Jan. 27, 1970 R. G. PEARSON 3,491,538

AIR BALANCED OIL WELL PUMPING SYSTEM

Filed March 4, 1968 2 Sheets-Sheet 1

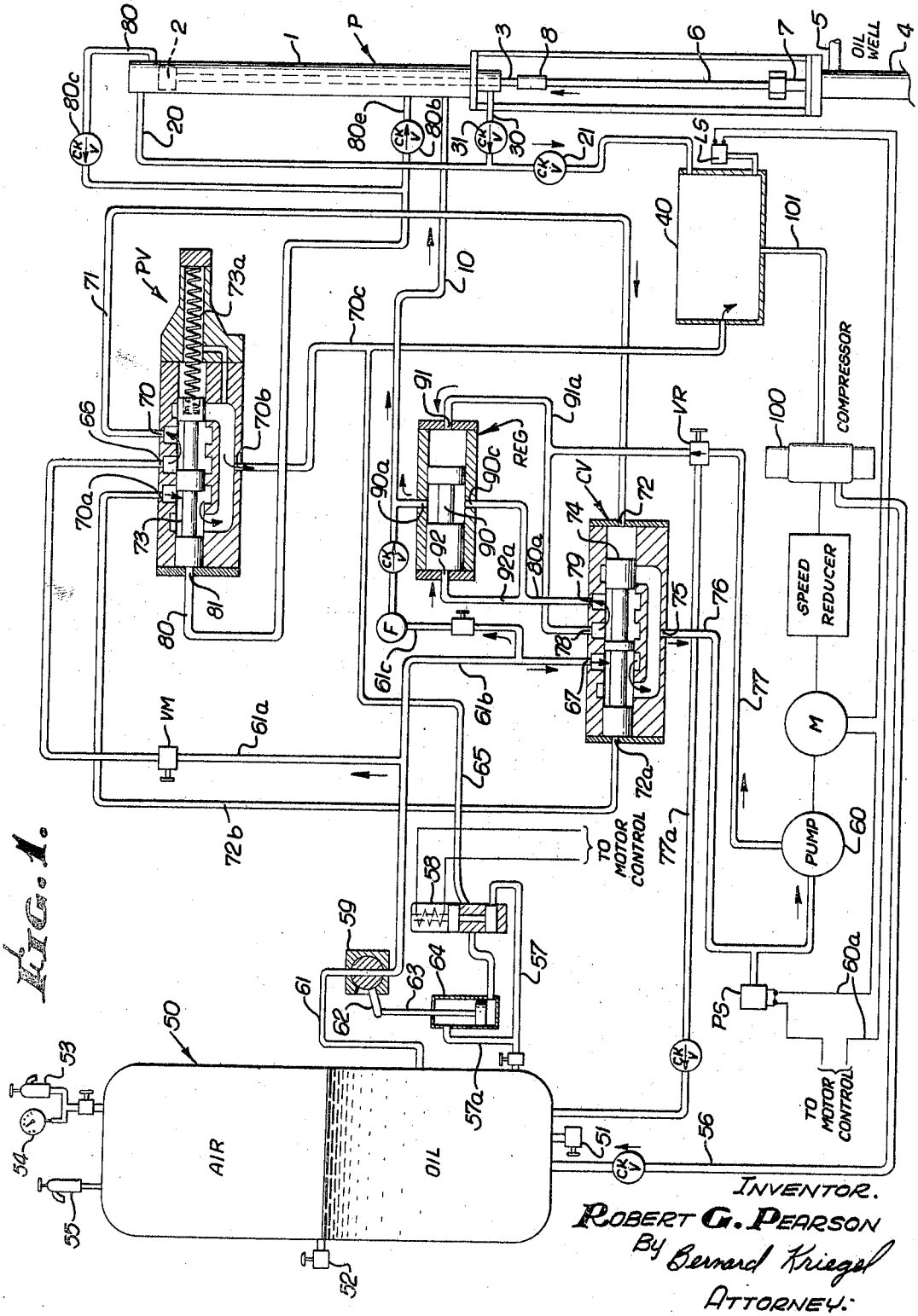


FIG. 1.

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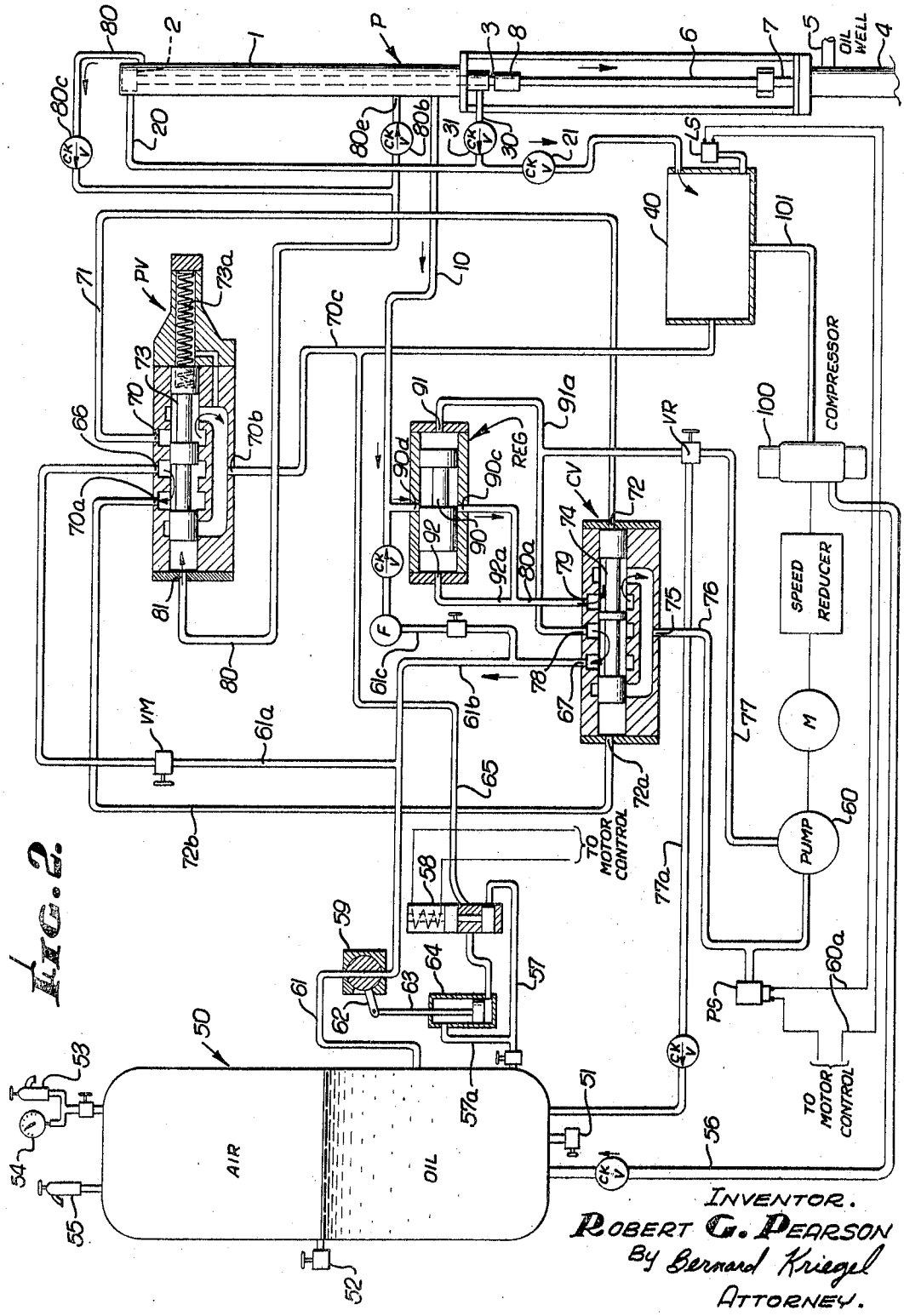


FIG. 2.

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3,491,538

AIR BALANCED OIL WELL PUMPING SYSTEM

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ABSTRACT OF THE DISCLOSURE

An oil well pumping system in which a pump jack is employed to left a string of pump sucker rods, and air pressurized hydraulic fluid is employed to partially balance the load on the pump jack, a pump causing the flow of hydraulic fluid, and a low-speed compressor returning hydraulic fluid from a system drain to the pressurized reservoir along with air to maintain the desired air pressure. Such a system is provided in which a pressure regulator prevents application of an inlet pressure to the pump in excess of discharge pressure.

In the production of certain oil wells which do not have sufficient formation pressure to effect flowing of the well fluids to the earth's surface, it is the practice to employ artificial fluid lift. One common lift comprises a reciprocating pump adapted to be installed in the well and operable by a string of reciprocable sucker rods which extend to the earth's surface, the sucker rod string being caused to reciprocate by power means such as a walking beam, or, as in the case of the present invention, by a pump jack operable by hydraulic fluid pressure.

Various pump jack operating and control systems have been proposed heretofore, including the use of air or other gas, such as nitrogen or the like, herein generically referred to as air, under pressure to apply a force to the hydraulically operable pumping jack, whereby to at least partially balance the dead weight of the sucker rod string and desirably a portion of the weight of the hydrostatic column of well fluid in the well production pipe. Such systems, obviously, reduce the required hydraulic pressure applicable to the pump jack periodically to effect lifting of the sucker rod string.

Ordinarily, such systems are periodically or constantly supplied with air under pressure from an outside source, so as to maintain a desired balancing force on the system, and more particularly, on the pump jack.

An object of the present invention is to provide a well pumping system of the air pressure loaded, hydraulically operated pump jack type which is relatively simple to build, and, therefore, inexpensive, but which, at the same time, is durable, and therefore has long life expectancy.

Another object of the invention is to provide an air pressure loaded, hydraulically operated pump jack operating system that requires the application of small additional horsepower to a pump to effect flow of the hydraulic fluid and lifting of the sucker rod string.

Yet another object is to provide an air pressurized, hydraulically operated pumping jack system, in which air is continuously supplied to the hydraulic fluid reservoir from the hydraulic system itself during operation of the system, thereby eliminating the need for the application of air pressure to the system, either periodically or continuously from an outside source. More specifically, in accordance with this objective, a low-speed compressor is employed to return hydraulic fluid from a system drain to the pressurized reservoir, such drain fluid inherently having air entrained therein, whereby to maintain the reservoir under the desired working or sucker rod counterbalancing pressure.

Still another object of the invention is to provide an air pressure loaded, hydraulically actuated, pump jack operating system wherein a control valve is moved between first and second positions to cause flow of hydraulic fluid to the pump jack and exhaust of hydraulic fluid from the pump jack, the control valve being controlled by a pilot valve which is responsive to fluid pressure when the pump jack reaches the end of its upstroke to cause shifting of the control valve to its second position, initiating, thereby, the downstroke of the pump jack.

A further object of the invention is to provide an air pressure loaded, hydraulically actuated, pump jack system in which a pump is employed to supplement the hydraulic pressure and cause flow to effect upstroke of the pump jack, wherein pressure regulator means are provided to prevent the application of an inlet pressure on the pump in excess of the pump outlet pressure, when the pump jack commences its downstroke.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a view diagrammatically illustrating an air pressure loaded, hydraulically operated, pump jack system in accordance with the invention, the system being conditioned for upstroke of the pump jack; and

FIG. 2 is a view similar to FIG. 1, but showing the system conditioned for downstroke of the pump jack.

In the system herein illustrated, it is desired that a pump jack P, comprising a fluid pressure operated actuator having a cylinder **1** and a piston **2** with rod **3**, be operated to effect reciprocation of a string of sucker rods (not shown) which extend downwardly into an oil well. Within the well, the sucker rod string would be connected to the plunger of a reciprocating pump (not shown) to cause the flow of well fluids upwardly through the well pipe **4** and into a flow line **5**, from which the well fluid will flow to a suitable reservoir or tank, as is well known.

At its upper end, the sucker rod string would be connected to a reciprocable polish rod **6** which extends through the usual stuffing box **7**, and this polish rod is connected by a coupling **8** to the lower end of the piston rod **3**. In order that the rod **6** may be reciprocated, the cylinder **1** has a conduit **10** for the admission and exhaust of hydraulic fluid under pressure below the piston **2**, upon operation of the air-hydraulic system hereinafter to be described. At the upper end of the cylinder **1** is an outlet conduit **20**, and at the lower end of the cylinder **1** is an outlet conduit **30**. Outlet conduits **20** and **30** may be respectively provided with check valves **21** and **31**, and each of these outlet conduits leads to a drain tank **40**. These conduits **20** and **30** carry leakage to the drain tank **40** and prevent vacuum interference with the operation of the pump jack in conjunction with check valves **21**, **31**.

As viewed in FIG. 1, the pump jack P is shown as upstroking, pressure fluid being supplied through conduit **10** below the piston **2**. In order to effect such upstroking of the pump jack P, the force derived from the pressure fluid supplied through the conduit **10** must overcome the weight of the entire string of sucker rods, plus the weight of the column of fluid in the well pipe **4**, and obviously must overcome friction. Thus, the necessary force may be substantial, as, for example, when the pump operated by the pump jack is located several thousands of feet down in

the earth. As will hereinafter be more fully described, the hydraulic fluid is pressurized to effect upstroke of the pump jack P by air pressure in a supply tank **50** and by supplemental pressure derived from a pump **60**. As previously indicated, the system may be pressurized by air so as to provide an upward force on the pump jack piston **2** equal to the weight of the entire sucker rod string, plus a desired portion of the weight of the column of well fluid to be lifted.

Referring to the supply tank **50**, it is preferably provided with a filler valve **51**, a shut-off valve **52** adapted to allow filling of the tank to the desired level, a working pop valve **53** and associated pressure gauge **54**, and a safety pop valve **55**. A return conduit **56** is provided, and at the lower end of the tank is an outlet conduit **57** leading to a normally open solenoid valve **58** which provides means for causing a ball valve **59** in an outlet conduit **61** to remain open during operation of the system. This outlet conduit **61** will supply fluid from the tank **50**, in a manner hereinafter to be described, to the pump **60** and to the pump jack inlet **10** when the valve **59** is open.

In order to open the valve **59**, it is provided with an operator lever **62** connected to the rod **63** of a differential area operated actuator cylinder **64**. Conduit **57** is connected to the lower portion of the tank **50** and has a branch **57***a* leading to one side of the piston of actuator cylinder **64**, line **57** leading to the other side of the actuator piston through the solenoid valve **58** when it is in one position. However, when the solenoid of valve **58** is energized, as seen in FIGS. 1 and 2, the valve **58** closes off conduit **57** and the larger end area of the actuator piston is exhausted to the drain tank **40** through a conduit **65**. Therefore, the pressure of fluid in the supply tank **50**, acting on the smaller effective area of the piston of the actuator cylinder **64**, will cause the rod **63** to open the valve **59**. Thus, energization of the solenoid valve **58** conditions the system for operation.

Hydraulic fluid flowing from the tank **50** through conduit **61** follows three courses: first, via a branch conduit **61***a* to the inlet **66** of a pilot valve means PV; second, via a branch conduit **61***b* to a port **67** of a control valve means CV; and a third, via a branch conduit **61***c* to the conduit **10** which leads into the pump jack cylinder **1**.

In the illustrative embodiment, the pilot valve means PV is a hydraulically controlled, spring biased four-way valve which is adapted to be shifted between a first position shown in FIG. 1 and a second position shown in FIG. 2, whereby to cause shifting of the control valve means CV between a first position shown in FIG. 1 and a second position shown in FIG. 2. More specifically, the pilot valve PV includes an outlet **70** communicating with a conduit **71**, which leads to an end port **72** of the control valve CV, and the pilot valve PV further includes a spool **73** spring loaded to the above-mentioned first position so that ports **66** and **70** are in communication, whereby pressure fluid flows from the pilot valve PV to the end port **72** of the control valve CV. This control valve CV has a spool **74** which is forced by pressure entering port **72** to the above-mentioned first position, so that the control valve port **67** is in communication with a control valve port **75** leading to an inlet conduit **76** connected to the inlet side of the aforementioned pump **60**.

When the pilot valve spool **73** is in the first position of FIG. 1, port **70***a* thereof is in communication with an exhaust port **70***b* which leads through an exhaust conduit **70***c* to a junction with the aforementioned conduit **65** leading to the drain tank **40**. An end port **72***a* of the control valve CV communicates through a conduit **72***b* with the pilot valve port **70***a*, whereby to exhaust this end of the control valve CV, so that the control valve spool **74** is held in its first position by the pressure of fluid at port **72** at the other end of the spool **74**.

The discharge side of the pump **60** is connected by a discharge conduit **77** to the center inlet port **78** of the control valve CV, which, when the spool **74** is in the first position of FIG. 1, communicates with a discharge port **79** of the valve CV. A conduit **80***a* leads from the valve port **79** to the abovementioned conduit **10** through a pump inlet pressure regulator valve REG, hereinafter to be described.

Thus, when the spool **73** of pilot valve PV and the spol **74** of control valve CV are in their first positions, pressurized fluid is supplied to the pump jack cylinder **1** via conduit **10** to cause the piston **2** to upstroke, lifting the polish rod **6** and attached string of pump sucker rods.

Various auxiliary valves and other equipment may be employed in the system as thus far described. For example, a metering valve VM may be installed in the inlet conduit **61***a* leading to the center port **66** of the pilot valve PV. A filter F may be installed in the system, as, for example, in the conduit **61***c*. A relief valve VR may be installed in the pump discharge conduit **77**, such relief valve having a conduit **77***a* leading back to the supply tank **50**. The pump **60** may be driven by an electric motor M and an electric circuit **60***a* to the motor M may include a low pressure shut-off switch PS in pressure communication with the pump inlet conduit **76**. A fluid level switch LS may also be in the circuit **60***a* to the motor M and in pressure communication with the drain tank **40** to shut off the motor if the fluid level in the drain tank rises above a predetermined level, for example, due to excessive leakage in the system.

The downstroke phase of operation of the pump jack will be described in relation to second positions of the spool **73** of the pilot valve PV and the spool **74** of the control valve CV. A conduit **80** leads from the upper end of pump jack cylinder **1** at a location at which, when the piston **2** is at any position below its uppermost position, the conduit **80** communicates with the aforementioned conduit **20** which leads to the drain tank **40**. This conduit **80** also communicates with an end port **81** of pilot valve PV so that the adjacent end of pilot valve spool **73** is exposed to atmosphere, thereby enabling the pilot valve spool **73** to assume and remain in its first position under the influence of the valve spring **73***a*, thereby causing the spool **74** of control valve CV to assume and remain in its first position under the influence of fluid pressure at port **72**, as previously described.

However, when the pump jack piston **2** reaches its uppermost position, it will be seen in FIG. 2 that the conduit **80** will be in communication with the pressure fluid inlet conduit **10**, but the conduit **20** will be shut off by piston **2**. Thus, pressure fluid will flow through the pump jack cylinder **1** to conduit **80** and to the end port **81** of pilot valve PV, causing a force which will move the valve spool **73** to the right or the second position shown in FIG. 2. At this time, port **72** of the control valve CV will communicate through conduit **71** with pilot valve port **70**, thereby exhausting the right hand end of the control valve CV to the drain tank through conduit **70***c*. In addition, the pilot valve inlet port **66** communicates with port **70***a*, so that pressure fluid from the supply tank **50** flowing through conduit **61***a* will flow through the pilot valve PV to the end port **72***a* of control valve CV, whereby to force the spool **74** to its second position (FIG. 2).

At this second position of spool **74** of the control valve CV, its port **78** and port **67** communicate so that the discharge side of the pump **60**, namely, the conduit **77**, is connected back to the supply tank **50**; while the inlet side of the pump **60**, namely, conduit **76**, is connected to the conduit **10** through the regulator valve REG.

This regulator valve, as previously indicated, serves to prevent the application of an inlet pressure on the pump **60** which exceeds the discharge pressure. In this connection, it will be understood that when the pump jack piston first commences its downstroke, following movement of the pilot and control valve spools **73** and **74** to their respective second positions, and the pump jack cylinder **1** below the piston **2** communicates with the pump inlet conduit **76**, the pump inlet pressure is a function of the

entire weight of the sucker rod string, plus the weight of the column of fluid in the well pipe **4**, and the effective cross-sectional area of the piston **2**, forcing fluid into the pump inlet conduit **76** as the entire weight moves downwardly. On the other hand, the discharge pressure of the pump **60** is, as previously indicated, a function of the pressure of the air in the supply tank **50**, which will be selected so as to balance the weight of the sucker rod string and a portion, say one-half, of the weight of the well fluid column. Under these circumstances, the inlet pressure at pump **60** may exceed the discharge pressure an amount resulting from one-half the weight of the well fluid column acting to force the piston **2** downwardly. This condition, as will be understood in the art, is a momentary condition, since the reciprocating pump plunger in the well has a travelling valve which closes on the upstroke of the plunger and opens responsive to downstroke of the plunger. Thus, when the just-mentioned travelling valve opens, the weight of the well fluid column will be supported by the well pump standing valve, and the inlet pressure on the pump **60** will be reduced.

In any event, the regulator valve REG reacts to the presence of an inlet pressure greater than outlet pressure at pump **60** to adjust the pressure at the pump inlet. Accordingly, while regulator means may be employed either in the pump inlet conduit **76** or in the pump discharge conduit, the valve REG, in the illustrative embodiment, is shown as being interposed between the control valve CV and the pump discharge conduit **77**. This valve REG includes a spool **90**, an end of the valve having a port **91** which is connected by a branch conduit **91***a* to the pump discharge conduit **77**, so that pump discharge pressure is always applied to one end of the spool **90**. The other end of the valve REG has a port **92** which is connected by a conduit **92***a* to the control valve port **79** which receives pump discharge during upstroke of the pump jack. Thus, during upstroke of the pump jack, the discharge pressure from the pump **60** is also applied to the regulator valve spool **90** through port **92**, as well as port **91**, and the spool **90** is balanced, the pump discharge flow passing through the full open center ports **90***c* and **90***d* of the regulator valve RFG. However, when the spool **74** of control valve CV is in its second position, the conduit **92***a* will be conducting fluid to port **79** from the pump jack cylinder **1**, and port **70** communicates with the inlet conduit **76** to pump **60**. Thus, the comparatively high pressure at the regulator valve port **92** will shift the regulator valve spool **90** to the right, as seen in FIG. 2, to reduce the flow through the regulator valve and thereby reduce the pressure at the inlet to pump **60** during the initial downward travel of the pump jack piston, until the well pump travelling valve opens to reduce the weight affecting the inlet pressure at pump **50**.

The downstroke of the pump jack will continue until the piston **2** passes a branch conduit **80***e* adjacent the lower end of the cylinder **1**, at which time the pressure in conduit **80** holding the pilot valve spool **73** in its second position will be vented through a check valve **80***b* in branch conductor **80***e* into the cylinder **1** above piston **2**, a check valve **80***c* being provided in the conduit **80** to prevent such venting when the piston **2** is above the branch conduit **80***e*. When conduit **80** is thus vented, the pilot valve will return to its first position; the control valve will be caused to assume its first position; and upstroke of the pump jack will occur.

In accordance with another feature of the invention, means are provided for replenishing the supply of oil or hydraulic fluid in the supply tank **50** from the drain tank **40**, while, at the same time, maintaining the air pressure in the supply tank **50**. In the illustrative embodiment, such means comprises a compressor **100** connected by an intake conduit **101** to the drain tank **40** and having the aforementioned return conduit **56** leading to the supply tank **50** from the discharge side of the compressor. Preferably, the compressor **100** is of the multiple piston type driven by the motor M through a speed reducer at such a speed as to constantly scavenge the drain fluid from the drain tank, along with air entrained in the fluid, and replenish the supply tank with compressed air and with the scavenged fluid. Preferably, the compressor **100** should operate at a speed which is more than adequate to scavenge the drain fluid, thus the pumping chambers of the compressor will fill partially with drain fluid and partially with air from the atmosphere. The speed of compressor **100** should also be such that tank **50** is supplied with air in greater volume than is required to maintain the desired balance pressure, excess air being relieved through the working pop valve **53**, or, in the event of failure of the valve **53**, through safety pop valve **55**.

The operation of the system as a whole is believed to be clear from the foregoing, without further elaboration, and while specific details and arrangements of conduits and valve, as well as other components, have been herein shown and described, changes and alterations may be made without departing from the spirit of the invention.

I claim:

1. In a system for operating a pump jack having a cylinder and a piston reciprocable in said cylinder for reciprocating a string of well pump sucker rods: a supply tank for hydraulic pump jack operating fluid, said tank having means enabling pressurizing the same with air, a drain tank, means including fluid operated control means for conducting said fluid to said pump jack cylinder from said supply tank and for returning said fluid from said pump jack cylinder cyclically, means for exhausting said control means to said drain tank, and a compressor connected to said drain tank and to said supply tank for returning fluid and compressed air from said drain tank to said supply tank to maintain the air pressure in said supply tank.

2. A system as defined in claim **1**; wherein said means for conducting said fluid includes a pump, control valve means interposed between the pump inlet and the pump discharge and movable between a first position at which said pump discharge is connected to said cylinder and said pump inlet is connected to said supply tank and a second position at which said pump discharge is connected to said supply tank and said pump inlet is connected to said cylinder, and means for moving said control valve means between said positions.

3. In a system for operating a pump jack having a cylinder and a piston reciprocable in said cylinder for reciprocating a string of well pump sucker rods: a supply tank for hydraulic pump jack operating fluid, said tank having means enabling pressurizing the same with air, a drain tank, means including fluid operated control means for conducting said fluid to said pump jack cylinder from said supply tank and for returning said fluid from said pump jack cylinder cyclically, means for exhausting said control means to said drain tank, and compressor means for returning fluid and compressed air from said drain tank to said supply tank to maintain the air pressure in said supply tank, said means for conducting said fluid including a pump, control valve means interposed between the pump inlet and the pump discharge and movable between a first position at which said pump discharge is connected to said cylinder and said pump inlet is connected to said supply tank and a second position at which said pump discharge is connected to said supply tank and said pump inlet is connected to said cylinder, and means for moving said control valve means between said positions, said moving means including pressure regulator means for preventing a pressure at said pump inlet greater than pressure at said pump discharge when said valve means is in said second position.

4. A system as defined in claim **1**; wherein said means for conducting said fluid includes a pump, control valve means interposed between the pump inlet and the pump discharge and movable between a first position at which said pump discharge is connected to said cylinder and

said pump inlet is connected to said supply tank and a second position at which said pump discharge is connected to said supply tank and said pump inlet is connected to said cylinder, and means for moving said control valve means between said positions including pilot valve means connected to said cylinder and to said control valve means and responsive to movement of said pump jack piston to the end of its movements in opposite directions to cause movement of said control valve means to said first and second positions.

5. A system as defined in claim 1; wherein said means for conducting said fluid includes a pump, control valve means interposed between the pump inlet and the pump discharge and movable between a first position at which said pump discharge is connected to said cylinder and said pump inlet is connected to said supply tank and a second position at which said pump discharge is connected to said supply tank and said pump inlet is connected to said cylinder, means for moving said control valve means between said positions, a source of power for said pump, and drive means connected to said source of power for operating said compressor means.

6. In a system for operating a pump jack having a cylinder and a piston reciprocable in said cylinder for reciprocating a string of well pump sucker rods: a supply tank for hydraulic pump jack operating fluid, said tank having means enabling pressurizing the same with air, a drain tank, means including fluid operated control means for conducting said fluid to said pump jack cylinder from said supply tank and for returning said fluid from said pump jack cylinder cyclically, means for exhausting said control means to said drain tank, and compressor means for returning fluid and compressed air from said drain tank to said supply tank to maintain the air pressure in said supply tank, said means for conducting said fluid including a pump, control valve means interposed between the pump inlet and the pump discharge and movable between a first position at which said pump discharge is connected to said cylinder and said pump inlet is connected to said supply tank and a second position at which said pump discharge is connected to said supply tank and said pump inlet is connected to said cylinder, means for moving said control valve means between said positions, a source of power for said pump, drive means connected to said source of power for operating said compressor means, said compressor means comprising a multiple piston compressor, and said drive means including speed reducer means for driving said compressor at low speed relative to said pump.

7. In an oil well pumping system for connection to a string of reciprocable pump sucker rods: a pump jack having a vertically disposed cylinder, a piston and rod reciprocable in said cylinder and connectible to said string of pump rods, an inlet and outlet conduit below said piston, means for cyclically supplying pressure fluid to said cylinder and exhausting said fluid from said cylinder through said conduit to effect upstroking and downstroking of said piston and rod, said means including a fluid supply tank having air therein for applying a load balancing force to said fluid during upstroking of said piston and rod, pump means having an inlet and a discharge, valve means movable between a first position connecting said pump means discharge to said conduit and said pump means inlet to said supply tank and a second position connecting said conduit to said pump means inlet and said pump means discharge to said supply tank, means for moving said valve means to said first position when said piston and said rod reach the end of said downstroke and for moving said valve means to said second position when said piston and rod reach the end of said upstroke, and pressure regulator means for preventing the application of pressure at said pump means inlet in excess of the pressure at said pump means discharge when said valve means is in said second position.

8. A pumping system as defined in claim 7; wherein said pressure regulator means includes a pressure operated regulator valve interposed between said pump means inlet and said pump means discharge.

9. A pumping system as defined in claim 7; wherein said pressure regulator means includes a pressure operated regulator valve interposed between said pump means inlet and said pump means discharge, said regulator valve having a spool, a conduit connecting said regulator valve to said pump means discharge to subject one end of said spool to the pressure at said pump means discharge, another conduit connecting said regulator valve to said valve means to subject the other end of said spool to fluid pressure, and said valve means including means for admitting the pressure of fluid from said pump means discharge to said another conduit when said valve means is in said first position and for admitting the pressure of fluid from said pump means inlet to said another conduit when said valve means is in said second position.

10. A pumping system as defined in claim 7; wherein the means for moving said valve means to said first and second positions includes pilot valve means movable to a first position for causing said first-mentioned valve means to move to said first position, said pilot valve means being movable to a second position to cause said first-mentioned valve means to move to said second position, and means for moving said pilot valve means to said first and second positions when said piston and rod reach the end of their downstroke and upstroke.

11. A pumping system as defined in claim 7; wherein the means for moving said valve means to said first and second positions includes pilot valve means including a spool movable to a first position for causing said first-mentioned valve means to move to said first position, said pilot valve means spool being movable to a second position to cause said first-mentioned valve means to move to said second position, and means for moving said pilot valve means spool to said first and second positions when said piston and rod reach the end of their downstroke and upstroke including conduit means connecting said pump jack cylinder to said pilot valve means to cause movement of said spool to said first and second positions when said piston and rod reach the end of their downstroke and upstroke.

12. In a well pumping system for connection to a string of reciprocable pump rods: a pump jack having a vertically disposed cylinder, a piston and rod reciprocable in said cylinder and connectible to said string of pump rods, a supply tank for air pressurized fluid, conduit means leading from said tank to said cylinder beneath said piston, pump means in said conduit means, control valve means in said conduit means for alternately reversing the flow between said tank and said cylinder upon reversal of said control valve means, pilot valve means in said conduit means for reversing said control valve means, said pilot valve means having fluid pressure responsive means for operating the same upon movement of said piston to an upper position and to a lower position, a pilot conduit leading to said pilot valve means and communicating with said cylinder below said piston when said piston reaches its upper position and above said piston when said piston reaches its lower position to conduct fluid pressure to said fluid pressure responsive means, a drain tank, an exhaust conduit leading from said pilot valve means to said drain tank, a compressor connected to said drain tank, and a conduit leading from said compressor to said supply tank for conducting compressed air and fluid from said drain tank to said supply tank.

13. A well pumping system as defined in claim 12; wherein said control valve means is fluid pressure operated, and including pilot conduit means connecting said control valve means to said pilot valve means, said pilot valve means having means for exhausting said pilot conduit means to said drain through said exhaust conduit upon reversal of said control valve means.

14. A well pumping system as defined in claim 12; wherein pressure regulator means are provided for preventing the application of an inlet pressure on said pump means in excess of the discharge pressure of said pump means when said control valve means reverses at the end of the upward movement of said piston.

15. A well pumping system as defined in claim 12; wherein said supply tank is provided with pop valve means for limiting air pressure in said supply tank in response to operation of said compressor.

16. A well pumping system as defined in claim 12; wherein shut-off valve means are provided in said conduit means leading from said supply tank to said cylinder, said shut-off valve means including an actuator cylinder, an actuator piston in said actuator cylinder having a rod projecting from said actuator cylinder and connected to said shut-off valve means to open and close the same upon shifting of said actuator piston, conduit means leading from said supply tank to said actuator cylinder at opposite sides of the actuator piston therein, and valve means for shutting off said conduit means at one side of said actuator piston and exhausting said actuator cylinder at the other side of said actuator piston.

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EDGAR W. GEOGHEGAN, Primary Examiner

U.S. Cl. X.R.

103—45