April 19, 1960 E. J. SARGENT ET AL 2,933,071

HYDRAULIC ENGINE

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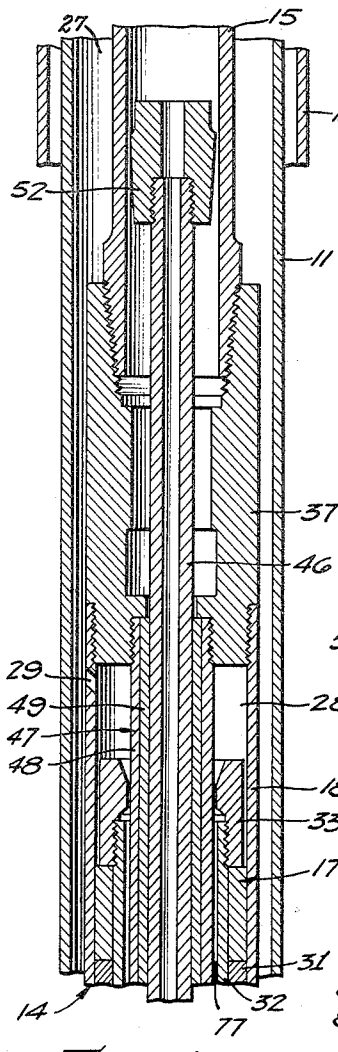


FIG. 1a.

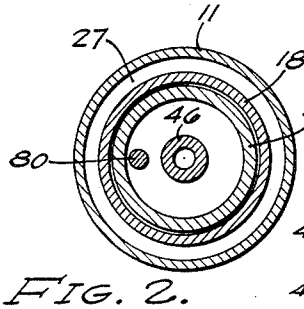


FIG. 2.

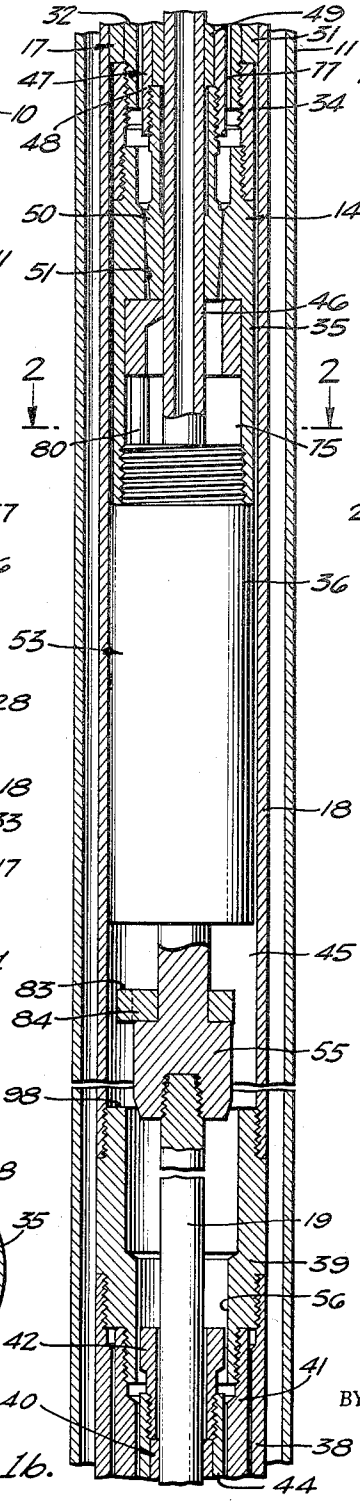


FIG. 1b.

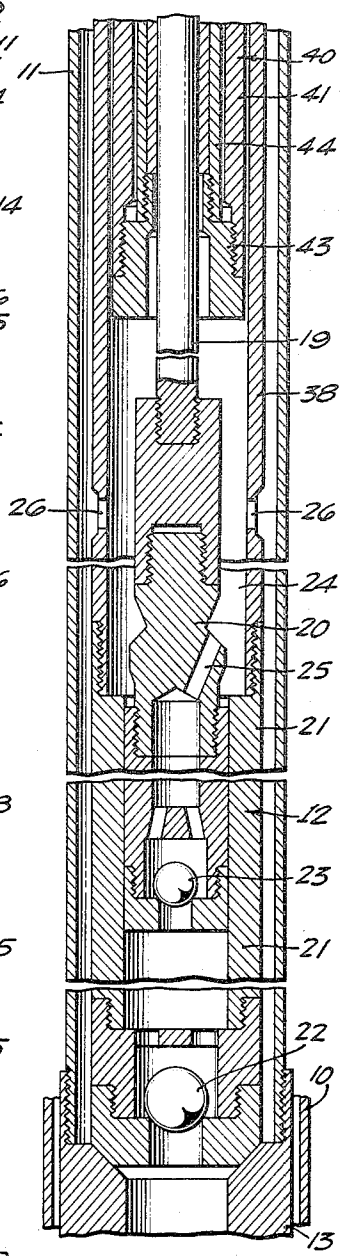


FIG. 1c.

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FIG. 3.
DOWNSTROKE

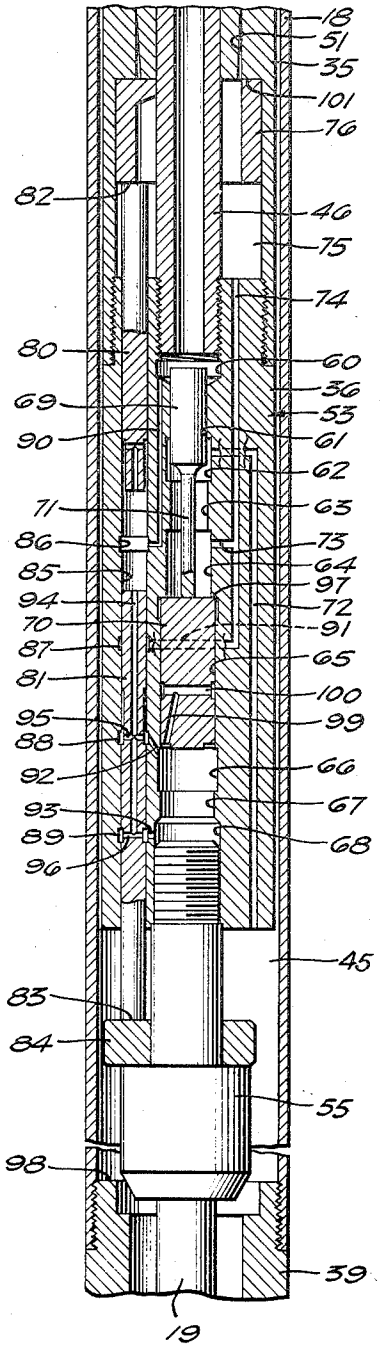
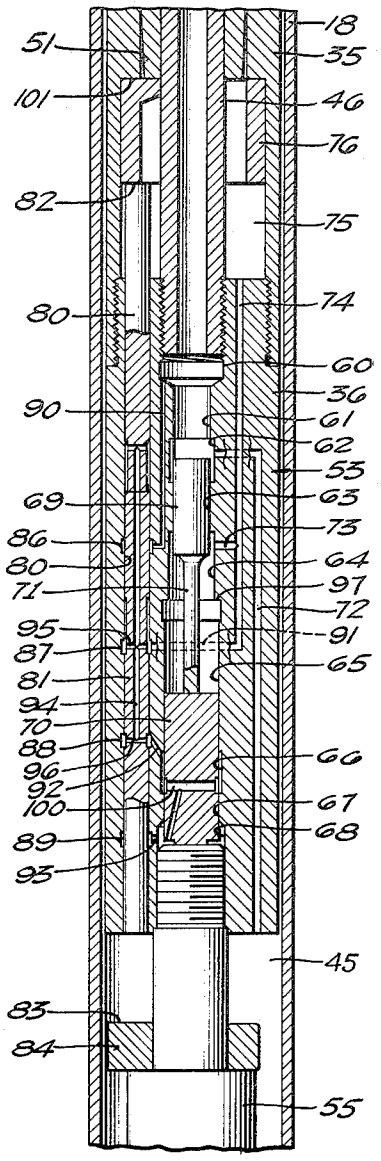


FIG. 4.
UPSTROKE



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HYDRAULIC ENGINE

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Application May 9, 1958, Serial No. 734,187

7 Claims. (Cl. 121—157)

This invention relates to reciprocating hydraulic engines of the type used to operate deep well pumps and is particularly directed to improvements over the hydraulic engine disclosed in the Edward J. Sargent Patent No. 2,821,141.

Hydraulic engines of this general type are commonly operated by pumping clean oil or other actuating liquid down one of two pipe strings in the well hole. The clean oil is controlled by a valve assembly in the engine to cause reciprocation of the driven part of the engine, and this reciprocating movement is employed to operate a well pump. The well pump may be of conventional design. The well fluid lifted by the pump and the spent actuating fluid discharged by the engine are mixed together and are conveyed to the surface through the other of the two pipe strings.

It has been found that difficulties in operation of the engine and pump sometimes occur when the well fluid produced from the formation contains considerable quantities of gas. In such wells, the hydraulic engine may fail to operate for the full normal length of the stroke and instead may reciprocate rapidly in a very short length of stroke with resulting wear and damage to precision-fitted parts.

It is the principal object of the present invention to provide an improved valve assembly for a hydraulic engine which overcomes this short stroking difficulty. Other and more detailed objects and advantages will appear hereinafter.

In the drawings:

Figures 1*a*, 1*b* and 1*c* show a transverse sectional view of a hydraulic engine and pump assembly of the general type to which my invention pertains. The figures are separated into three portions because the length of the assembly is too long to be conveniently shown intact.

Figure 1*b* comprises an extension of the lower end of Figure 1*a*, and Figure 1*c* comprises an extension of the lower end of Figure 1*b*.

Figure 2 is a transverse sectional view taken substantially on the lines 2—2 as shown in Figure 1*b*.

Figure 3 is a sectional view of the valve assembly embodying our invention, the parts being shown in the downstroke position.

Figure 4 is a sectional view similar to Figure 3, the parts being shown in the upstroke position.

Referring to the drawings, a casing **10** extends into the well bore from the surface and an eduction tubing **11** is positioned within the casing **10** and carries the well pump assembly **12** at its lower end. This pump assembly **12** may rest on the shoe **13** connected to the tubing **11**. The hydraulic engine generally designated **14** is provided for operating the well pump assembly **12** and this engine is carried on the lower end of a motive fluid supply tubing **15**, known in the art as "macaroni." The engine **14** with the well pump **12** at its lower end may be lowered into position on the macaroni **15** within the eduction tubing **11** to rest the lower end of the well pump **12** and the shoe **13**.

Motive fluid such as clean oil is supplied under pressure through the macaroni **15** to cause the piston **17** to reciprocate within the stationary cylinder **18**, thereby reciprocating the rod **19** and pump plunger **20**. Reciprocating movement of the pump plunger **20** within the pump barrel **21** causes formation fluid to move upward past the standing valve **22** and traveling valve **23** into the space **24** via the plunger ports **25**. The well fluid then passes through ports **26** into the annular space **27** within the lower end of the eduction tubing **11**.

Spent motive fluid exhausted from the hydraulic engine **14** passes into the space **28** and outward through ports **29** to mix with the production fluid in the annular space **27**. Both the production fluid and the spent motive fluid pass upward in the eduction tubing **11** to the surface.

The piston **17** of the hydraulic engine **14** includes a plurality of stacked ring sections **31** encircling a central tubular element **32** and held in place by a nut **33** at the upper end and an internally threaded collar **34** at the lower end. This collar **34** is also connected to the valve carrier **35** which is threadedly connected to the valve housing **36**. The pump-actuating rod **19** is fixed to the lower end of the valve housing **36**.

The stationary barrel **18** of the hydraulic engine **17** is connected to the lower end of the macaroni **15** by means of the coupling piece **37** and the lower end of this stationary cylinder or housing **18** is connected to the stationary tube **38** by means of the coupling collar **39**. The tube **38** contains the pump discharge ports **26** and the lower end of the stationary tube **38** is connected to the stationary housing or barrel **21** of the production pump **12**. A lower seal assembly **40** is fixed on the coupling member **39** by means of the tubular parts **41** threaded collars **42** and **43** and sleeve **44**. This sealing assembly slidably receives the pump-actuating rod **19** and cooperates with the parts **39** and **18** to form a pressure chamber **45** below the piston **17**.

A power oil tube **46** extends axially through the piston **17** and is fixed to the upper end of the valve housing **36**. This tube **46** reciprocates with the piston **17** and with the valve housing **36**. The tube extends through the seal assembly **47** carried on the coupling member **37** and which includes the threaded sleeve **48** and the inner sealing sleeve **49**. A stationary part **50** fixed to the lower end of the sleeve **48** cooperates with an opening **51** in the member **35** to produce a dash-pot action to slow down the motion of the piston **17** as it approaches the upper end of its stroke. Similarly, the lower enlarged portion of the rod coupling **55** enters the bore **56** in the coupling collar **39** to produce a dash-pot action to reduce the speed of the piston **17** and actuator rod **19** as they approach the lower end of the stroke.

The upper end of the power oil tube **46** projects into the macaroni **15** and the extreme upper end carries an enlarged collar **52**. Power oil under pressure delivered through macaroni **15** passes through the opening in the collar **52** and through the central passage in the power oil tube **46** into the valve housing **36**. The function of the valve assembly generally designated **53** is to direct pressure fluid into the pressure chamber **45** below the piston **17** and then to discharge the pressure fluid therefrom into the exhaust chamber **28** above the piston **17**, thereby causing the piston **17**, actuating rod **19** and pump plunger **20** to reciprocate. Since the power oil tube **46** constantly projects into the interior of the macaroni **15**, a downward force is constantly applied to the piston **17**. When hydraulic fluid under pressure is directed into the pressure chamber **45** this downward force is overcome by a larger upward force since the effective area of the piston **17** (less the effective area of the actuating rod **19**) is greater than the effective area of the

power oil tube 46. As a result, the upward forces on the piston 17 are substantially greater than the downward forces and accordingly, the piston 17 and related parts move upward. When the pressure chamber 45 is exhausted in the manner described below, the relatively small downward force applied through the power oil tube 46 moves the piston 17 and related parts through the downstroke.

In accordance with our invention, the housing 36 of the valve assembly 53 is provided with a series of axially aligned central bores 60, 61, 62, 63, 64, 65, 66, 67 and 68. Aligned bores 61 and 63 are of the same diameter and slidably receive the upper end of the two-part main valve 69 and 70. The bores 65 and 67 are the same diameter and slidably receive the lower part 70 of this two-part main valve. A small diameter stem 71 formed integrally with the valve part 69 contacts the upper surface of the valve part 70. The pressures applied to the valve parts 69 and 70 are such as to maintain contact between them so that they move as a unit; the parts 69 and 70 are formed as separate pieces in order that slight misalignment between the bores 61, 63 and 65, 67 can be tolerated without interfering with free axial movement of the valve parts.

Bore 62 communicates with the pressure chamber 28 by way of the passage 72 in the housing 36. Similarly, bore 64 communicates through port 73 and passage 74 in the housing 36 to the space 75. This space 75 communicates with a discharge chamber 28 through the interior of the bumper ring 76, bore 51 and annular space 77 (see Figure 1*a*). When the two part main valve 69, 70 is in the upper position as shown in Figure 3, the pressure chamber 45 is vented through passage 72, bore 62, bore 63, bore 64, port 73, passage 74 to the discharge space 75. Spent motive fluid in the pressure chamber 45 is thus discharged through space 75, annular passage 77, chamber 45, and lateral ports 29 into the annulus 27 between the tubing 11 and the macaroni 15. The pressure of the clean oil within the macaroni 15 acting on the upwardly projecting tube 46 then moves the piston 17 downward within the stationary cylinder 18, carrying the valve assembly 53 and actuator rod 19 with it.

When the two part main valve 69, 70 is in the lower position, as shown in Figure 4, pressure of clean oil within the tube 46 passes downward through housing bores 60, 61 and 62 and through passage 72 into the pressure chamber 45. The pressure in the chamber 45 below the piston 17 causes the piston 17 to move upward in the stationary cylinder 18, overbalancing the smaller downward force exerted on the piston through the clean oil tube 46. Spent motive fluid in the chamber 28 passes through lateral ports 29 into the annulus 27 between the tubing 11 and macaroni 15.

A two part pilot valve 80, 81 is provided on the valve housing 36 for controlling the action of the main valve parts 69 and 70. The upper pilot valve part 80 projects from the upper end of the valve housing 36 and the extreme upper end of the valve part 80 is engageable with a shoulder 82 provided on the upper bumper ring 76. Similarly, the pilot valve part 81 projects from the lower end of valve housing 36 and the extreme lower end thereof is engageable with the shoulder 83 on the lower bumper ring 84 which is slidably mounted on the rod coupling 55. A vertical bore 85 is provided in the housing 36 and the pilot valve parts 80 and 81 are slidable within this bore. The bore 85 is interrupted at longitudinally spaced locations by enlarged grooves 86, 87, 88 and 89. Groove 86 is connected by passage 90 with the enlarged bore 60 at the upper end of the valve part 69. Groove 87 is connected by passage 91 with ports 73 and passage 74. Groove 88 is connected by inclined passage 92 with the bore 66, and groove 89 is connected by lateral port 93 with the bore 68 below the main valve part 70.

On the downstroke as shown in Figure 3 pressure of motive fluid in the clean oil tube 46 passes through bore 60 and passage 90 to the groove 86 and bore 85. This pressure serves to separate the pilot valve parts 80 and 81 and holds the part 80 against the upper bumper ring 76 and holds the part 81 against the lower bumper ring 84. Pressure fluid admitted into the groove 86 passes downward through the small axial bore 94 in the pilot valve part 81 and passes through cross bores 95 and 96 to enter grooves 88 and 89 respectively, and then passes inwardly through ports 92 and 93 into bores 66 and 68 respectively below the main valve part 70. This pressure below the main valve part 70 holds in its upper position as shown in Figure 3, resting against the shoulder 97 on the housing 36. As explained above, when the main valve parts 69 and 70 are in the upper position as shown in Figure 3, piston 17 moves downward within the stationary cylinder 18.

The downstroke is terminated when the lower bumper ring 84 engages the shoulder 98 on the tubular coupling 39. Continued downward movement of the valve housing 36 causes the lower pilot valve part 81 to shift with respect to the housing 36 and to move to the position shown in Figure 4, where it remains during the upstroke. This shifting of the lower pilot valve part 81 with respect to the valve housing 36 cuts off the supply of pressure fluid to the space below the main valve part 70 and causes venting of the bore 68 through internal passages 99 and 100 in the main valve part 70 and through bore 66, inclined port 92, cross passage 96, bore 94, groove 88 and passages 91 and 74. The upper part 69 of the main valve holds the valve parts in the lowest position with the lower end of the part 70 of the main valve resting against the upper end of the rod coupling 55. The full pressure of the clean oil in the tube 46 acts on the upper end of the main valve part 69 to hold the parts in a position shown in Figure 4. The upper end of the passage 72 which communicates with the bore 62 is thus subjected to pressure of clean oil in the tube 46 and this pressure is transmitted to the pressure chamber 45, thereby causing upward movement of the piston 17 within the stationary cylinder 18.

The piston 17 and valve housing 36 continue upward movement until the extreme upper end of the pilot valve part 80 is brought to rest by engagement of the bumper ring 76 under the shoulder 101 on the part 35. Continued upward movement of the valve housing 36 causes relative shifting movement of the upper pilot valve 80 to a position flush with the upper end of the valve housing 36. The lower end of the pilot valve part 80 contacts the upper end of the lower pilot valve part 81 and shifts the latter back to the position shown in Figure 3. This action changes the porting to apply pressure below the main valve part 70, as described above, with the result that the main valve parts 69 and 70 return to the upper position as shown in Figure 3. This action in turn serves to vent the pressure chamber 28 and cause the piston 17 and valve housing 36 to begin the downstroke, as described above. High pressure transmitted through passage 90 into the groove 86 and into the bore 85 between the pilot valve parts 80 and 81 maintains the pilot valve parts in axially separated position, as shown in Figure 3 and the parts remain in this position during the downstroke. The cycle of operations then repeats.

It will be observed that the separation of the pilot valve into the two parts 80 and 81, together with the described porting, serves to make available the full operating pressure of the clean oil to hold the lower pilot valve part 81 in its lower position on the upstroke and in its upper position on the downstroke. Accordingly, erratic or unusual loading of the pump plunger 20 occasioned by encountering a high proportion of gas in the well fluid produced from the formation, cannot result

in untimely shifting of the pilot valve part 81. Objectionable short stroking is thereby eliminated.

Having fully described our invention, it is to be understood that we do not wish to be limited to the details herein set forth, but our invention is of the full scope of the appended claims.

We claim:

1. In a reciprocating hydraulic engine for operating a well pump and having a piston slidable within a stationary cylinder, the piston having a pump actuating rod fixed thereto and extending downward therefrom and also having a motive fluid delivery tube fixed thereto and extending upward therefrom, and means connected to the stationary cylinder forming a sliding seal with the actuating rod to define a pressure chamber, the improvement comprising, in combination: a valve housing fixed relative to the piston and having a main valve movable within the valve housing for alternately introducing motive fluid into said pressure chamber and exhausting it therefrom, a pilot valve assembly ported to shift the main valve and including upper and lower axially separable aligned pilot valve parts mounted to slide within an axial bore in the valve housing, means whereby the pilot valve parts may be mechanically shifted at opposite ends of the stroke of the piston, passage means in the valve housing for introducing motive fluid under pressure into said axial bore at a location above the lower pilot valve part, said passage means being cut off by shifting of the lower pilot valve part upward relative to the valve housing.

2. In a reciprocating hydraulic engine for operating a well pump and having a piston slidable within a stationary cylinder, the piston having a pump actuating rod fixed thereto and extending downward therefrom, and means connected to the stationary cylinder forming a sliding seal with the actuating rod to define a pressure chamber, the improvement comprising, in combination: a valve housing fixed relative to the piston and having a main valve movable within the valve housing for alternately introducing motive fluid into said pressure chamber and exhausting it therefrom, a pilot valve assembly ported to shift the main valve and including upper and lower axially separable aligned pilot valve parts mounted to slide within an axial bore in the valve housing, means whereby the pilot valve parts may be mechanically shifted at opposite ends of the stroke of the piston, passage means in the valve housing for introducing motive fluid under pressure into said axial bore at a location between the pilot valve parts to separate them axially on the downstroke of the piston, said passage means being cut off by shifting of the lower pilot valve part upward relative to the valve housing, and the lower end of the lower pilot valve part being exposed to the pressure within said pressure chamber.

3. In a reciprocating hydraulic engine for operating a well pump and having a piston slidable within a stationary cylinder, the piston having a pump actuating rod fixed thereto and extending downward therefrom, the improvement comprising, in combination: a valve housing fixed relative to the piston and having a main valve movable within the valve housing for intermittently directing motive fluid into the cylinder below the piston, a pilot valve assembly ported to shift the main valve and including upper and lower axially separable aligned pilot valve parts mounted to slide within an axial bore in the valve housing, means including stationary shoulders fixed relative to the cylinder whereby the pilot valve parts may be mechanically shifted at opposite ends of the stroke of the piston, passage means in the valve housing for introducing motive fluid under pressure into said axial bore at a location between the pilot valve parts to separate them axially on the downstroke of the piston, said passage means being cut off by shifting of the lower pilot valve part upward relative to the valve housing.

4. In a reciprocating hydraulic engine for operating a well pump, the hydraulic engine having a piston slidable within a stationary cylinder, the piston having a pump-actuating rod fixed thereto and extending downward therefrom and also having a motive fluid delivery tube fixed thereto and extending upward therefrom, and means connected to the stationary cylinder forming a sliding seal with the pump actuating rod to define a pressure chamber, the improvement comprising, in combination: a valve housing fixed relative to the piston and having a main valve movable within the valve housing for alternately introducing motive fluid into said pressure chamber and exhausting it therefrom, a pilot valve assembly ported to shift the main valve and including upper and lower axially separable aligned pilot valve parts mounted to slide within an axial bore in the valve housing, means including stationary shoulders fixed relative to the cylinder whereby the pilot valve parts may be mechanically shifted at opposite ends of the stroke of the piston, passage means in the valve housing for introducing motive fluid under pressure into said axial bore at a location between the pilot valve parts to separate them axially on the downstroke of the piston, said passage means being cut off by shifting of the lower pilot valve part upward relative ot the valve housing, and the lower end of the lower pilot valve part being exposed to the pressure within said pressure chamber.

5. In a reciprocating hydraulic engine for operating a well pump, the engine having a piston slidable within a stationary cylinder, the piston having a pump actuating rod fixed thereto and extending downward therefrom, the improvement comprising, in combination: a valve housing fixed relative to the piston and having a main valve movable within the valve housing for intermittently directing motive fluid into said cylinder below the piston, a pilot valve assembly for shifting the main valve and including upper and lower axially separable aligned pilot valve parts mounted to slide within an axial bore in the valve housing, means whereby the pilot valve parts may be mechanically shifted at opposite ends of the stroke of the piston, passage means in the valve housing for introducing motive fluid under pressure into said axial bore at a location between the pilot valve parts to separate them axially on the downstroke of the piston, passage means in the valve housing and lower pilot valve part for intermittently directing motive fluid into the valve housing to shift the main valve, said passage means being cut off by shifting of the lower pilot valve part upward relative to the valve housing, and the lower end of the lower pilot valve part being exposed to the pressure within the pressure chamber to maintain the lower pilot valve part in the upper position on the upstroke of the piston.

6. A valve assembly for a hydraulic engine having a stationary member and a reciprocating driven member, comprising in combination: a valve housing adapted to be fixed relative to one of the members and having a main valve movable therein intermittently directing motive fluid below the reciprocating member, a pilot valve assembly ported to shift the main valve and including first and second separable aligned pilot valve parts mounted to slide within a bore in the valve housing, means on the valve assembly cooperable with the other member whereby the pilot valve parts may be mechanically shifted at opposite ends of the stroke of the reciprocating member, passage means in the valve housing for introducing motive fluid under pressure into said bore at a location between the pilot valve parts to separate them, said passage means being cut off by shifting of one of the pilot valve parts relative to the valve housing.

7. A valve assembly for a hydraulic engine having a piston reciprocable within a cylinder, comprising in combination: a valve housing, adapted to be fixed relative to the piston and having a main valve movable within the valve housing for intermittently directing motive fluid into the cylinder below the piston, a pilot valve assembly

ported to shift the main valve and including upper and lower axially separable aligned pilot valve parts mounted to slide within an axial bore in the valve housing, means on the valve assembly cooperable with elements on the cylinder whereby the pilot valve parts may be mechanically shifted at opposite ends of the stroke of the piston, passage means in the valve housing for introducing motive fluid under pressure into said axial bore at a location between the pilot valve parts to separate them axially on the downstroke of the piston, said passage means being

cut off by shifting of the lower pilot valve part upward relative to the valve housing.

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