Nov. 11, 1952 I. M. WHITE 2,617,256

HYDRAULIC PUMPING JACK CONTROL

Filed June 12, 1948 2 SHEETS—SHEET 1

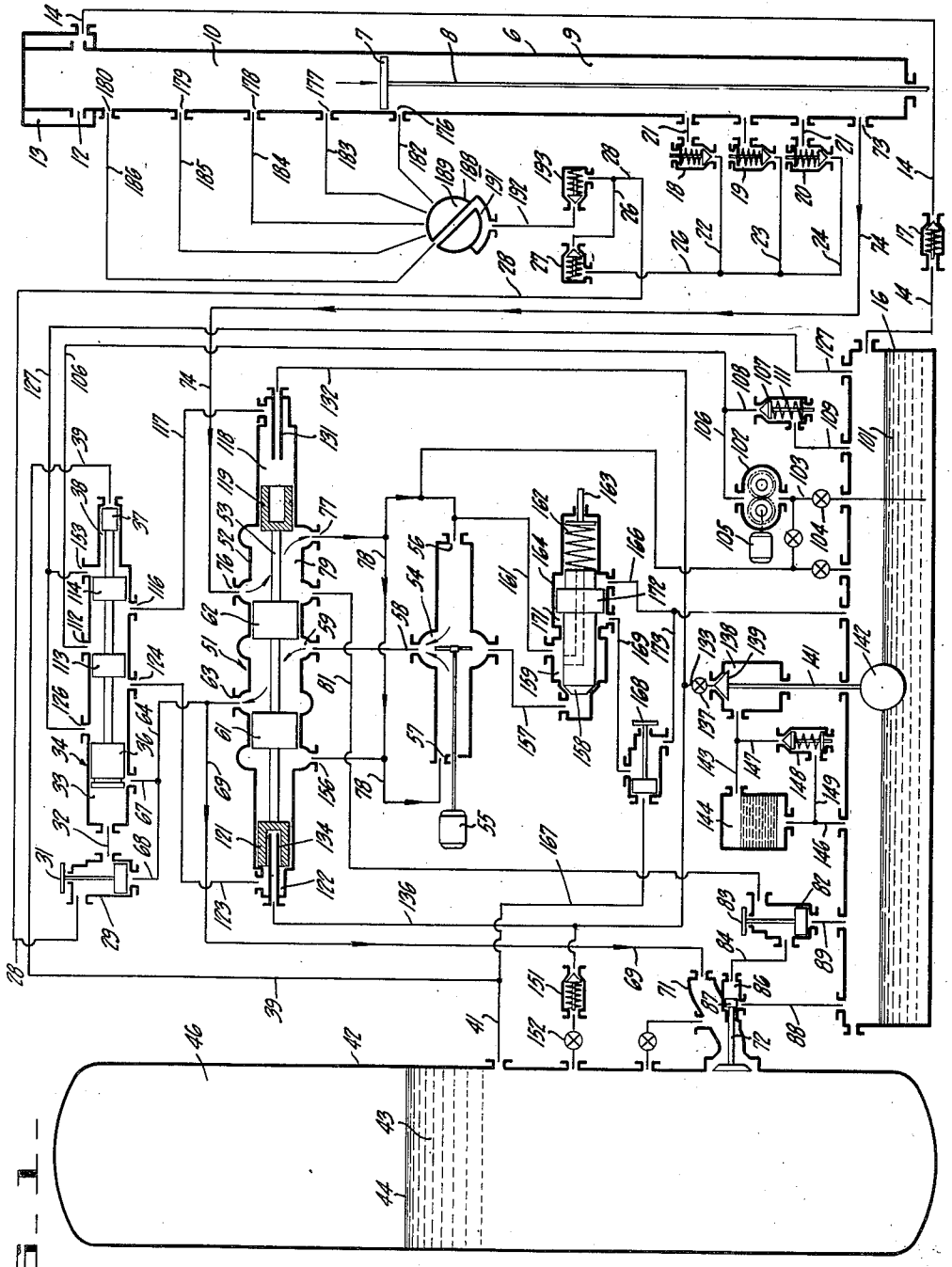

FIG. 1

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HYDRAULIC PUMPING JACK CONTROL

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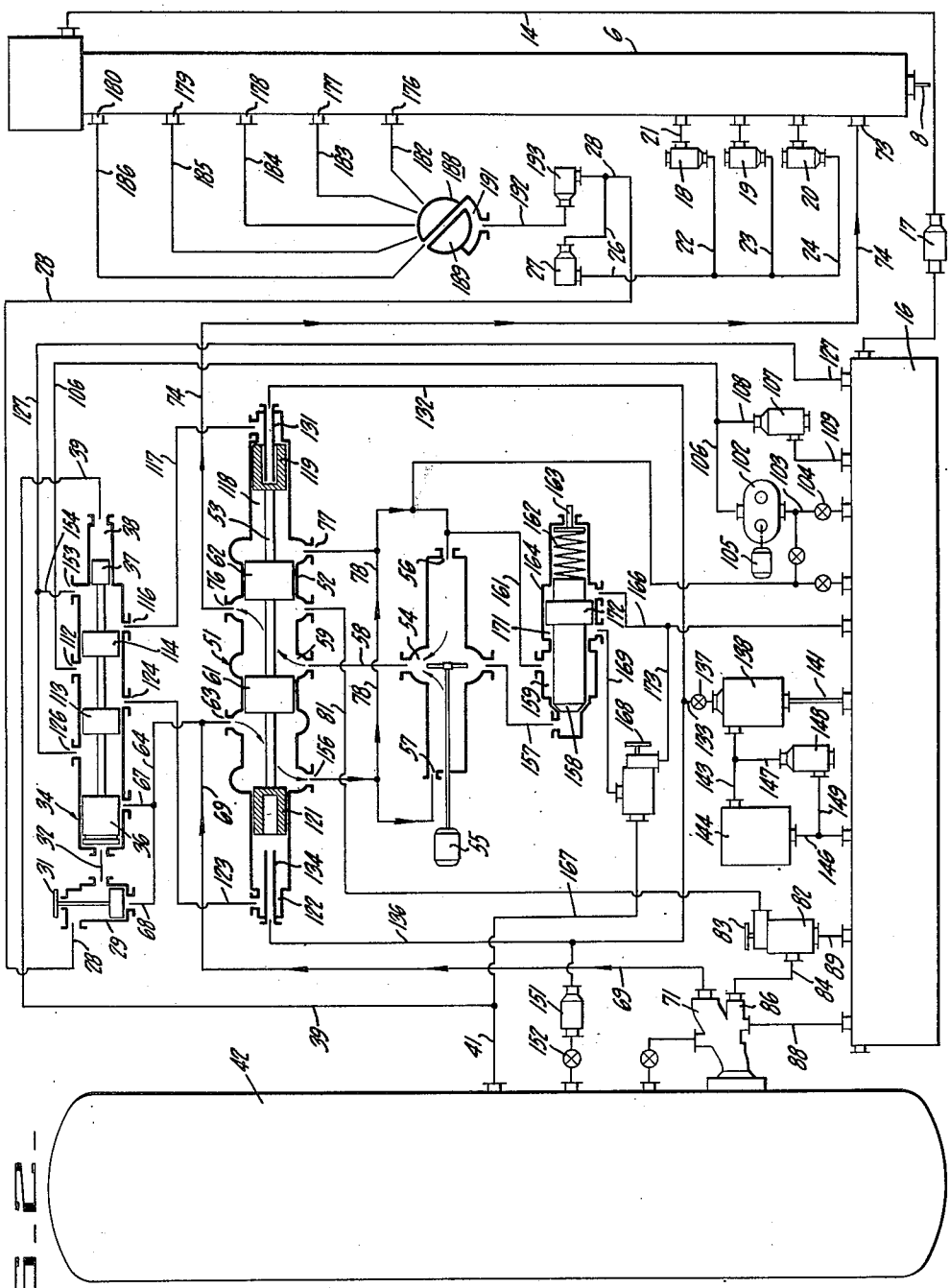

FIG. 2

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UNITED STATES PATENT OFFICE

2,617,256

HYDRAULIC PUMPING JACK CONTROL

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Application June 12, 1948, Serial No. 32,629

7 Claims. (Cl. 60—52)

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My invention relates to hydraulic pumping jacks including mechanism adapted to be attached to a deep well pump for reciprocating the pump rod in a carefully controlled manner. Hydraulic pumping jacks are coming increasingly into successful use as oil wells need to be pumped in increasingly great depths. The pump is located adjacent the bottom of the well, perhaps ten or eleven thousand feet from the surface, while the jack itself is located at the surface and the jack and pump are then interconnected by an extensive metallic rod. It has been found by protracted experience that this rod because of its metallic and consequently somewhat elastic nature, is prone to break if excessive stress is imposed upon it. A breakage of the sucker rod is of great financial consequence, not only because of the loss of pumping time, but also because of the difficulty in recovering or retrieving the broken mechanism and its replacement or repair. It therefore is highly important to provide a very close and careful regulation of the operation of the jack with respect to the sucker rod so that strain over an allowable amount does not occur. It has likewise been found in practice that while one mechanical arrangement may operate quite satisfactorily under some conditions of operation, especially under some temperature conditions of operation, it may not be entirely satisfactory under other temperature conditions. In hydraulic jacks, the working fluid is an oil, the viscosity of which varies with temperature. The pumping jacks are installed often in remote locations and are completely exposed to the atmosphere so that they function at ambient temperatures, for example from below 40 degrees to 115 or more degrees Fahrenheit. Even under these conditions, substantial variations in the application of force to the sucker rod are not permissible.

It is therefore an object of my invention to provide a hydraulic pumping jack in which the control of the jack is substantially the same under all operating conditions.

An additional object of the invention is to provide a hydraulic pumping jack control which is reliable under operating conditions to produce the desired or predetermined operation of the jack mechanism.

An additional object of the invention is to provide a timing means for regulating the operation of the pumping jack somewhat independently of the reciprocation of the jack itself.

A further object of the invention is in general to improve pumping jacks and especially their control mechanisms.

A further object of the invention is to provide

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a pumping jack control system which can readily be varied in timing by a simple variation in the structure.

Another object of the invention is to provide a pumping jack which is consistent in its operation over wide ranges in temperature and other operating conditions and yet is of a type which is generally acceptable.

Other objects together with the foregoing are attained in the embodiment of the invention described in the accompanying description and illustrated in the accompanying drawings in which:

Figure 1 is a diagram showing a pumping jack control mechanism in accordance with my invention and disposed in one extreme position, most of the parts included in the diagram being disclosed in cross-section on median planes.

Figure 2 is a view similar to Figure 1 but showing the mechanism in a different extreme position with some of the parts being shown diagrammatically in side elevation rather than in cross-section.

In its preferred form the pumping jack control system of my invention comprises an actuating cylinder adapted to be reciprocated between extreme positions and to be connected by a sucker rod to the pump. The cylinder or jack is connected to a balancing tank containing operating oil and air and is alternately supplied with or deprived of oil through an oil pump and valve structure which is effective to impart opposite directions of reciprocation to the pumping jack. The hydraulic system includes a main valve for governing flow to and from the jack, the main valve itself being operated in response to the functioning of a pilot valve. The pilot valve is provided with a supply of operating fluid, not from the main pump but rather from an auxiliary pump so that flow to operate the main valve through the pilot valve is in response to the operation of the auxiliary pump.

While the pumping jack and control can be incorporated in numerous different ways and can incorporate sundry variations depending upon the environment in which it is to be particularly utilized, it has been satisfactorily and successfully embodied in commercial use substantially as diagrammatically disclosed herein.

As first shown in Figure 1 in which the mechanism is undergoing a downward movement, there is provided a pumping jack cylinder which is appropriately mounted and is of the general type shown in my co-pending application filed October 30, 1945, Serial No. 625,502, now Patent

No. 2,562,837 issued July 31, 1951. Within the elongated cylinder 6 is a reciprocable piston 7 connected to a polish rod 8 extending from the cylinder at its lower end and connected to a pump, not shown, disposed many feet below the piston 7 in an oil or comparable well. As the piston 7 descends, it carries the weight of the connected pump and rod with it and consequently presses with such weight upon a body of oil in the compartment 9 below the piston. However above the piston 7, the compartment 10 is subject to substantially atmospheric pressure, since it is connected through apertures 12 with an overflow chamber 13 joined by a pipe 14 to the upper portion of an auxiliary oil tank 16. A check valve 17 is interposed in the pipe 14 so that no sub-atmospheric pressure can be imposed upon the tank 16, but so that the pressure in the chamber 10 cannot greatly exceed atmospheric.

As the piston 7 descends, it eventually uncovers one of a group of stroke-limiting valves 18, 19 and 20 respectively, which are all substantially identical and which are connected to the cylinder 6 by interposed pipes 21. The valves 18, 19 and 20 are manually controlled and but one of them at a time is left open. The others remain closed. Consequently, the open one of the valves is effective to communicate the pressure conditions within the cylinder 6 through any one of the lines 22, 23 and 24 to a connecting line 26. In the line 26 is a check valve 27 which permits flow in the direction of the cylinder 6 but not in the contrary direction. The pipe 26 is itself joined to a duct 28 that continues to a valve 29 carrying a handle 31 so that the valve can be variously positioned. In the location shown in Figure 1, the valve 29 affords access from the pipe 28 through a pipe 32 with a chamber 33 at one end of a pilot valve generally designated 34.

Within the pilot valve, there is a valve bobbin 36 reciprocable between the extreme right hand position shown in Figure 1 and an extreme left hand position shown in Figure 2. At the right hand end of the pilot valve and opposite to the bobbin 36 is a relatively smaller bobbin 37, operable in a chamber 38 connected by a conduit 39 to a pipe 41, extending into the side of a storage or balancing tank 42. This tank has a body of jack operating oil 43 in the lower portion thereof and extending to a convenient level 44 and in the upper part contains a body 46 of air. Since the oil 43 is under pressure, the air 46 is likewise under pressure, and this pressure is conveniently an average or mean pressure between the load on the jack piston 7 when it is going up and the load upon it when it is going down.

The result of this mechanism as so far described is that the bobbin 37 has a relatively high or tank pressure exerted upon it, while the bobbin 36 is subject to the lower pressure in the compartment 33 emanating from the chamber 9, the pressures differing by the pump increment. Since the bobbin 36 is larger than the bobbin 37, the auxiliary valve or pilot valve occupies its right hand position as shown in Figure 1. When, however, the piston 7 uncovers whichever one of the valves 18, 19 and 20 is operative, the high pressure below the piston gives way to the substantially atmospheric pressure above the piston and this then permits the chamber 33 to discharge through the pipe 32 and the valve 29 and through the conduit 28 and the check valve 27 to the chamber 10 above the piston. Since the pressure on the auxiliary valve through the pipe 39 from the tank 42 onto the bobbin 37 still exists, the bobbin is immediately transferred to its other extreme position as shown in Figure 2, and a different portion of the cycle of events takes place.

But prior to the actual shifting of the auxiliary or pilot valve from its Figure 1 position into its Figure 2 position, and while the valve is in its Figure 1 position, it governs the operation of a main valve, generally designated 51. The main valve itself comprises a housing 52 having a shuttle, generally designated 53, reciprocable therein between two extreme positions as shown in Figures 1 and 2, the shuttle being in its left hand extreme position in Figure 1 and is in its right hand extreme position in Figure 2. The purpose of the main valve is to direct oil flow to and from a pump 54. This is the main actuating oil pump and is driven by a relatively heavy source of power such as an independent internal combustion engine or a relatively large electric motor 55. The pump transfers oil from two pump inlets 56 and 57 through a discharge pipe 58 into a median port 59 in the housing of the main valve 51. When the valve shuttle is positioned as shown in Figure 1, oil flows through the housing 51 between valve lands 61 and 62 therein and discharges through an outlet 63. One branch 64 of the outlet is blocked to oil flow since the bobbin 36 occupies one of its connections 67 and the hand valve 29 occupies its other connection 68. The only other path for the oil is through a conduit 69 extending to an inlet fitting 71 on the tank 42. This fitting is substantially the same as shown in my said Patent No. 2,562,837. The effect of the fitting 71 in its normal position with its poppet valve 72 open, is to permit flow of liquid back into the tank 42.

In this position of the structure, the pump 54 drives the oil flowing into its inlets 56 and 57 from the lower end of the jack cylinder 6. A port 73 in such cylinder is connected by a conduit 74 to an opening 76 in the casing 51 of the main valve and in the position of the valve, shown in Figure 1, flow occurs through such valve into an outlet opening 77 joined by a loop pipe 78 to the two inlets 56 and 57. The pressure imposed upon the chamber 79 of the main valve is carried by a duct 81 through a hand valve 82 provided with a manual control 83 to a pipe 84 connected to a chamber 86. Therein it is effective upon a piston 87 fixed on one end of the poppet valve 72 and normally urges such valve open. A drain line 88 extends from the chamber 86 and a drain line 89 extends from the valve 82 to the tank 16. Thus in the position of the parts shown in Figure 1, the piston 7 descends because the motor or engine driven pump 54 withdraws oil from beneath the piston and transfers it into the tank 42. Yet, as previously described, when the piston travels over the operative one of the valves 18, 19 or 20, the cycle is interrupted by the shifting of the auxiliary or pilot valve and the main valve correspondingly is shifted to reverse the flow and send it in the opposite direction as will appear from the description of Figure 2.

The reversal of the main valve under the control of the pilot valve is effectuated by a novel mechanism not immediately or directly dependent upon the hydraulic system which interconnects the pump 54, the jack cylinder 6 and the storage or balancing tank 42. In accordance with this invention, the hydraulic fluid 101 within the auxiliary tank or drainage or scavenge tank 16 is utilized for this purpose. To this end, I provide an auxiliary oil pump 102, located near

the tank 16 and connected to it through a conduit 103 in which a hand valve 104 is disposed. The pump 102 is a pump of the positive displacement type. It is not a centrifugal pump or a pump which has a variable or undetermined amount of slip. Rather it is a pump which is of the metering or predetermined displacement type so that the amount of oil flowing through it in a given time at a known speed is known or established.

There are various ways of regulating the output or effective output of the auxiliary pump 102. The pump 102 can be driven by the motor 55 or it can be run by a separate source of power 105, itself readily controllable. In either case the auxiliary pump 102 discharges a measured or predetermined amount of liquid under all usual operating conditions. The pump 102 is usually operated upon the same liquid utilized elsewhere in the hydraulic system. When a change in temperature and a corresponding change of viscosity occurs in the main body of oil 43 used directly to actuate the pumping jack, there may be a similar and quite comparable change in viscosity of the oil passing through the pump 102. All structures depending for their timing upon the rate of oil flow through pipes or orifices likewise vary and may vary differently so that their relative timing is changed, and the jack reversal points change erratically. But all mechanisms responsive to the quantity of oil displaced by the auxiliary pump 102 operate at the same relative point as before despite the viscosity change. If, for example, the oil viscosity decreases due to a general rise in temperature, the pump 54, largely because of orifice effects, is effective to discharge at a faster rate. When the pump 102 is driven in synchronism with the pump 54, it also, due largely to orifice effects also discharges at a faster rate, but the relationship of the timing is retained so that the reversal points remain the same, and the jack piston maintains its stroke length in the cylinder.

Oil discharged from the pump 102 passes into a line 106. A relief valve 107 is disposed between the line 106 and the tank 16 by ducts 108 and 109, respectively, and is preferably provided with a pressure spring 111 so that the pressure within the line 106 can be set at a maximum value and excessive pressure will be bled off to the auxiliary tank 16. Oil flowing through the pipe 106 continues at not to exceed a maximum pressure to a port 112 in the housing of the auxiliary valve. In the position of the valve shown in Figure 1, this oil travels from the port 112 between lands 113 and 114 to an outlet port 116 from whence it flows through a conduit 117 into a chamber 118 at one end of the main valve 51. Pressure within the chamber 118 is effective upon a plunger 119 at one end of the bobbin 53 and is therefore effective to maintain or translate the bobbin into its left hand position as shown in Figure 1, providing the pressure at the other end of the bobbin is suitable.

When the bobbin is disposed as shown in Figure 1, the plunger 121 at its opposite end within the chamber 122 is in communication by means of a pipe 123 with a port 124 in the auxiliary valve casing. This is disposed between the lands 36 and 113 in the right hand position of the auxiliary valve. Flow from the port 124 is through the auxiliary valve between the lands 36 and 113 out through a port 126 into a line 127 leading back to the auxiliary tank 16. Since the tank 16 is normally maintained under atmospheric pressure, the chamber 122 is likewise subject to atmospheric pressure. The superior pressure within the chamber 118 is effective to situate the main valve as shown in Figure 1.

The only other possible means for variation of the pressure within the chambers 118 and 122, arises out of certain connecting lines. Extending into the chamber 118 is a sleeve 131 communicating through a line 132 with a pipe 133. Similarly a sleeve 134 extends into the compartment 122 and is connected by a line 136 to the pipe 133. A manual valve 137 governs flow into a valve casing 138, within which a poppet valve 139 is disposed. The lower end of the poppet valve is connected by a stem 141 to a float 142 operating in the body of oil 101 within the tank 16. When the float 142 is high because the oil level in the tank 16 is high, the poppet 139 is closed and the only possibility of flow from either of the chambers 118 or 122 is into the tank 42. When, however, the oil level 101 is low, the float 142 drops, the poppet 139 opens and if the hand valve 137 is open, as it normally is, oil can flow from either of the chambers 118 or 122 into the tank 16 as makeup. The actual flow of oil from the valve housing 138 is through a pipe 143 and thence through a filter 144 and a final pipe 146 into the tank. If the filter is clogged and its resistance is great, flow is alternatively through a line 147 and a relief valve 148 and a connecting line 149.

In this way a level of liquid is maintained in the auxiliary tank 16 so that there is always adequate oil for the pump 102 to actuate the pilot valve and produce a constant effect upon the main valve. That is, when the pilot valve shifts to an extreme position, for example as shown in Figure 1, and the auxiliary pump 102 supplies oil through the pilot valve to the chamber 118 in order to shift the main valve, the rate at which the main valve shifts depends entirely upon the output of the auxiliary pump 102 which in turn is related to the rate at which the main body of oil flows from the cylinder 6 through the main pump 54 and into the tank 42. The motion of the main valve is independent of the temperature or viscosity or other variable characteristics of the oil flowing through the main valve. Rather, it is responsive only to the operation of the auxiliary pump. Since this is a metering or positive displacement pump, the motion of the main valve is precisely regulated despite fluctuations in operating conditions.

After the piston 7 has uncovered one of the ports 21 and has caused a shift in the position of the auxiliary valve, the valve occupies the location shown in Figure 2. Then flow from the auxiliary pump 102 is directed through the port 112, not into the port 116 any longer, but rather into the port 124 and into the line 123 so that a pressure is exerted through it upon the chamber 122. This pressure likewise is communicated through the duct 136, to provide makeup oil if required, although if it is excessive in amount, it opens a relief valve 151 so returning excess to the main tank 42 in the event a manual valve 152 is open as it normally is. The pressure exerted in the chamber 122 is effective to overcome the pressure within the chamber 118. The same shift of the auxiliary valve which permits the pressure to be exerted upon the chamber 122, likewise connects the port 116 with a port 153 in the auxiliary valve housing joined by a pipe 154 with the duct 127, the drain line returning to the atmospheric pressure tank 16. Extra or dis-

charge fluid from the chamber 118 returns to the tank 16 and the main valve readily makes its shift into the opposite extreme position. In this opposite extreme position, the two lands 61 and 62 span the ports 59 and 76, so that the flow is then from the outlet of the pump 54 under pressure through the line 74 and the port 73 into the bottom of the cylinder 6 beneath the piston 7. Since this is high pressure, it lifts the piston 7 and the sucker or polish rod 8.

During the time that the piston 7 is rising, the main pump 54 is driven to withdraw oil from the tank 42 through the open poppet valve 72 and the duct 71 and then upwardly (in Figure 2) through the line 69 to the port 63. The flow then is through the main valve body between the plunger 121 and the land 61 and out through a port 156 into the line 78 communicating with both of the pump inlets 56 and 57. The flow is then outwardly from the pump through the line 58 into the port 59 and to the jack cylinder 6.

If during the pump operation the pressure differential between the pump inlets and the outlet 54 should be excessive, it is relieved. The outlet pressure is exerted through a line 157 upon a poppet relief valve 158 to displace the valve toward the right in Figure 2, thus uncovering an opening into a chamber 159, affording a short circuit through a conduit 161 to the pipe 78, and allowing the excess oil to flow back to the pump inlet 56. In this way differential pressure is prevented from exceeding a set value. The amount of pressure difference is established by a coil spring 162 provided with a regulator 163 so that the spring is effective upon the plunger 158.

Leakage and drainage from the casing 164 enclosing the relief valve flows to the auxiliary oil tank 16 through a line 166, and means are provided for actuating the poppet valve 158 other than by excessive pressure within the pump outlet 54. A pressure line 167 is connected to the line 41 in communication with the body of oil 43 within the tank 42. Normally this pressure is kept from the pressure relief valve by a hand valve 168, but when the hand valve is opened to a position opposite that shown in Figure 1, pressure fluid flows through a line 169 into a chamber 171 in the relief valve and it then displaces an enlarged piston 172 to the right (as seen in Figure 2) against the urgency of the spring 162.

When the valve 158 is to be restored to its former position, the valve 168 is shut. This action then affords communication between the line 169 and a drain line 173 joined to the line 166 and leading back to the auxiliary tank 16. When the valve 168 is shut, the pressure fluid in the chamber 171 discharges to atmospheric pressure and the poppet valve 158 shuts under the superior urgency of the spring 162. The manual control of the relief valve is provided for starting and emergency purposes and normally the spring-pressed valve 158 automatically controlls excessive pressure. Thus the piston 7 is driven upwardly by the operation of the main pump 54 at a controlled rate since the pressure of the oil cannot be excessive.

As the piston 7 ascends in the upper portion of its stroke, it passes over a series of control apertures 176, 177, 178, 179 and 180 inclusive. Each of these apertures is appropriately connected by a suitable duct 182, 183, 184, 185 and 186 to an upper stroke limit control valve 188. In the event this valve is ineffective, the piston 7 rises over all of the apertures and finally uncovers the aperture 12 so that the pressure oil beneath it escapes immediately through the duct 14 and the check valve 17 to the auxiliary tank 16. This is an emergency overtravel safety device and normally does not come into operation.

Normally the upper stroke limit control valve 188 is arranged so that a rotatable plug 189 therein is disposed in any one of five selected positions. Each of these positions is in alignment with any selected one of the ducts 182, 183, 184, 185 and 186 and establishes communication with such duct and a common communication conduit 191. Joined to the casing of the valve 189 is a pipe 192 leading through a check valve 193 to the pipe 28. In any one of the selected positions of the selector valve 189, the piston 7 uncovers the appropriate one of the apertures 176, 177, 178, 179 or 180 and permits pressure fluid then to flow through the selector valve and through the collector conduit 191 into the pipe 192. That pressure opens the check valve 193 and imposes pressure through the line 28 and the valve casing 29 upon the spool 36 of the pilot valve. The pressure so exerted within the compartment 33 translates the auxiliary valve from its position shown in Figure 2 toward the right into its position shown in Figure 1. During this time the chamber in which the plunger 37 is disposed is connected through one line 39 to the balancing tank 42.

During the upstroke of the piston 7, the pump 54 maintains a pressure within the cylinder 6 in excess of the pressure within the balancing tank 42. The area of the spool 36 being several times the area of the plunger 37, a prompt translation of the auxiliary valve occurs as soon as the piston 7 rises above whichever of the cylinder apertures is in communication through the selector valve 188 with the auxiliary valve housing.

When the auxiliary valve is so translated, the auxiliary pump 102 is then effective to discharge liquid at a predetermined or set rate through the inlet port 112. Instead of continuing through the outlet port 124 to the left hand end of the main valve, it immediately is shifted to flow between the lands 113 and 114 into the outlet port 116 and so to the right hand end of the main valve. This translates the main valve from its right hand position (shown in Figure 2) back into its left hand position as shown in Figure 1. The speed of the translation or return of the main valve back to its original position is, however, entirely dependent upon the speed of operation of the auxiliary pump 102, so that the reversal of motion of the main piston 7, in changing from its up-stroke back to its down-stroke is at a corresponding rate. This is substantially independent of oil viscosity and of temperature conditions and hence imposes no more than the designed or predetermined stress upon the pump or sucker rod 8.

When the motion has been reversed at the upper end of the stroke, the parts are restored to their initial positions as the piston 7 descends. This is because fluid is again transferred by the main pump 54 from the cylinder 6 back into the balancing tank 42. The motion reversal repeats as the piston 7 moves nearer the lower end of the cylinder and in turn uncovers the effective one of the ducts 21. The complete cycle is inclusive of two reversals, one at the top and one at the bottom of the stroke. Both of the reversals are governed as to speed or rate of accomplishment by the speed or rate of displacement of the auxiliary pump and are suitably controlled by an independent means,

that is, the pump 102, whether it is driven by the motor 55 or a separator motor 105, and are independent of random variations which otherwise produce erratic and undesired operation of the pumping jack.

I claim:

1. A hydraulic pumping jack control comprising a jack cylinder, a first oil pump, means for connecting said pump to pump oil alternatively into or out of said cylinder, a hydraulic displacement device having an unobstructed inlet and an unobstructed outlet and actuated by hydraulic fluid for operating said connecting means, and a positive displacement second oil pump for supplying hydraulic fluid to said hydraulic displacement device at a predetermined rate.

2. A hydraulic pumping jack control comprising a jack cylinder, a first oil pump having an inlet and an outlet, a valve casing, means connecting said casing with said inlet and said outlet, a conduit connecting said casing with said cylinder, a valve in said casing for connecting said conduits to said inlet connecting means or said outlet connecting means, a hydraulic displacement device having an unobstructed inlet and an unobstructed outlet for operating said valve, and a positive displacement second oil pump for operating said hydraulic displacement device at a predetermined rate.

3. A hydraulic pumping jack control comprising a jack cylinder, a first oil pump having an inlet and an outlet, means for interconnecting said first pump and said cylinder, said means including a valve in a first position connecting said cylinder and said inlet and in a second position connecting said cylinder and said outlet, a hydraulically expansible device having an unobstructed inlet and an unobstructed outlet for moving said valve between said positions, a positive displacement hydraulic second pump, means for driving said second pump at a predetermined rate, and means for hydraulically connecting the outlet of said second pump to said hydraulically expansible device.

4. A hydraulic pumping jack control comprising a jack cylinder, a first oil pump having an inlet and an outlet, means for interconnecting said first pump and said cylinder, said means including a valve in a first position connecting said cylinder and said inlet and in a second position connecting said cylinder and said outlet, a hydraulically expansible device having an unobstructed inlet and an unobstructed outlet for moving said valve between said positions, a positive displacement hydraulic second pump, means for driving said second pump at a predetermined rate, means including a pilot valve for hydraulically connecting the outlet of said second pump to said hydraulically expansible device, and means responsive to pressure in said cylinder for operating said pilot valve.

5. A hydraulic pumping jack control comprising a jack cylinder, a piston in said cylinder, a first oil pump having an inlet and an outlet, means for interconnecting said first pump and said cylinder beneath said piston, said means including a valve in a first position connecting said cylinder and said inlet and in a second position connecting said cylinder and said outlet, a hydraulically expansible device having an unobstructed inlet and an unobstructed outlet for moving said valve between said positions, a positive displacement hydraulic second pump, means for driving said second pump at a predetermined rate, means including a pilot valve for hydraulically connecting the outlet of said second pump to said hydraulically expansible device, and means responsive to the position of said piston in said cylinder for operating said pilot valve.

6. A hydraulic pumping jack control comprising a jack cylinder, a first hydraulic pump having an inlet and an outlet, means for driving said first pump, means for interconnecting said first pump and said cylinder, said means including a valve in a first position connecting said cylinder and said inlet and in a second position connecting said cylinder and said outlet, a hydraulically expansible device having an unobstructed inlet and an unobstructed outlet for moving said valve between said positions, a positive displacement second hydraulic pump driven at a predetermined rate, and means for hydraulically connecting the outlet of said second pump to said device.

7. A hydraulic pumping jack control comprising a jack cylinder, a balancing tank, a pump effective to transfer oil between said cylinder and said tank, a valve for controlling the direction of said transfer, a hydraulic actuator for said valve, said actuator operating by hydraulic displacement and having an unobstructed inlet and an unobstructed outlet, and means for pumping hydraulic fluid through said inlet and said outlet at a constant rate to displace said actuator at a constant rate.

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