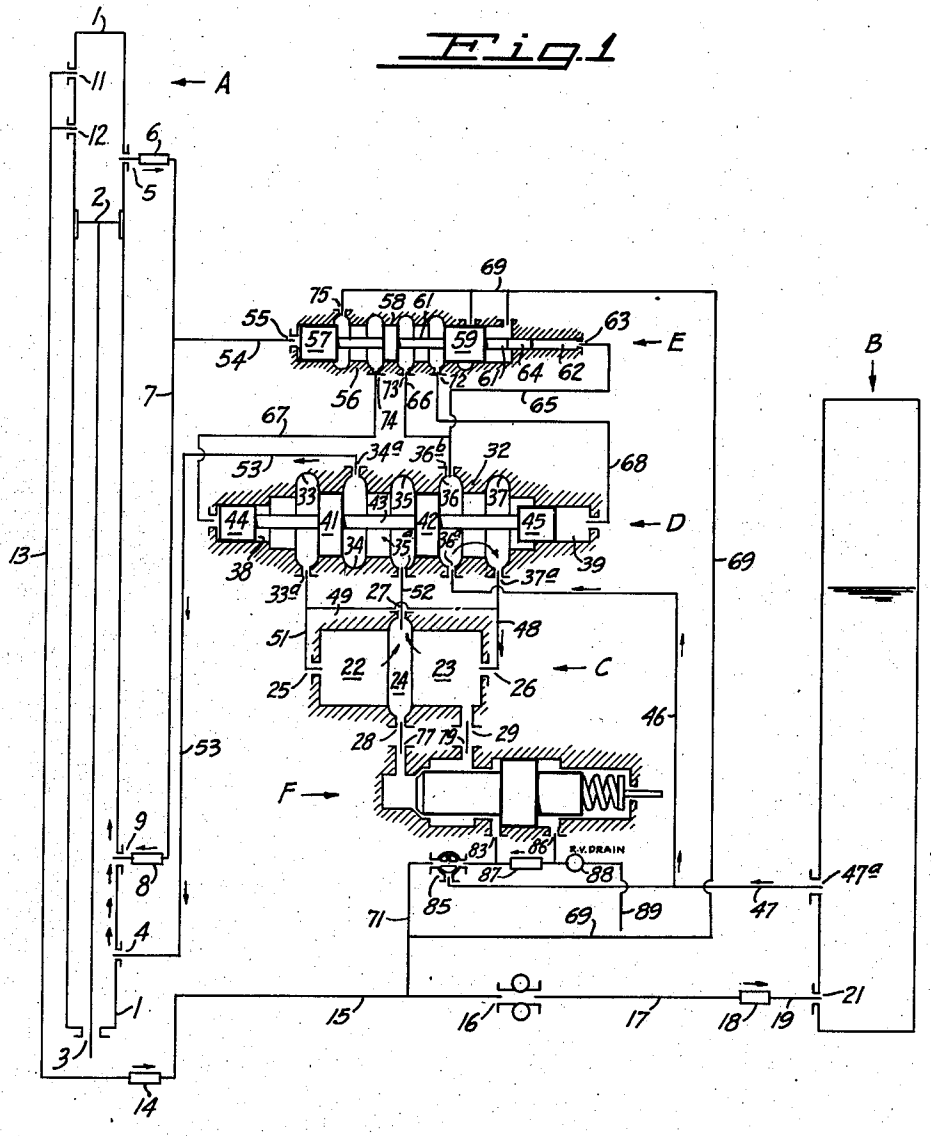
May 17, 1949. S. C. KYLE 2,470,252

HYDRAULIC PUMPING JACK WITH CONTROL RESPONSIVE TO ABNORMAL CONDITIONS

Filed Nov. 9, 1945 3 Sheets-Sheet 1

Fig. 1



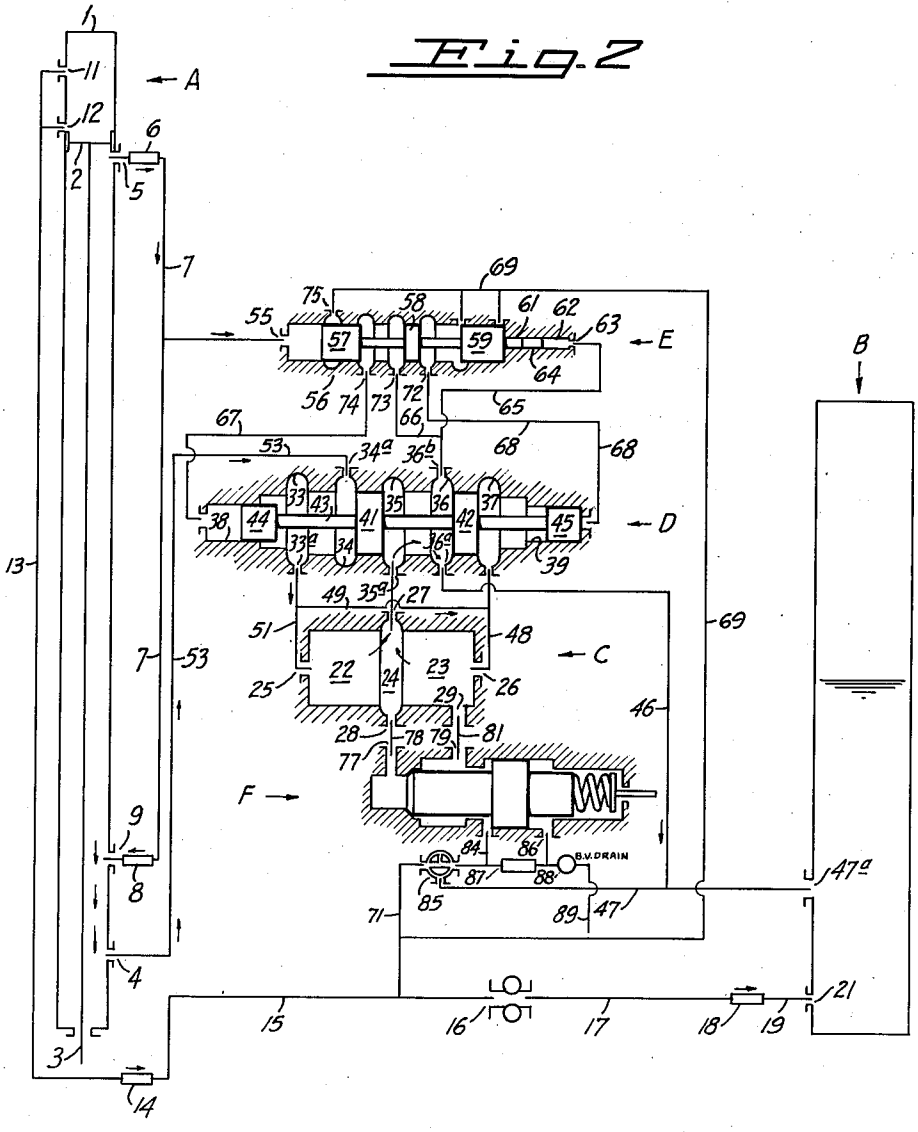
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HYDRAULIC PUMPING JACK WITH CONTROL RESPONSIVE TO ABNORMAL CONDITIONS

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Fig. 2



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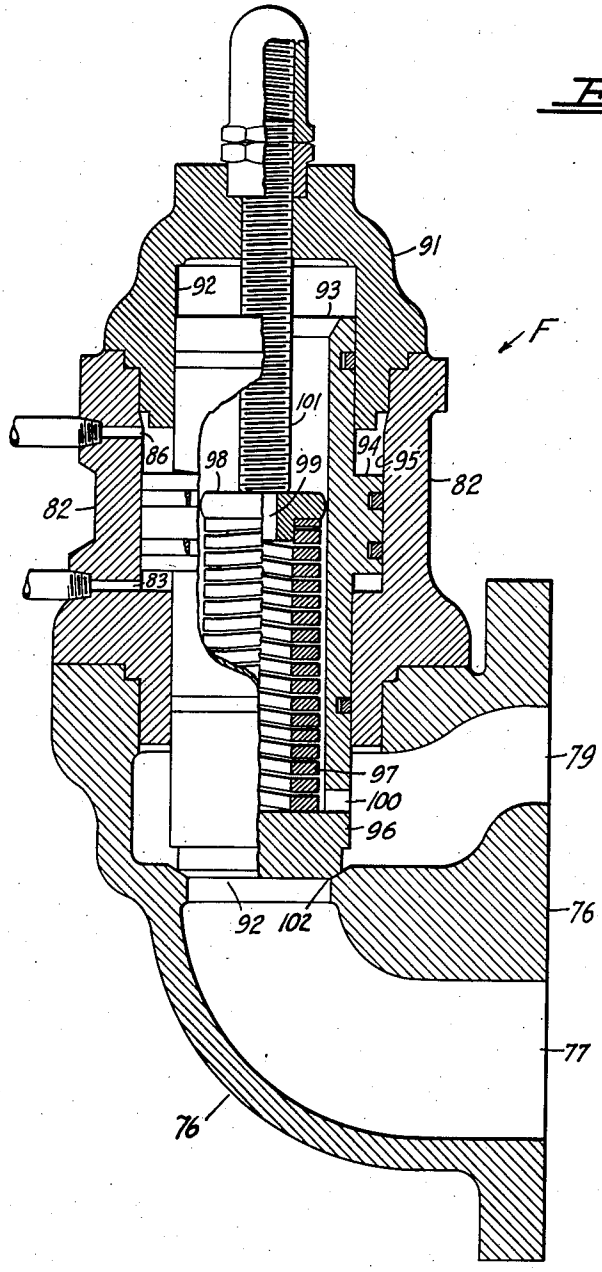
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Filed Nov. 9, 1945 3 Sheets-Sheet 3

Fig. 3



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HYDRAULIC PUMPING JACK WITH CONTROL RESPONSIVE TO ABNORMAL CONDITIONS

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6 Claims. (Cl. 60—51)

1

This invention relates in general to a hydraulic deep well pumping jack system including a hydraulic jack; a balancing pressure tank, a constant displacement main pump and an automatic control valve. The balancing pressure tank of the system is maintained at a pressure such that the resulting lifting force of the pressure applied in the hydraulic jack equals the rod weight plus one-half of the fluid weight normally lifted by the jack. The main operating pump and control valve are disposed between the jack and the balancing tank so that operation of the main pump and control valve to produce flow from the tank to the jack will lift the piston in the jack cylinder while operation of the main pump and control valve to produce flow from the jack to the tank will lower the piston in the jack cylinder. A special hydraulic control mechanism is provided automatically to reverse the action as the jack piston reaches the terminal point at each end of the stroke. By maintaining the pressure in the balancing tank as described above, the main pump is subjected to a substantially constant load during the upstroke and downstroke of the jack. During the upstroke the main pump must develop sufficient pressure which when applied to the jack will augment the balancing tank pressure and lift the entire rod plus the fluid load. Conversely, during the downstroke, the main pump must sufficiently reduce the pressure within the jack so as to remove fluid from the jack so that the load on the jack will be reduced to the rod load only. Associated with and forming an integral part of this system is a drain system for returning fluid from the upper end of the hydraulic jack cylinder and from the control and pilot valves to the lower end of the balancing pressure tank.

Normally the drain system is maintained at or slightly below atmospheric pressure by means of a scavenging pump and suitable check valves inserted in the drain lines and serves to return leakage and low-pressure fluid to the balancing pressure tank thereby retaining it in the system. Under certain conditions, however, fluid delivered to the drain system may exceed the capacity of the scavenging pump to return such fluid to the tank. The resulting back pressure on the jack piston and the control and pilot valves will then arise, hindering the general operation and if high enough causing a hydraulic lockout of the whole system.

In general, the object of this invention is the provision in a pumping jack system of the character described of a valve automatically responsive to any excessive pressure in the drain for establishing communication between the pressure and suction sides of the main pump.

2

Another object of this invention is to reduce the operation of the main pumping system when an abnormal condition occurs in the drain pumping system.

Another object of this invention is in general to improve pumping jacks.

The invention possesses other advantageous features, some of which with the foregoing will be set forth at length in the following description where that form of the invention, which has been selected for illustration in the drawings accompanying and forming a part of the present specification, is outlined in full. In said drawings, one form of the invention is shown, but it is to be understood that it is not limited to such form, since the invention, as set forth in the claims, may be embodied in a plurality of forms.

Referring to the drawings:

Fig. 1 diagrammatically illustrates a hydraulic jack system embodying the invention and shows the system in the upstroke position of the hydraulic jack.

Fig. 2 is a view similar to Fig. 1 but shows the system in the downstroke position of the jack.

Fig. 3 is an enlarged longitudinal section of the relief valve forming part of the system illustrated in Figs. 1 and 2.

In general, the system shown in these figures includes a hydraulic jack A, the piston of which carries a polished rod; a balancing pressure tank B, maintained at a pressure sufficient to produce a lifting load in the jack equal to the rod load plus one-half of the fluid load supported by the jack; a constant displacement main pump C capable of producing a pressure above the tank pressure sufficient to lift the rod weight plus the fluid weight, and also capable of reducing the pressure in the jack below the pressure in the balancing tank so as to permit the sucker rod to drop; a main control valve D, disposed between the main pump and the balancing pressure tank for alternately delivering fluid from the pressure tank to the hydraulic jack on the upstroke of the jack and then from the jack to the tank on the downstroke of the jack; a pilot valve E, responsive differentially and hydraulically to the terminal movements of the hydraulic jack piston for operating the main control valve; and a normally closed relief valve F for establishing communication between the discharge and suction of the main pump in response to any excessive pressure in the drain system.

As disclosed in Figs. 1 and 2, the hydraulic jack A includes a cylinder 1, with which is operatively associated a piston 2. Depending from the piston 2 through a suitable stuffing box in the lower end of the cylinder 1, is a polished rod 3, to which is fastened the sucker rod of an oil well pump. The cylinder 1 is provided on its lower end with a fluid inlet and outlet port 4 and at its upper end with a fluid outlet port 5 communicating through a check valve 6, a line 7 and a check valve 8 with an intake port 9 provided in the lower end of the cylinder above the port 4. Also provided in the upper end of the cylinder 1 are a pair of longitudinally spaced outlet drainage ports 11 and 12, communicating through a drain circuit including a line 13, a check valve 14, a line 15, a scavenging pump 16, a line 17, a check valve 18 and a line 19 with an intake port 21 provided in the lower end of the balancing pressure tank B.

The main pump C is of the constant displacement type, including a pair of opposed suction chambers 22 and 23 and a discharge compartment 24 with a discharge outlet 27 and with a relief valve outlet 28 communicating through the relief valve F with an inlet port 29 associated with the suction chamber 23.

The main control valve D is of the piston type including a main cylinder 32 provided with five longitudinally spaced annular channels 33, 34, 35, 36 and 37. Provided on either end of the valve D, coaxially with the main cylinder 32, are smaller cylinders 38 and 39. Operatively associated with the main cylinder 32 are a pair of longitudinally spaced pistons 41 and 42 mounted on a piston shaft 43, and carried on the ends of the shaft 43 are pistons 44 and 45 operatively associated with the cylinders 38 and 39. The simultaneous movement of the pistons 41, 42, 44 and 45 from their positions as shown in Fig. 1 to the positions shown in Fig. 2 is effected through the pilot valve E in a manner which will be described later in connection with the description of the valve E. The annular channel 36 communicates through a port 36*a*, a line 46 and a line 47 with a port 47*a* provided in the lower end of the tank B. Fluid from the tank B passes through the port 47*a*, the line 47, the line 46, and the port 36*a* into the channel 36. From this channel the fluid passes into the channel 37, through a port 37*a* associated with the channel 37 and through a line 48 and the inlet port 26 into the suction chamber 23. The line 48 communicates through a line 49 with a line 51 which, in turn, communicates with the inlet port 25 of the suction chamber 22 and with a port 33ª associated with the annular chamber 33. It will, therefore, be seen that the fluid passing through the channels 36 and 37 of the main control valve will be delivered to both of the suction chambers 22 and 23 of the main pump C. The main pump C then delivers this fluid through its outlet port 27, through a line 52 and a port 35*a* associated with the channel 35 into the channel 35. From the channel 35, the fluid passes through the channel 34, through a port 34*a* associated with this channel and through a line 53 and the port 4, into the lower end of the cylinder 1. In this position or condition of the hydraulic circuit the main pump C operates to pass fluid from the tank B through the main control valve D into the lower end of the cylinder 1, thereby to raise the piston 2.

Any fluid which may have moved upwardly past the piston 2 is delivered through the ports 11 and 12, the line 13, the check valve 14, the line 15, the scavenging pump 16, the line 17, the check valve 18, and the line 19 through the port 21 associated with the lower end of the tank B into the tank B. This drain circuit thus returns such fluid to the tank B as a reservoir. In this connection, it should be noted that the scavenging pump 15 is operated so as normally to maintain substantially atmospheric pressure on the check valve 14 and in the line 15.

When the piston 2 rises above the port 5, fluid under the main pump pressure passes through the port 5, the check valve 6, the upper portion of the line 7, and the line 54 to the left end port 55 associated with the pilot valve E.

The pilot valve E is of the same type as the main control valve D, and includes a main cylinder 56 with which are operatively associated three longitudinally spaced coaxial pistons 57, 58 and 59, fastened to a common shaft 61. Formed on the right end of the pilot valve E is a cylinder 62 of a smaller diameter than the main cylinder 58 and provided with an outlet port 63. Operatively associated with the cylinder 62 is a piston 64, fastened to or forming a continuation of the right end of the shaft 61. Communication between the port 63 and the port 36*b* associated with the channel 36 of the main control valve D, is established by a line 65. With the main valve in the position as shown in Fig. 1, fluid from the tank B is delivered from the channel 36 through the line 65 to the smaller cylinder 62. However, since the area of the piston 64 is less than the area of the piston 57, the fluid pressure in the line 54 will cause the pistons 57, 58, 59 and 64 to move to the right to assume the position shown in Fig. 2.

With the pilot valve E in the position as shown in Fig. 2, and the main control valve in the position as shown in Fig. 1, fluid under tank pressure passes upwardly through the line 46, the port 36*b*, the line 66, the valve E and the line 67 into the left end cylinder 38 of the main valve D to force the pistons 41, 42, 44 and 45 to the right, as shown in Fig. 2. Due to the right hand movement of the piston 45, fluid contained in its cylinder 39 passes through a drain circuit including a line 68, the pilot valve E, and a line 69, line 71, to the drain line 15 from which the pressure is increased by the scavenging pump 16 sufficient to restore the fluid to the bottom of the tank B through the check valve 18.

With main valve D, as well as pilot valve E, in the positions as shown in Fig. 2, the main pump C operates to draw liquid from the lower end of the hydraulic jack cylinder 1, through the port 4, upwardly through the line 53, through the intercommunicating ports 34*a* and 33*a* of the main control valve D, and into the suction chambers 22 and 23 of the main pump. The main pump then operates to deliver this fluid from its discharge compartment 24 through the intercommunicating ports 35*a* and 36*a* of the main control valve D, the line 46 and the port 47*a* to the lower end of the balancing tank B.

When the piston 2 of the hydraulic jack passes the port 5 on its downward stroke, no effect is produced on the pilot valve E because the check valve 6 does not permit the flow of fluid back into the cylinder 1. When, however, the piston 2 passes the port 9 on its downward stroke, the port 55 of the pilot valve E is placed in communication through line 7, the line 54, the check valve 8, the cylinder 1, the line 13, the check valve 14, the scavenging pump 16 and the check valve 18

with the lower end of the tank B. Concurrently, the right hand end of the small piston 64 of the pilot valve is subject to tank pressure through the interconnecting ports 36b and 36a of the main control valve D and through the line 65. Since at this point in the cycle of operation the left end of the piston 57 is under the influence of substantially atmospheric pressure, the tank pressure on the piston 64 moves it to the left, whereby the pilot valve E assumes its original position as shown in Fig. 1. In this latter position, or condition of the system, fluid under tank pressure passes through the lines 47 and 46, the intercommunicating ports 36a and 36b of the main valve, the line 66, the intercommunicating ports 73 and 72 of the pilot valve and the line 68 to the right end cylinder 39 of the main valve. Since the left end piston 44 of this valve is now in communication with the drain system through the line 67, the intercommunicating ports 74 and 75 of the pilot valve, the line 69 and the line 71, the tank pressure on the piston 45 results in moving this piston and its associated pistons to the left to assume their original position as shown in Fig. 1. The system so far described is in condition to repeat the complete cycle of operation as above disclosed.

The valve F comprises a flanged section 76 provided with a port 77, communicating through a line 78 with the port 28 of the main pump C, and with a port 79, communicating through a line 81 with the port 29 of the main pump. Connected to the flanged section 76 is a central section 82 provided with a port 83, communicating through a line 84 and a three-way valve 85 with the line 71, and with a port 86 communicating through a check valve 87, with the three-way valve 85 and through a relief valve 88 and a line 89 to an atmospheric drain. Threaded to the central section 82 is an end section 91 forming a cylinder 92 for the reception of a hollow piston 93. Provided intermediate the ends of the piston 93 is a section 94 of enlarged diameter, operatively associated with a cylinder 95 formed in the central section 82. Disposed within the piston 93 and seated against its lower closed end 96 is a spring 97. Seated on the upper end of the spring 97 is a flanged ring 98 formed with a central opening 99, and contacting the ring 98 is an adjustment screw 101 extending through the upper end of the piston 93 and threaded through the upper end of the casing section 91. The casing section 76 is provided intermediate its ports 77 and 79 with a seat 102 on which the lower end 96 of the piston 93 seats normally to close off communication between the ports 77 and 79.

The piston 93 is formed with ports 100 which provide communication between the port 79 and the end of the cylinder 92 above the piston end 96. Accordingly, as long as operating conditions are normal, the opposite sides of piston 93 are subjected to the differential pressure of the main pump C. As the main pump discharge is normally always above the main pump suction pressure, the piston 93 is maintained in its closed position under normal operation by means of the spring 97. If the operating differential on the main pump C exceeds normal limits, the valve will open so as to by-pass fluid from the port 77 to the port 79 and thereby relieve the excessive pressure.

In addition to normal relief valve operation, added protective features are incorporated in the valve through the connection from the port 83

to the drain line 15 so that if excessive pressure should develop in the drain line 15, that pressure will be exerted on the lower side of the piston section 94 so as to overcome the hydraulic and spring balance of the piston 93 and thereby elevate the piston to establish communication between the pressure and suction sides of the main pump C. This reduces the effective displacement of the main pump C slowing the main hydraulic system while allowing the scavenging pump 16 to carry away the excess drainage at its normal rate. As the excess is removed, the drain pressure falls gradually to restore the system to normal operating conditions as the valve F slowly closes in response to the pressure drop due to the gradual removal of the excess oil from the drain system. A hydraulic lockout of the entire mechanism is thereby forestalled by slowing up operation of the main pumping system until the abnormal condition that would otherwise produce a lockout is overcome.

I claim:

1. A hydraulic pumping jack system comprising: a hydraulic jack; a balancing pressure tank; a pumping system having a pump for delivering fluid alternately from said tank to said jack on the upstroke of said jack and from said jack to said tank on the downstroke of said jack; a drain system for returning drain fluid from the hydraulic jack and pumping system to said tank at a predetermined pressure; a normally closed valve disposed between the low and high pressure sides of said pump; and means for opening said valve in response to abnormally high pressures in said drain system to establish communication between the discharge and suction sides of said pump.

2. A hydraulic pumping jack system comprising: a hydraulic jack; a balancing pressure tank; a pumping system having a main pump for delivering fluid alternately from said tank to said jack on the upstroke of said jack and from said jack to said tank on the downstroke of said jack; a drain system including a scavenging pump for returning drain fluid from the hydraulic jack and pumping system to said tank at a predetermined differential pressure; and a normally closed relief valve connected to the low and high pressure sides of said main pump, said valve being responsive to an excessive scavenging pump differential pressure so as to establish communication between the discharge and suction sides of said main pump.

3. A hydraulic pumping jack system comprising: a hydraulic jack; a balancing pressure tank; a pumping system having a pump, and a control valve in circuit with said pump, said tank and said jack and effective in one position to connect said pump to deliver fluid from said tank to said jack during the upstroke of said jack and in another position to connect said pump to deliver fluid from said jack to said tank during the downstroke of said jack; a drain system for delivering drain fluid from said jack and said pumping system to said tank at a predetermined pressure; and a valve responsive to an excessive pump differential pressure and to pressures in said drain system in excess of said predetermined pressure for establishing direct communication between the high and low pressure sides of said pump.

4. A hydraulic pumping jack system comprising a hydraulic jack; a balancing pressure tank; a hydraulic circuit interconnecting said jack and said tank; a pump in said circuit for interchang-

ing fluid between said jack and said tank; a drain circuit for conducting fluid from said hydraulic circuit to said tank; and means responsive to pressure in said drain circuit for reducing the interchanging of said fluid by said pump.

5. A hydraulic pumping jack system comprising a hydraulic jack; a hydraulic reservoir; a hydraulic circuit for interconnecting said jack and said reservoir; a main pump in said hydraulic circuit; a drain circuit for conducting fluid from said hydraulic circuit to said reservoir; a relief valve responsive to pressures in said hydraulic circuit for connecting the outlet of said main pump directly to the inlet thereof; and means responsive to pressures in said drain circuit for augmenting the effect of pressures in said hydraulic circuit upon said valve.

6. A hydraulic pumping jack system comprising a hydraulic jack; a hydraulic reservoir; a

main pumping circuit for the circulation of fluid between said reservoir and said jack and from which drain fluid flows; a drain pumping circuit for restoring said drain fluid to said reservoir; and means responsive to excessive drain fluid in said drain pumping circuit for reducing said circulation in said main pumping circuit.

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