewith, a first conduit extending from said plug through said first piston to a region exterior of said first piston, said first piston being slidable on said first conduit, a second conduit extending from said plug through said second piston to a region exterior of said housing, said second piston being slidable on said second conduit, said plug being provided with first and second passages in communication at their respective first ends with said first and second conduits, said sleeve member being provided with first and second passages in communication at their respective first ends with regions within said cylinder on opposite sides of said plug, and latching means to retain said plug and said sleeve member in first and second positions relative to one another, the second end of the first passage in said plug being in communication with the second end of the first passage in said sleeve member and the sencond end of the second passage in said plug being in communication with the second end of the second passage in said sleeve member at said first position, and the second end of the first passage in said plug being in communication with the second end of the second passage in said sleeve member and the second end of the second passage in said plug being in communication with the second end of the first passage in said sleeve member at said second position.

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