

PATENT APPLICATION

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TITLE OF THE INVENTION

5 HYDRAULIC OIL WELL PUMPING APPARATUS

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CROSS-REFERENCE TO RELATED APPLICATIONS

15 Priority of US Provisional Patent Application Serial No. 60/764,481, filed 1 February 2006, incorporated herein by reference, is hereby claimed.

Priority of US Provisional Patent Application Serial No. 60/824,123, filed 31 August 2006, incorporated herein by reference, is hereby claimed.

20 STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

REFERENCE TO A "MICROFICHE APPENDIX"

Not applicable

BACKGROUND OF THE INVENTION

25 1. Field of the Invention

The present invention relates to oil well pumps and more particularly to an improved hydraulic oil well pump that is electronically controlled using limit or proximity switches to control a valving arrangement that eliminates shock or excess load from the pumping string or sucker rod during pumping, and especially when changing direction of
30 the sucker rod at the bottom of a stroke.

2. General Background of the Invention

Several patents have issued that relate generally to the pumping of oil from an oil

well. Examples of those patents are contained in the following table, wherein the order of listing has no significance other than chronological.

TABLE

PATENT NO. TITLE ISSUE DATE
MM-DD-YY

4,503,752	Hydraulic Pumping Unit	03-12-1985
4,761,120	Well Pumping Unit and Control System	08-02-1988
5,143,153	Rotary Oil Well Pump and Sucker Rod Lift	09-01-1992
5,390,743	Installation and Method for the Offshore Exploitation of Small Fields	02-21-1995
6,394,461	Pressure Compensated Stuffing Box for Reciprocating Pumping Units	05-28-2002
2003/0085036	Combination Well Kick Off and Gas Lift Booster Unit	05-08-2003
6,595,280	Submersible Well Pumping System with an Improved Hydraulically Actuated Switching Mechanism	07-22-2003
2005/0155758	Well Tubing/Casing Vibrator Apparatus	07-21-2005

BRIEF SUMMARY OF THE INVENTION

The present invention provides a hydraulic oil well pumping apparatus. The system of the present invention utilizes a hydraulic cylinder having a piston or rod that is movable between upper and lower piston positions. A pumping string or sucker rod extends downwardly from the piston, the pumping string or sucker rod being configured to extend into an oil well for pumping oil from the well.

A prime mover such as an engine is connected to a compensating type hydraulic pump.

A directional control valve moves between open flow and closed flow positions. A hydraulic flow line connects the pump and the hydraulic cylinder.

Electronic controls are provided that control movement of the piston as it moves between the upper and lower positions.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For a further understanding of the nature, objects, and advantages of the present invention, reference should be had to the following detailed description, read in conjunction with the following drawings, wherein like reference numerals denote like elements and wherein:

5 Figure 1 is an exploded, elevation view of the preferred embodiment of the apparatus of the present invention;

 Figure 2 is an elevation view of the preferred embodiment of the apparatus of the present invention;

 Figure 2A is a partial elevation view of the preferred embodiment of the apparatus
10 of the present invention;

 Figure 3 is a sectional view of the preferred embodiment of the apparatus of the present invention, taken along lines 3-3 of figure 2;

 Figures 4A, 4B and 4C are fragmentary, elevation views of the preferred
15 embodiment of the apparatus of the present invention illustrating operation of the apparatus;

 Figure 5 is a partial perspective view of the preferred embodiment of the apparatus of the present invention;

 Figures 6-7 are schematic diagrams of the preferred embodiment of the apparatus of the present invention;

20 Figure 8 is a partial perspective view of the alternate embodiment of the apparatus of the present invention;

 Figure 9 is a fragmentary top view of the alternate embodiment of the apparatus of the present invention;

 Figure 10 is a partial elevation view of the alternate embodiment of the apparatus
25 of the present invention;

 Figure 11 is a partial end view of the alternate embodiment of the apparatus of the present invention;

 Figure 12 is another fragmentary elevation view of the alternate embodiment of the apparatus of the present invention;

30 Figure 13 is a fragmentary side view of the alternate embodiment of the apparatus of the present invention;

 Figure 14 is a flow diagram illustrating the alternate embodiment of the apparatus

of the present invention;

Figures 15-16 are schematic diagrams showing the alternate embodiment of the apparatus of the present invention;

5 Figure 17 is a fragmentary view of the alternate embodiment of the apparatus of the present invention showing the manifold in a bypass condition;

Figure 18 is a fragmentary view of the alternate embodiment of the apparatus of the present invention showing the manifold in an upstroke position;

Figure 19 is a fragmentary view of the alternate embodiment of the apparatus of the present invention showing the manifold in a downstroke position;

10 Figure 20 is a partial perspective view of the preferred embodiment of the apparatus of the present invention showing an alternate manifold construction;

Figure 21 is a schematic diagram of the preferred embodiment of the apparatus of the present invention showing the alternate manifold arrangement;

15 Figure 22 is a schematic diagram of the preferred embodiment of the apparatus of the present invention showing the alternate manifold arrangement;

Figure 23 is a fragmentary view of the manifold of figures 21 and 22;

Figure 24 is a fragmentary view of the manifold of figures 21 and 22;

Figure 25 is a fragmentary view of the manifold of figures 21 and 22;

Figure 26 is a fragmentary view of the manifold of figures 21 and 22;

20 Figure 27 is a fragmentary view of the manifold of figures 21 and 22;

Figure 28 is a fragmentary view of the manifold of figures 21 and 22;

Figure 29 is a schematic diagram of another alternate embodiment of the apparatus of the present invention in the up stroke position;

25 Figure 30 is a schematic diagram of another alternate embodiment of the apparatus of the present invention in the down stroke position;

Figure 31 is a fragmentary diagram of another alternate embodiment of the apparatus of the present invention in the up stroke position;

Figure 32 is a fragmentary diagram of another alternate embodiment of the apparatus of the present invention in the down stroke position;

30 Figure 33 is a fragmentary diagram of another alternate embodiment of the apparatus of the present invention in the up stroke position;

Figure 34 is a fragmentary diagram of another alternate embodiment of the

apparatus of the present invention in the down stroke position;

Figure 35 is a top fragmentary view of a manifold portion of the system of figures 29-34, shown in the downstroke mode or position;

Figure 36 is a sectional view taken along lines 36-36 of figure 35;

5 Figure 37 is a sectional view taken along lines 37-37 of figure 35;

Figure 38 is a sectional view taken along lines 38-38 of figure 35;

Figure 39 is a top, plan view of the manifold of figure 35 shown in the upstroke mode or position;

Figure 40 is a sectional view taken along lines 40-40 of figure 39;

10 Figure 41 is a sectional view taken along lines 41-41 of figure 39; and

Figure 42 is a sectional view taken along lines 42-42 of figure 39.

DETAILED DESCRIPTION OF THE INVENTION

Figures 1-7 show generally the preferred embodiment of the apparatus of the present invention designated generally by the numeral 10.

15 Oil well pump 10 provides a reservoir 11 for containing hydraulic fluid. A prime mover 12 such as an engine is provided for driving a compensating pump 13. The pump 13 is used to transmit hydraulic pressure, pressurized hydraulic fluid received from reservoir 11 via flow line 33 to a hydraulic cylinder or petroleum lift cylinder 14. Lift cylinder 14 can be a Parker (www.parker.com) model GG699076A0. The hydraulic lift
20 cylinder 14 includes a cylinder body 15 having a hollow interior 16.

A cylinder rod 17 is mounted in sliding or telescoping fashion to the cylinder body 15 extending into the interior 16 of cylinder body 15. The cylinder rod 17 has an upper end portion 18 and a lower end portion 19. During use, the lower end portion 19 extends below cylinder body 15 as shown in figures 1-4C and 6-7.

25 In figure 1, the lower end portion 19 of cylinder rod 17 is attached with coupling 20 to a pumping string or sucker rod 21. The pumping string or sucker rod 21 is comprised of a number of joints, connected end to end. A pumping part of the sucker rod 21 is generally positioned next to a perforated zone of the well. Such a pumping string 21 or sucker rod 21 is known in the art and is used to pump oil from an oil well as the
30 sucker rod 21 moves up and down.

The lift cylinder 14 is mounted upon Christmas tree 22. The Christmas tree 22 is mounted at the well head of an oil well at the upper end portion of well pipe 23. A

suitable structural frame 38 can be used for supporting hydraulic cylinder 14 and its cylinder rod 17 above Christmas tree 22 as shown in figures 1-4C and 6-7.

A plurality of proximity or limit switches 24, 25, 26 are provided. Switches 24, 25, 26 can be for example those manufactured by Turck Company, model number N120-CP40AP6X2/510. As shown in figures 2-2A, these proximity or limit switches 24, 25, 26 can be mounted to frame 38. During use, these proximity or limit switches 24, 25, 26 can be used to sense the position of the lower end portion 19 of cylinder rod 17 and then send an electronic signal to the controller 39 (commercially available), then the controller 39 sends a signal to the manifold 35 that includes directional valve 28, proportioning valve 31, and ventable relief valve 37 (e.g. Parker Sterling model no. A04H3HZN).

Hydraulic fluid flow lines are provided for transmitting hydraulic fluid under pressure to hydraulic lift cylinder 14 via flow lines 27, 29. Directional valve 28 receives flow from flow line 29. Flow line 27 extends between directional valve 28 and cylinder 14. To initiate operation, pump 13 transmits fluid flow through the manually vented relief valve 37 thus removing pressure from the system prior to start up. When the engine or prime mover 12 is started, it activates the hydraulic pump 13, flow still initially traveling through the relief valve 37 and flow line 34 to reservoir 11.

The cycle of operation begins by vent closure of valve 37 so that oil flowing in flow line 29 now travels to directional valve 28. At about the same time, the directional valve 28 is energized so that oil under pressure is directed via flow line 27 to hydraulic lift cylinder 14 body 15 and its hollow interior 16. The cylinder rod 17 will then elevate, lifting the pumping string 21 or sucker rod 21 with it (see figure 2).

Frame 38 carries the plurality of proximity or limit switches 24, 25, 26. When the cylinder rod 17 reaches the top of its stroke, the proximity switch 24 (which is an uppermost proximity switch) senses the position of coupling 20 and energizes the directional valve 28 so that it closes the flow line 29 and flows through proportional valve 31. Valve 31 is a manual proportional valve with flow check for restricted flow on return of hydraulic oil to the reservoir, thus allowing a restricted flow to control the rate of descent of cylinder rod 17. Because the pump 13 is a compensating pump, it continues to run but does not continue to pump fluid. It can be set to halt fluid flow at a certain pressure value (e.g. 3000 psi, or 210.92 kgf/cm²) which can be set by design depending upon the weight of sucker rod 21. In other words, pump 13 is volume compensating and

pressure responsive. Such a compensating pump is manufactured by Parker such as their model no. P1100PS01SRM5AC00E1000000.

When the directional valve 28 is used to close flow line 29, the compensating pump 13 continues to rotate with the engine 12 but no longer pumps fluid in flow line 29.

5 The directional valve 28 opens drain line 30 at about the same time that line 29 is closed. Fluid in hydraulic cylinder 14 now drains via flow lines 27 and 30 through proportioning valve 31 and cylinder rod 17 descends relative to cylinder body 15. The hydraulic fluid draining from cylinder body 15 interior 16 continues to flow via flow lines 27 and 30 through proportioning valve 31 and cooler 36 and then into flow line 32 which is a drain

10 line to reservoir 11. The flow line 32 can be provided with oil cooler 36 (e.g. Thermal Transfer model BOL-8-1-9) and an oil filter (e.g. Parker model no. RF2210QUP35Y9991) if desired.

Since pressure no longer forces cylinder rod 17 upwardly, it begins to drop (see figures 4A and 7). As it drops relative to lift cylinder body 15, coupling 20 will meet a

15 second proximity or limit switch 25 which is below limit switch 24 (see figures 2, 4A, 4B, 4C). The limit switch 25 is closer to the lower end portion (for example, 1 foot, or 0.30 meters) of cylinder body 15 than to upper end portion of body 15. When the coupling 20 reaches proximity or limit switch 25, in one embodiment (figure 2A) it signals the directional valve 28 that it should switch to allow the flow of fluid to travel through the

20 proportioning valve 31 via flow lines 27, 30.

The proportioning valve 31 is a manual proportioning valve with flow check for restricted flow on return of hydraulic oil to the reservoir. When the coupling 20 reaches the proximity or limit switch 25, the directional valve switches to direct the flow to lift the cylinder 14. The choking action that takes place in the proportioning valve 31 has the

25 effect of gradually slowing the speed of the cylinder rod 17 and its connected sucker rod 21. The use of Parker No. FMDDDSM Manapac manual sandwich valve located between directional valve and the solenoid controls dampens the transition of the directional valve from the upstroke or downstroke to allow bumpless transfer of fluid to the cylinder 14 and balances pressures. This choking of flow by the proportioning valve 31 also slows action

30 of cylinder rod 17, preventing undue stress from being transmitted to the sucker rod 21 as the bottom of the downstroke of cylinder rod 17 is approached, then reached.

Directional valve 28 can be a Parker® valve model number D61VW001B4NKCG.

Proportioning valve 31 can be a Parker® valve model number DFZ01C600012.

Figures 8-9 show a second embodiment of the apparatus of the present invention designated generally by the numeral 40 in figures 14-16. The alternate embodiment of figures 8-19 employs lift cylinder 14, rod 17, sucker rod 21, frame 38, coupling 20, proximity switches 24, 25, 26 of the preferred embodiment. In figures 15, 16, oil well pump apparatus 40 provides a reservoir 41 for containing a hydraulic fluid to be used for operating manifold 44 and lift cylinder 14. A prime mover such as engine 42 operates compensating pump 43. The pump 43 pumps hydraulic fluid under pressure via flow line 62 to inlet 51 (see figure 12) of manifold 44 fluid transfer block 45. Fluid then exits fluid transfer block 45 via outlet 53 (see figure 13) for communicating with lift cylinder 14. Notice in figure 16 that flow is reversed in line 63 when the lift cylinder 14 is being emptied of hydraulic fluid, when the pushrod 17 is falling. In figure 16, fluid is discharged via outlet 52 (see figure 12) and flows through flow line 65 (see figure 16) to inlet of cooler 55. Hydraulic fluid continues in flow line 66 through filter 56 until it empties into reservoir 41.

In figures 8-13 and 17-19, manifold 44 is shown in more detail. The lower end portion of manifold 44 provides fluid transfer block 45 which is fitted with directional valve 46, proportioning valve 47, relief valve 48, bypass valve 49 and fan flow control 50. It should be understood that the directional valve 46, proportional valve 47, relief valve 48, function in the same manner as they function with respect to the preferred embodiment of figures 1-7 wherein they are designated by the numerals directional valve 28, proportioning valve 31, and relief valve 37.

Valves 46, 47, 48 can be controlled with a programmable logic controller or "PLC" controller 39. Fluid transfer block 45 can be provided with a gauge port 54 that can be used to monitor pressure within the fluid transfer block 45.

Instrumentation lines 69, 70, 71, 72 are provided that enable controller 39 to communicate with and control the valves 46, 47, 48 and 49. Instrumentation line 69 enables PLC 39 to control bypass valve 49. The valve 49 is a bypass valve that can be used to transfer fluid from pump 43 through line 62 to fluid transfer block 45 and then to reservoir 41 via flow lines 65, 66. The flow line 66 can be provided with a filter 56 for filtering any foreign matter from the hydraulic fluid contained in the system 40. Pump 43 receives hydraulic fluid from reservoir 41 via flow line 60 and its valve 61.

Instrumentation line 70 enables PLC 39 to control proportional valve 47. Instrumentation line 71 enables PLC 39 to control directional valve 46.

The manifold 44 eliminates friction and maintenance of hoses or the like. The bypass valve 49 of the alternate embodiment is a feature that enables the prime mover 42, pump 43 and hydraulic fluid being pumped from reservoir 41 to warm up for a period of time (e.g. 2 - 30 minutes) before beginning to operate lift cylinder 14. Otherwise, the lift cylinder 14 can be operated with three switches 24, 25, 26 of the preferred embodiment of figures 1 - 7 and in the same manner using valve 46, 47, 48 which can be the same valves (e.g. Parker brand) as valves 28, 31, 37 respectively of the preferred embodiment.

Block 44 is provided with channels (phantom lines figures 17-19) that interconnect ports 50, 51, 52, 53, 54 and valves 47, 48, 49.

In figure 17, block 45 is shown in detail in the bypass position PLC controller 39 is used to operate bypass valve 49 so that fluid flows from line 62 to port 51 and then to port 52 and line 65 via channel 73 of block 44.

In figure 18, the upstroke cycle is shown wherein a channel 74 in block 44 connects inlet 51 and flow line 62 to outlet 53 and flow line 63 so that hydraulic fluid can be pumped under pressure to cylinder 14 for uplifting the rods 17, 21.

In figure 19, the downstroke cycle is shown wherein inlet 51 is closed and hydraulic fluid empties from cylinder 14 via flow line 63, outlet 53 and a channel 75 of block 44 that is fluid communication with flow line 65. In figure 19, the proportioning valve 47 gradually meters flow back to reservoir via flow line 65 and channel 75.

Figures 20-28 show an alternate configuration for the manifold, designated generally by the numeral 76. It should be understood that the manifold 76 will be used in combination with a reservoir 11, prime mover 12 (for example, engine), compensating pump 13, hydraulic lift cylinder 14, and pumping string/sucker rod 21 of the embodiments of figures 1-19.

In figures 20-28, a slightly different valving arrangement is provided that utilizes a poppet valve having a conically shaped valving member.

Manifold 76 provides a fluid transfer block 77. Attached to the fluid transfer block 77 as shown in figures 20-28 are a directional valve block 78 and a proportional throttle valve block 80. The directional valve block 78 carries a directional valve assembly 79 that includes poppet valve 85 with a conically shaped valving member 100. The proportional

throttle valve block 80 carries a proportional throttle valve 81. The fluid transfer block 77 supports a relief valve 82, bypass valve 83, fan flow control valve 84, poppet valve 85, and shuttle valve 86. The operation of the manifold 76 shown in figures 20-24 is similar to the operation of the alternate embodiment of figures 8-19 in that the manifold 76 and its various valves can be preferably controlled with a programmable logic controller or PLC and the instrumentation shown in figures 21-22.

Figures 21, 23 and 28 illustrate an upstroke orientation for manifold 76, as when the hydraulic lift cylinder 14 and pumping string/sucker rod 21 are being elevated. In figures 21 and 23, block 77 provides an inlet fitting 88 fitted with a flow line 87. Flow line 89 connects inlet fitting 88 with outlet fitting 93 as shown in figure 21. In figure 21, poppet valve 85 is open thus allowing fluid flow from inlet fitting 88 through flow line 89 to valve 85 and then to outlet fitting 93 via flow line 91. In figure 21, the proportional throttle valve 81 is closed. Thus, flow line 94 is also closed.

In figures 22, 25, 26, 27 a downstroke condition is shown. Poppet valve 85 is closed using a PLC or programmable logic controller. The proportional throttle valve 81 is opened using the PLC controller. Valve 81 can provide a conically shaped valving member 101. Valve 81 works in combination with the limit switches 24, 25, 26. When the prime mover 12 operates compensating pump 13, pressure is generated in flow line 87 that attaches to block 77 at inlet fitting 88. This pressurized hydraulic fluid travels via flow lines 89, 91 to outlet fitting 93 and then via flow line 98 to the hydraulic lift cylinder 14.

When the hydraulic lift cylinder 14 reaches an uppermost position, coupling 20 trips the uppermost limit switch 24. The limit switch 24 activates the programmable logic controller to begin closing valve 85 and opening valve 81. The valve 81 is a proportional throttle valve that opens a desired percentage of opening as controlled by the programmable logic controller. In figure 22, valve 85 has been closed. The valve 81 has opened allowing hydraulic fluid in cylinder 14 to travel through a return flow line to block fitting 93 and then to flow lines 91, 94 as shown in figure 22 exiting fitting 97. This hydraulic fluid then travels via flow line as indicated by arrow 96 in figure 22 to the reservoir 11.

When the falling pumping string/sucker rod 21 is lowered so that coupling 20 reaches the second lowest limit switch 25, valve 81 can begin to throttle or close so that

the rate of descent of the pumping string/sucker rod 21 is slowed. When the coupling 20 reaches the lowest proximity or limit switch 26, the valve 81 is closed and the valve 85 is opened so that the cycle repeats.

Valve 85 provides a conically shaped or tapered valving member 100. Thus, fluid traveling from the pump 13, flow line 87 and inlet fitting 88 reaches block 77 and then travels via flow line 89 to inlet 98. The outlet 99 enables fluid to travel through valve 85 to flow line 91. The tapered shape of valving member 100 eliminates any surge as the gradually tapering valving member 100 moves in relation to inlet 98 as it is opened.

Relief valve 82 can be used to protect the system from overpressure. Valve 84 can be used to control the cooling from motor. Shuttle valve 86 can be used to control flow of instrumentation fluid to directional valve 79 (see figures 21, 22).

The poppet valve 85 can be for example a Parker Hannifin valve (part number D1VW020HNKCG). The proportional throttle valve can be a Parker Hannifin valve (part number TDA025EW09B2NLW).

Figures 29 - 34 show another alternate embodiment of the apparatus of the present invention, designated generally by the numeral 102. As with the preferred embodiment, oil well pump 102 employs a reservoir 11, compensating pump, prime mover to power pump 103 (e.g. engine), hydraulic lift cylinder 14, cylinder rod 17, coupling 20, sucker rod or pumping string 21, frame 38, limit switches 24, 25, 26 and a controller (such as for example a programmable logic controller 39). In the embodiment of figures 29-34, a controller 39 such as a programmable logic controller or "PLC" can be used to control the up-stroke and downstroke of the hydraulic cylinder 14 cylinder rod 17. Frame 38 can be provided to support limit switches 24, 25, 26 and lift cylinder 14, as with the embodiments of figures 1-28.

In figures 29 - 34 a pump 103 is a compensating pump, such as a variable volume pump as seen for example in US Patent number 3,726,093 entitled "Pump Control System" and assigned to Parker Hannifin Corporation which is hereby incorporated herein by reference. Pump 103 can be for example a Parker model hydraulic piston pump model PAVC100B2R422. The pump 103 has a cam plate or swash plate 110 that can be placed in different positions for controlling flow as is described in the '093 patent (see figure 1 of US Patent 3,726,093 and accompanying text. The directional control valve of the '093 patent is of the four-way closed center type for controlling the actuation of a double

acting fluid motor and comprises the housing having a bore intersected axially therealong by the inlet port, by a pair of motor ports and by a pair of return ports. The motor ports are communicated with the ports of the fluid motor by way of check valves one of which opens when the associated motor port is pressurized and the other of which is cam-
5 opened when the associated motor port is communicated with the adjacent return port.

All control is achieved by the proper positioning of the swash plate 110. This is achieved by servo piston 119 acting on one end of the swash plate 110 working against the combined effect of the off-setting forces of the pistons 120 and a centering spring on the other end. The control spool 123 acts as a metering valve which varies the pressure
10 behind the servo piston 119.

The amount of flow produced by pump 103 is dependent upon the length of stroke of the pumping pistons 120. This length of stroke, in turn, is determined by the position of the swash plate 110. Maximum flow is achieved at an angle of about 17 degrees.

The rotating piston barrel 121, driven by the prime mover and drive 108, moves
15 the pistons 120 in a circular path and piston slippers are supported hydrostatically against the face of the swash plate 110. When the swash plate 110 is in a vertical position (figure 34), perpendicular to the centerline of the piston barrel 121, there is no piston stroke and consequently no fluid displacement. When the swash plate 110 is positioned at an angle (figure 33), the pistons 120 are forced in and out of the barrel 121 and fluid displacement
20 takes place. The greater the angle of the swash plate 110, the greater the piston 120 stroke.

The centerline of the pumping piston assembly is offset from the centerline of the swash plate 110 as shown in figures 33-34. Therefore, the pistons 120 effective summation force tends to destroke the swash plate 110 to a vertical (neutral) position.
25 This destroking force is balanced as the swash plate 110 is angled by the force of the servo piston 119.

In figure 29, prior to starting a prime mover (electric motor, natural gas engine or diesel engine), a control valve (e.g. solenoid valve) 105 is energized to dump pump control signal, bringing the pump 103 to a minimum pressure (standby) position that is
30 shown in figures 32 and 34 (see arrow 104, figure 34). Any flow discharged from pump 103 travels via flow line 114 to reservoir 11. Hydraulic fluid does not flow in pump discharge line 114 because directional valve 106 is closed (figure 30). Flow line 114 can

be provided with check valve 115 to prevent back flow from valve 106 to pump 103. When the prime mover is started, it rotates drive 108 and the hydraulic pump 103 turns up to a selected speed such as about 1800 RPM with the pressure still at standby (figures 32, 34) as swash plate 110 is in the low pressure position of figures 30 and 32. Pump 103
5 intakes hydraulic fluid from reservoir 11 via flow line 140. Excess pump pressure can be relieved using relief valve 143 that dumps excess pressure to reservoir 11 via flow line 141 or flow line 141 can empty into flow line 119 which then empties into reservoir 11.

An up-stroke cycle (see figures 31 and 33) begins by de-energizing the two position solenoid valve 105, closing flow line 113, enabling swash plate 110 to move to
10 the position in figures 29 and 31 and allowing pump 103 pressure to increase. The controller 39 energizes the directional valve 106 (see figure 29). When the directional valve 106 is energized, hydraulic fluid is directed via flow lines 114, 116 into the rod end 105 of the hydraulic cylinder 14 at 117 (see figure 29).

The rod 17 will elevate or retract (see arrows 111, figure 29) until an upper
15 proximity switch 24 is actuated by the coupling 20 on the rod 17. Proximity switch 24 then signals controller 39 to de-energize the directional valve 106 thus halting the flow of hydraulic fluid in flow lines 114, 116 to cylinder 14. Proximity switch 24 sends a signal to controller 39 which signals the proportional flow control valve 107 to open to a point at which hydraulic fluid discharges via lines 118, 119 to reservoir 12.

20 The cylinder rod 17 will lower or extend at a desired velocity and until the coupling 20 reaches second proximity switch 25 positioned a selected distance (e.g. approximately one foot, or 0.30 meters) from the bottom travel of the rod 17. The current signal to the proportional valve 107 will then be decreased and it closes further, forcing the cylinder rod 17 and attached pumping string or sucker rod 21 to decelerate,
25 until the coupling 20 lowers further and reaches third proximity switch 26. At that point, the current signal will be removed from the proportional valve 107, closing it and halting the flow of hydraulic fluid from cylinder 14 to reservoir 11 via flow lines 118, 119, with a voltage signal again sent to the directional valve 106, beginning the cycle again (see figures 29 and 31).

30 It should be understood that the compensating pump 103 is a commercially available known pump such as Parker Model No. PAVC100B 2R422, described in a Parker publication entitled "Series PAVC Variable Displacement Piston Pumps". The

control and movement of swash plate 110 between a lower or minimum pressure position of figure 32 and a higher pressure position of figure 31 is also known. Parker's publication entitled "Series PAVC Variable Displacement Piston Pumps" at page 6 describes a control option "M" that could be used as part of the method of the present invention to control the pump 103 and move swash plate 110 between the positions shown in figures 29-34.

In the figure 32 lower or minimum position, servo piston 119 has moved swash plate 110 to an inner position (see arrow 104) wherein the pump pistons 120 move the smallest amount as the cylinder barrel 121 rotates. In figure 32, spring 141 only applies minimal pressure against swash plate 110. A wear plate or plates (e.g. brass) 122 form an interface between pump pistons 120 and swash plate 110.

Pump 103 can provide a control spool and sleeve 123 that shifts between different positions (figures 31, 32). In figure 32, the minimally pressured pump 103 transmits minimal hydraulic fluid via channels 125, 126, 124, 127, 139 and then to reservoir 11. Flow in channel 129 is throttled using orifice 128.

Swash plate 110 angle controls the output flow of the pump 103. Swash plate 110 angle is controlled by the force generated against the swash plate 110 by the pumping pistons 120 and by the force of the servo piston 119. The force of the servo piston 119 is greater than the force of the pumping pistons 120 when both are at the same pressure.

In figures 29-34, control of pump 103 can employ a proportionally controlled pressure control device installed in the flow line that is in between pump 103 discharge and the reservoir 11. Pump 103 could then maintain pressure approximately equal to the pressure at the pump discharge at location 142 plus the pump differential setting.

By means of internal porting (figures 31, 32), pressure is connected from the output channel 125 to the servo piston 119 via orifice or channel 124 and to the control spool 123 via passage 126. As long as the pressures at both ends of the control spool 123 remain equal, the spool 123 will remain offset upward, due to the added force of the spring 137.

When pressure reaches the setting of the pressure compensator control 138, the spool 123 leaves its seat causing the pressure in the spool chamber to be reduced. The spool 123 now moves downward causing pressure in the servo piston 119 cavity to vent via channel 139. The reduced pressure at the servo piston 119 allows the servo piston

119 to move to the right. This movement reduces the angle of the swash plate 110 and thereby reduces the pumps 103 output flow.

As pump pressure on the control spool 123 drops below pressure and spring force in the spool chamber, the control spool 123 moves upward to maintain an equilibrium on both sides of the spool 123. If pump pressure falls below compensator control setting, the control spool moves up, bringing the pump 103 to maximum displacement.

In figure 31, the upstroke position of the apparatus 102 places pump 103 in a high pressure position, swash plate 110 forming a greater angle with the direction 130 of influent flow thus increasing the volume of fluid pumped by each pump piston during pumping. In figure 31, valve 106 is open. Flow of fluid in channel 128 is throttled by orifice 128. However, pressure does travel to channel 127 in the direction of arrows 131, 132 to controller 133 and then to piston 119. Piston 119 is operated to increase the angle of swash plate 110 to the figure 31 position by pressurized fluid transmitted to piston 119 via channels 125, 126, 124.

A cooling fan or other heat exchanger 134 can be used to cool the hydraulic fluid flowing in flow line 119. Flow line 135 and valve 136 can be used to provide flow to operate cooling fan 134. Flow line 145 supplies oil from line 114 to operate fan 134. Flow line 145 discharge from fan 134 and empties to reservoir 11.

With the oil well pump embodiment of figures 29-34, the swash plate 110 of pump 103 is thus adjusted between high volume pumping (figures 31 and 33) and low or no volume pumping (figures 32 and 34) positions. Control valve 105 is thus operated to control pressure on pump 103 at 142 (figure 32) to start the downstroke cycle and to start the apparatus when beginning in an unloaded pump 103 position (figures 32, 34).

In figures 35-42, a manifold 144 is shown that could be used to channel fluids to the various components shown in figures 29-30. The manifold 144 is shown in the downstroke position in figures 35-38. The manifold 145 is shown in the upstroke position in figures 39-42.

The following is a list of parts and materials suitable for use in the present invention.

30

PARTS LIST

Part Number

Description

10

oil well pump

	11	reservoir
	12	prime mover
	13	compensating pump
	14	hydraulic lift cylinder
5	15	cylinder body
	16	hollow interior
	17	cylinder rod
	18	upper end portion
	19	lower end portion
10	20	coupling
	21	pumping string/sucker rod
	22	oil well Christmas tree
	23	well pipe
	24	proximity or limit switch
15	25	proximity or limit switch
	26	proximity or limit switch
	27	hydraulic flow line
	28	directional valve
	29	hydraulic flow line
20	30	drain line
	31	proportioning valve
	32	drain line
	33	flow line
	34	flow line
25	35	manifold
	36	cooler
	37	ventable relief valve
	38	frame
	39	programmable logic controller
30	40	oil well pump
	41	reservoir
	42	prime mover

	43	compensating pump
	44	manifold
	45	fluid transfer block
	46	directional valve
5	47	proportional valve
	48	relief valve
	49	bypass valve
	50	fan flow control
	51	inlet
10	52	outlet to cooler and reservoir
	53	outlet to hydraulic lift cylinder
	54	gauge port
	55	cooler
	56	filter
15	57	fan motor
	58	manifold
	59	manifold
	60	flow line
	61	valve
20	62	flow line
	63	flow line
	64	flow line
	65	flow line
	66	flow line
25	67	flow line
	68	flow line
	69	instrumentation line
	70	instrumentation line
	71	instrumentation line
30	72	instrumentation line
	73	channel
	74	channel

	75	channel
	76	manifold
	77	fluid transfer block
	78	directional valve block
5	79	directional valve block
	80	proportional throttle valve block
	81	proportional throttle valve block
	82	relief valve
	83	bypass valve
10	84	fan flow control valve
	85	poppet valve
	86	shuttle valve
	87	flow line
	88	inlet fitting
15	89	flow line
	90	arrow
	91	flow line
	92	arrow
	93	exit fitting
20	94	flow line
	95	arrow
	96	arrow
	97	outlet fitting to reservoir
	98	inlet
25	99	outlet
	100	conical valving member
	101	conical valving member
	102	oil well pump
	103	compensating pump
30	104	arrow
	105	valve
	106	directional valve

	107	proportional control valve
	108	drive
	109	rod end
	110	swash plate
5	111	arrow
	112	flow line
	113	suction line
	114	flow line
	115	check valve
10	116	flow line
	117	position
	118	flow line
	119	servo piston
	120	pump piston
15	121	piston barrel
	122	wear plate
	123	control spool
	124	channel
	125	channel
20	126	channel
	127	channel
	128	orifice
	129	channel
	130	direction
25	131	arrow
	132	arrow
	133	channel
	134	cooling fan
	135	flow line
30	136	valve
	137	spring
	138	compensator control

	139	channel
	140	suction line
	141	spring
	142	location
5	143	relief valve
	144	manifold
	145	cooling fan flow line

All measurements disclosed herein are at standard temperature and pressure, at sea level on Earth, unless indicated otherwise.

10 The foregoing embodiments are presented by way of example only; the scope of the present invention is to be limited only by the following claims.

CLAIMS

1. A hydraulic oil well pumping apparatus, comprising:
 - a) a hydraulic cylinder having a rod that is movable between an upper and lower rod positions;
 - 5 b) a pumping string that extends downwardly from the rod, the string being configured to extend into an oil well for pumping oil from the well;
 - c) a prime mover;
 - d) a hydraulic pump that is powered by the prime mover, said pump having a compensator that regulates pump flow and pump pressure;
 - 10 e) a directional control valve that moves between open flow and closed flow positions;
 - f) a flow line connecting the pump and the hydraulic cylinder, the control valve being positioned in the flow line so that it can control flow between the hydraulic pump and hydraulic cylinder;
 - 15 g) a proportioning valve;
 - h) a hydraulic fluid reservoir for containing hydraulic fluid to be supplied to the hydraulic pump;
 - i) a flow line that transmits hydraulic fluid from the hydraulic cylinder to the reservoir via the proportioning valve; and
 - 20 j) an electronic control system that controls movement of the rod as it moves between the upper and lower positions by controlling the control valve and the proportioning valve wherein the control system includes an electrical signal that opens or closes the proportioning valve so that a control of rod movement is enabled when the rod changes direction at the lower position of the rod, and wherein the proportioning valve is choked to lower flow through it as the rod is descending from the upper toward the lower position.
2. The hydraulic oil well pumping apparatus of claim 1 wherein the electronic control system includes at least one proximity switch that activates a choking of the proportioning valve at a selected position of the rod relative to the switch.
- 30 3. The hydraulic oil well pumping apparatus of claim 1 wherein the electronic control system includes a plurality of proximity switches that each send an electronic signal when the rod assumes a selected position relative to the cylinder.

4. The hydraulic oil well pumping apparatus of claim 3 wherein the electronic control system includes a proximity switch that activates the directional control valve to move between open flow and closed flow positions.

5. The hydraulic oil well pumping apparatus of claim 3 wherein the electronic control system includes a proximity switch that activates the directional control valve to move from an open flow position to a closed flow position when the rod reaches the upper rod position relative to the cylinder.

6. The hydraulic oil well pumping apparatus of claim 3 wherein the electronic control system includes a proximity switch that activates the directional control valve to move from a closed flow position to an open flow position when the rod reaches the lower rod position relative to the cylinder.

7. The hydraulic oil well pumping apparatus of claim 1 wherein the electronic control system includes a plurality of three proximity switches that each send an electronic signal when the rod assumes a selected position relative to the cylinder.

8. The hydraulic oil well pumping apparatus of claim 1 wherein one of the proximity switches is activated when the rod is at the upper rod position relative to the cylinder.

9. The hydraulic oil well pumping apparatus of claim 1 wherein one of the proximity switches is activated when the rod is at the lower rod position relative to the cylinder.

10. The hydraulic oil well pumping apparatus of claim 1 wherein one of the proximity switches is activated when the rod is at a position that is in between the upper and lower rod positions.

11. The oil well pumping apparatus of claim 1 wherein the hydraulic pump has a swash plate that is movable between low volume and high volume positions.

12. The oil well pumping apparatus of claim 1 wherein the hydraulic pump has a swash plate that is movable between low pressure and high pressure positions.

13. A hydraulic oil well pumping apparatus, comprising:

a) a hydraulic cylinder having cylinder body and a piston that is movably mounted to the cylinder to travel between an upper and lower piston positions;

b) a pumping string that extends downwardly from the piston, the string being configured to extend into an oil well and including one or more sucker rods for pumping

oil from the well;

c) a prime mover;

d) a compensating hydraulic pump that is powered by the prime mover, said pump having a compensator that lessens pump flow as pump pressure increases;

5 e) a directional control valve that moves between open flow and closed flow positions;

f) a flow line connecting the pump and the hydraulic cylinder, the directional control valve being positioned in the flow line so that it can control flow between the hydraulic pump and hydraulic cylinder;

10 g) a proportioning valve;

h) a hydraulic fluid reservoir for containing hydraulic fluid to be supplied to the hydraulic pump;

i) a flow line that transmits hydraulic fluid from the hydraulic cylinder to the reservoir via the proportioning valve; and

15 j) an electronic control system that controls movement of the piston as it moves between the upper and lower piston positions by controlling the directional control valve and the proportioning valve wherein the control system includes an electrical signal that opens or closes the proportioning valve so that a control of piston movement is enabled when the rod changes direction at the lower position of the piston, and wherein
20 the proportioning valve is choked to lower flow through it as the piston is descending from the upper toward the lower position.

14. The hydraulic oil well pumping apparatus of claim 13 wherein the electronic control system includes at least one proximity switch that is positioned on the hydraulic cylinder and that activates a choking of the proportioning valve at a selected
25 position of the piston relative to the cylinder.

15. The hydraulic oil well pumping apparatus of claim 13 wherein the electronic control system includes a plurality of proximity switches that each send an electronic signal when the piston assumes a selected position relative to the cylinder.

16. The hydraulic oil well pumping apparatus of claim 15 wherein the
30 electronic control system includes a proximity switch that activates the directional control valve to move between open flow and closed flow positions.

17. The hydraulic oil well pumping apparatus of claim 15 wherein the

electronic control system includes a proximity switch that activates the directional control valve to move from an open flow position to a closed flow position when the piston reaches the upper piston position relative to the cylinder.

5 18. The hydraulic oil well pumping apparatus of claim 15 wherein the electronic control system includes a proximity switch that activates the directional control valve to move from a closed flow position to an open flow position when the piston reaches the lower piston position relative to the cylinder.

10 19. The hydraulic oil well pumping apparatus of claim 13 wherein the electronic control system includes a plurality of three proximity switches that each send an electronic signal when the piston assumes a selected position relative to the cylinder.

20. The hydraulic oil well pumping apparatus of claim 13 wherein one of the proximity switches is activated when the rod is at the upper piston position relative to the cylinder.

15 21. The hydraulic oil well pumping apparatus of claim 13 wherein one of the proximity switches is activated when the rod is at the lower piston position relative to the cylinder.

22. The hydraulic oil well pumping apparatus of claim 13 wherein one of the proximity switches is activated when the piston is at a position that is in between the upper and lower rod positions.

20 23. The oil well pumping apparatus of claim 13 wherein the hydraulic pump has a swash plate that is movable between low volume and high volume positions.

24. The oil well pumping apparatus of claim 13 wherein the hydraulic pump has a swash plate that is movable between low pressure and high pressure positions.

25 25. A hydraulic oil well pumping apparatus, comprising:

a) a hydraulic cylinder having a cylinder rod that is movable between an upper and lower rod positions;

b) a pumping string that extends downwardly from the rod, the string being configured to extend into an oil well for pumping oil from the well;

c) a prime mover;

30 d) a hydraulic pump that is powered by the prime mover, said pump having a compensator that regulates pump flow and pump pressure;

e) a directional control valve that moves between open flow and closed flow positions;

f) a flow line connecting the pump and the hydraulic cylinder, the control valve being positioned in the flow line so that it can control flow between the hydraulic pump and hydraulic cylinder;

g) a proportioning valve;

h) a hydraulic fluid reservoir for containing hydraulic fluid to be supplied to the hydraulic pump;

i) a flow line that transmits hydraulic fluid from the hydraulic cylinder to the reservoir via the proportioning valve; and

j) an electronic control system that controls movement of the cylinder rod as it moves between the upper and lower positions by controlling the control valve and the proportioning valve wherein the control system includes an electrical signal that opens or closes the proportioning valve so that the rod slows down its travel speed as it approaches the lower rod position.

26. The hydraulic oil well pumping apparatus of claim 25 wherein the electronic control system includes at least one proximity switch that is positioned on the hydraulic cylinder and that activates a choking of the proportioning valve at a selected position of the rod relative to the cylinder.

27. The hydraulic oil well pumping apparatus of claim 25 wherein the electronic control system includes a plurality of proximity switches that each send an electronic signal when the rod assumes a selected position relative to the cylinder.

28. The hydraulic oil well pumping apparatus of claim 27 wherein the electronic control system includes a proximity switch that activates the directional control valve to move between open flow and closed flow positions.

29. The hydraulic oil well pumping apparatus of claim 27 wherein the electronic control system includes a proximity switch that activates the directional control valve to move from an open flow position to a closed flow position when the rod reaches the upper rod position relative to the cylinder.

30. The hydraulic oil well pumping apparatus of claim 27 wherein the electronic control system includes a proximity switch that activates the directional control valve to move from a closed flow position to an open flow position when the rod reaches

the lower rod position relative to the cylinder.

31. The hydraulic oil well pumping apparatus of claim 25 wherein the electronic control system includes a plurality of three proximity switches that each send an electronic signal when the rod assumes a selected position relative to the cylinder.

5 32. The hydraulic oil well pumping apparatus of claim 25 wherein one of the proximity switches is activated when the rod is at the upper rod position relative to the cylinder.

33. The hydraulic oil well pumping apparatus of claim 25 wherein one of the proximity switches is activated when the rod is at the lower rod position relative to the
10 cylinder.

34. The hydraulic oil well pumping apparatus of claim 25 wherein one of the proximity switches is activated when the rod is at a position that is in between the upper and lower rod positions.

35. The oil well pumping apparatus of claim 25 wherein the hydraulic pump
15 has a swash plate that is movable between low volume and high volume positions.

36. The oil well pumping apparatus of claim 25 wherein the hydraulic pump has a swash plate that is movable between low pressure and high pressure positions.

37. A hydraulic oil well pumping apparatus, comprising:

a) a hydraulic cylinder having cylinder body and a piston that is movably
20 mounted to the cylinder to travel between an upper and lower piston positions;

b) a pumping string that extends downwardly from the piston, the string being configured to extend into an oil well and including one or more sucker rods for pumping oil from the well;

c) a variable displacement hydraulic pump;

25 d) a prime mover that is connected to and that powers the pump;

e) a directional control valve that moves between open flow and closed flow positions;

f) a first flow line connecting the pump and the hydraulic cylinder, the directional control valve being positioned in the flow line so that it can control flow
30 between the hydraulic pump and hydraulic cylinder;

g) a proportioning valve;

h) a hydraulic fluid reservoir for containing hydraulic fluid to be supplied to

the hydraulic pump;

i) a second flow line that transmits hydraulic fluid from the hydraulic cylinder to the reservoir via the proportioning valve;

5 j) a control system that controls movement of the piston as it moves between the upper and lower piston positions by controlling the directional control valve and the proportioning valve wherein the control system generates an electrical signal that opens and closes the proportioning valve;

k) a control of piston movement being enabled when the rod changes direction at a lower position of the piston

10 l) wherein the proportioning valve is choked to lower flow through it as the piston is descending from the upper toward the lower position; and

m) wherein the control system changes pump displacement to a lower displacement when the piston is lowering and a higher displacement when the piston is elevating.

15 38. The oil well pumping apparatus of claim 37 wherein the hydraulic pump has a swash plate that is movable between low volume and high volume positions.

39. The oil well pumping apparatus of claim 37 wherein the hydraulic pump has a swash plate that is movable between low pressure and high pressure positions.

20 40. The oil well pumping apparatus of claim 37 wherein the pump is a variable displacement piston pump.

41. The inventions substantially as shown and described herein.