Nov. 13, 1951 I. M. WHITE 2,575,241

HYDRAULIC PUMPING JACK

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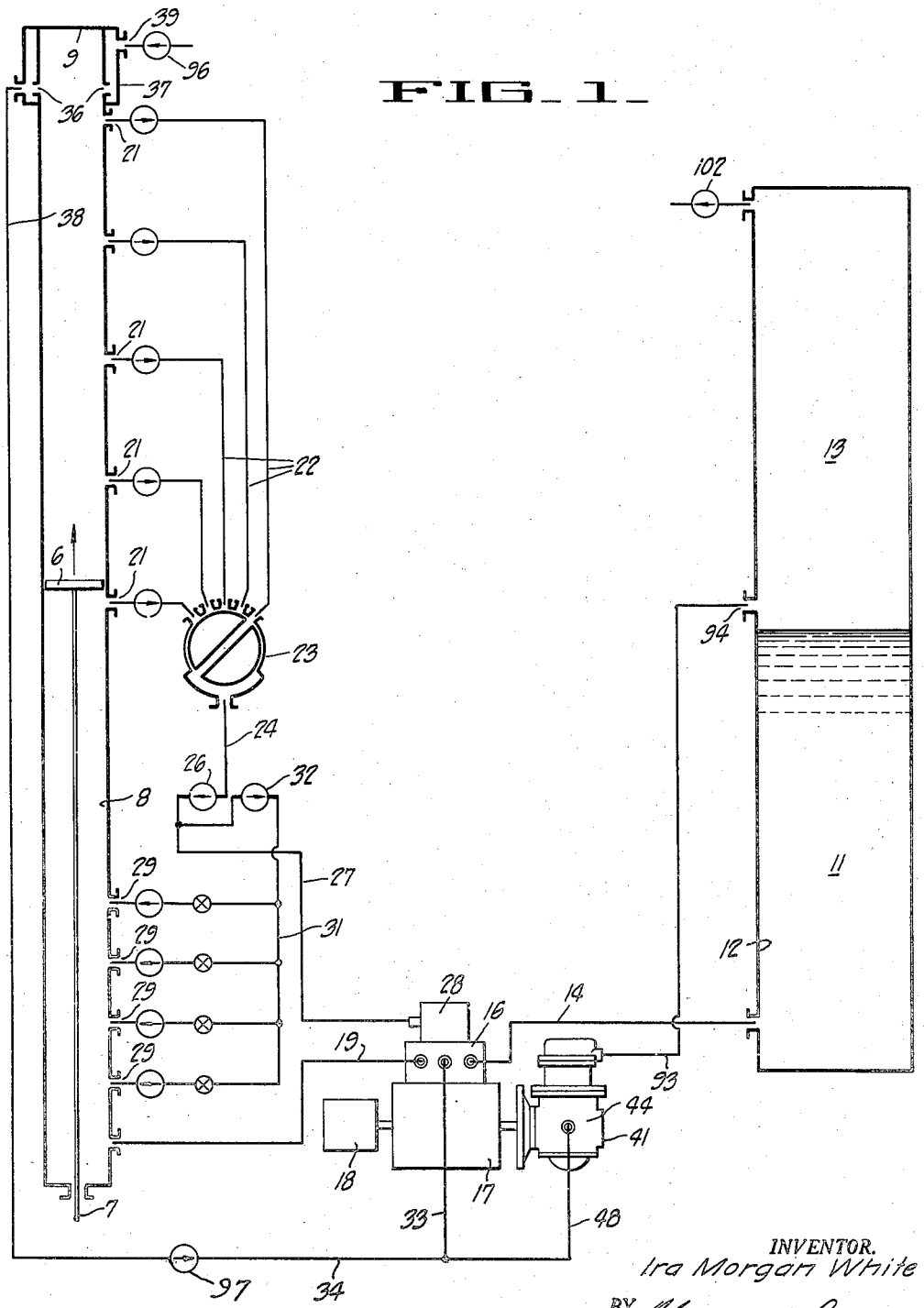
FIG. 1



INVENTOR.
Ira Morgan White

BY Masson Lothrop

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HYDRAULIC PUMPING JACK

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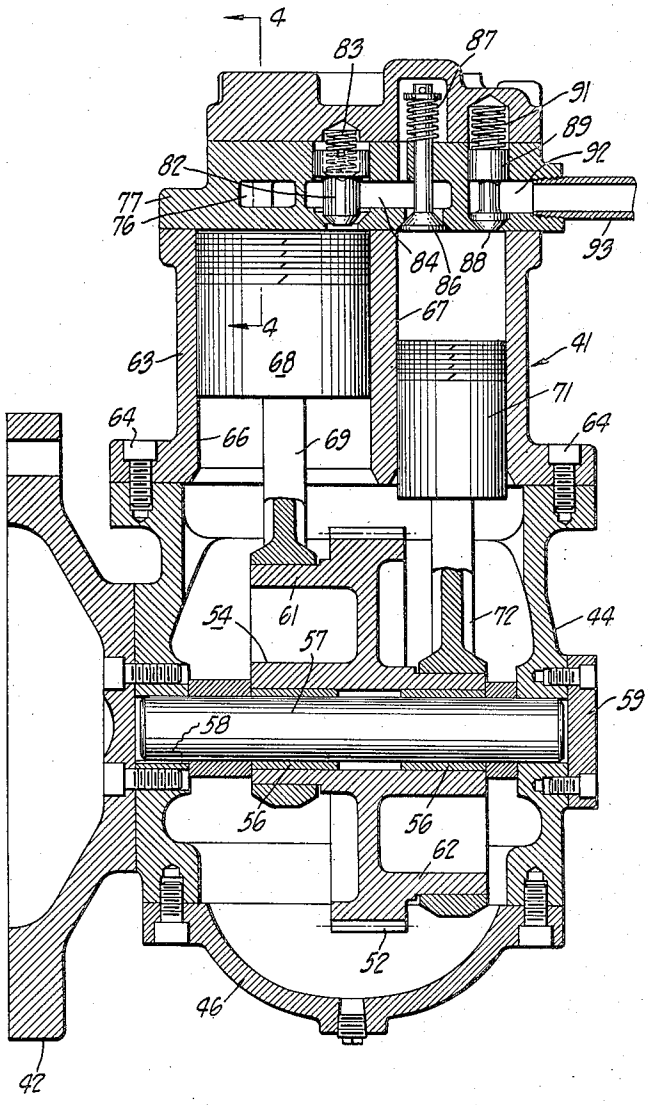

FIG. 2.

INVENTOR.
Ira Morgan White
BY Mason Lothrop

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HYDRAULIC PUMPING JACK

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FIG. 4.

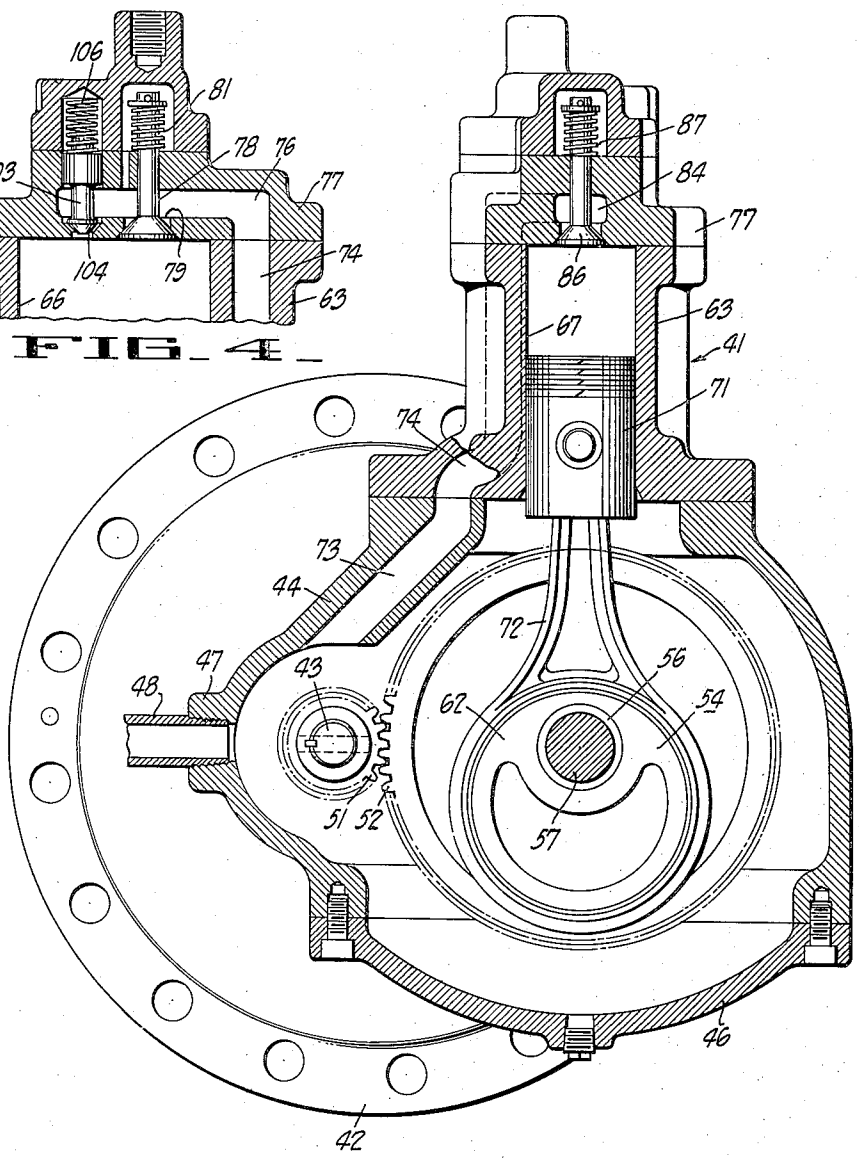

FIG. 3.

INVENTOR.
Ira Morgan White
BY Mason Lotter

Patented Nov. 13, 1951 2,575,241

UNITED STATES PATENT OFFICE

2,575,241

HYDRAULIC PUMPING JACK

Ira Morgan White, Berkeley, Calif., assignor to The Pelton Water Wheel Company, San Francisco, Calif., a corporation of California

Application September 6, 1949, Serial No. 114,180

14 Claims. (Cl. 60—51)

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My invention relates to hydraulic machinery especially designed for operating pumps located at the bottom of deep oil wells and to similar structures in comparable environments. Pumping jacks hydraulically actuated have become increasingly popular in recent years and one of the characteristics of most of them is the provision of a cylinder and piston combination hydraulically reciprocated at the surface to operate the oil pump at the well bottom. A prime mover operates a main pump for furnishing working oil to the jack to reciprocate the piston in the cylinder. In order to balance part of the load on the piston there is usually provided a balancing tank containing oil and air under an intermediate pressure. The mechanism, like most hydraulic structures, is subject to more or less leakage from time to time particularly after it gets old in use. Some of the operating instrumentalities such as valves and the like, are power actuated by oil and as a consequence actuating oil is from time to time released from the high pressure part of the system. It is customary to provide some sort of means for returning this released oil and leakage oil to the balancing tank and it is also customary to provide some way for maintaining the desired pressure on the balancing tank usually by regulating the air pressure. While various structures for this purpose have been utilized in the past, it is a general object of my invention to improve upon previously known devices.

Another object of my invention is to provide a pumping jack mechanism in which the oil return or scavenge pump is effective over a long period of time, that is, has a long practical life.

Another object of my invention is to provide a pumping jack mechanism in which the supply of air to the balancing tank is established at the desired pressure.

A further object of my invention is to simplify the arrangement of a pumping jack mechanism.

A further object of my invention is to provide a pumping jack mechanism including a scavenge pump effective to handle relatively large momentary quantities of oil and to do so without serious strain on the hydraulic system.

A further object of my invention is to provide a pumping jack mechanism in which the relative quantities of oil and air returned to the system are variable over wide limits.

A still further object of my invention is to provide in a pumping jack mechanism a scavenge pump structure capable of long and satisfactory use under overload conditions and without serious danger of overheating or excessive wear.

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A still further object of my invention is in general to improve pumping jacks.

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

Figure 1 is a schematic layout showing a pumping jack mechanism constructed in accordance with my invention. While the present showing is diagrammatic some of the parts are illustrated approximately as they appear in practice.

Figure 2 is a cross section on a longitudinal, axial plane of a scavenge pump constructed in accordance with my invention for incorporation with the pumping jack mechanism.

Figure 3 is a cross section on a transverse vertical plane through the structure shown in Figure 2.

Figure 4 is a fragmentary cross section to the same scale as Figure 2, the plane of section being on the line 4—4 of Figure 2.

While my pumping jack mechanism is susceptible to incorporation or embodiment in a number of different ways and is satisfactorily utilized in a number of different environments or fields it has been particularly successful in connection with a pumping jack of the type shown in my pending application Serial No. 32,629, filed June 12, 1948 and entitled Hydraulic Pumping Jack Control and also as shown in the patent of Kyle and White 2,325,138 issued July 27, 1943. In such environment the embodiment of the invention attains most of its advantages.

In its preferred form the pumping jack mechanism of my invention includes a jack cylinder in which the jack piston is reciprocable, being operated by the transfer of oil between the cylinder and a balancing tank containing oil and air. In order to restore leakage and process or utility oil to the balancing tank and to keep the tank supplied with air, a positive displacement piston pump serves as a scavenge pump and takes air and oil or mixtures of air and oil and restores them to the balancing tank.

In the particular embodiment chosen for illustration, there is provided a jack piston 6 normally operated in a vertical direction along the axis of a piston rod 7 extending to the bottom of a well and actuating a pump there disposed. The piston 6 is reciprocable within a jack cylinder 8 suitably mounted and provided with a closure plate 9 at its upper end. A supply of actuating oil is disposed in a body 11 in the lower part of a balancing tank 12 appropriately located, the upper part of the tank containing a volume 13

of air under the same pressure as the oil. Oil from the body 11 is withdrawn through a duct 14 into a reversing valve 16 and then passes through a force pump 17 driven by an electric motor 18 or other suitable prime mover.

The pump 17 discharges the working oil from the reversing valve 16 through a line 19 into the lower end of the cylinder 8 beneath the piston 6. This has the effect of lifting the piston. As soon as the piston uncovers one of a series of top stroke selector ports 21 the normally atmospheric or substantially atmospheric pressure on the port when it is above the piston 6 is suddenly increased because the port is then exposed to the pressure of the operating fluid beneath the piston 6. This pressure is transmitted to a line 22 and through a selector valve 23 to a main line 24. The valve 23 renders any desired one of the ports 21 effective and excludes the others so that the upper limit of the piston stroke is set by the positioning of the selector valve 23.

Pressure transmitted through the line 24 passes a check valve 26 and is imposed upon a conduit 27. This leads to a pilot valve 28 responsive to the pressure within the line 27 and in turn controlling the reversing valve 16. When such valve is actuated, the effect of the main pump 17 is no longer to transfer oil from the body 11 through the pipe 19 and the cylinder 8 but rather is to withdraw the oil from the cylinder 8 through the pipe 19 and to pass it through the pump 17 and back through the line 14 into the body 11 within the tank 12. In this way the piston 6 is permitted to descend into the cylinder 8 until such time as the pressure which normally has been exerted on the effective one of a series of lower stroke limiting ports 29 is released. This occurs as the piston passes such port and subjects it to atmospheric pressure rather than to line pressure. The effect is felt through a connector 31 extending from the various ports 29 through a check valve 32 to the conduit 27. Thus, when the piston 6 lowers to a selected low point, the pilot valve 28 is affected, the reversing valve 16 is again changed and oil is no longer pumped from the tank 12 back into the cylinder 8 beneath the piston.

This is the customary cycle of operation of the hydraulic pumping jack. As an incident to such operation, the oil transferring mechanism, particularly the pilot valve 28 and the reversing valve 16, releases some of the pressure fluid normally within the conduit 14 from the pressure system. This released oil loses its pressure promptly and is discharged through a drain or scavenge line 33 to a sump line 34 at a low point in the system.

As an incident to the operation of the piston 6 within the cylinder 8 and since no hydraulic mechanism is entirely tight over a long period of time, some fluid or oil leaks from beneath the piston to a position above the piston at a much lower pressure. This leakage oil at the uppermost part of the stroke is forced or spilled from the cylinder 8 through ports 36 and enters a surrounding closed housing 37 and passes from such housing into a conduit 38 extending to the sump pipe 34. The substantially closed upper end of the cylinder is made to serve as a preliminary or booster air pump chamber. It is supplied with air at approximately atmospheric pressure through a port 39 in the wall of the housing 37. As the piston 6 lowers and increases the volume of the space above it, air is drawn

in through the port 39 and as the piston rises, decreasing the volume, the air is expelled.

In the sump pipe 34 leakage oil from the line 38 and the oil released from the scavenge line 33 are comingled. In order to return this oil to the system and also to furnish suitable makeup air under pressure for the body of air 13 in the tank 12 I provide in accordance with my invention a special scavenge pump 41. This pump is illustrated diagrammatically in Figure 1 and as actually embodied in Figures 2, 3 and 4. The pump is preferably mounted to be driven by the motor 18 and includes a mounting bracket 42 removably fastened on one end of the housing 17 of the pump. The shaft of the motor 18 passes through the pump housing and a section 43 of such shaft passes through the mounting bracket 42 and extends into the crank case 44 of the pump. The crank case has a lower, removable cover 46 but in operation is closed to the atmosphere. It is provided with a boss 47 into which the sump pipe 34 is connected by an inlet pipe 48. Fluid from the various drain and scavenge lines and air from the line 38 thus can flow freely into the interior of the pump crank case.

Within the crank case the extension shaft 43 is provided with a pinion gear 51 transmitting its rotary motion to a ring gear 52 centrally disposed on and forming part of a crank shaft 54. This is preferably of tubular form and runs on bearings 56 supported by a stationary shaft 57 spanning the space between the walls of the crank case 44 and keyed in position by a lock 58. It is readily removable by removal of a cap 59 from one side of the crank case. Included in the crank shaft are eccentrics 61 and 62 which are rotated in unison with the rotation of the central gear 52.

The scavenge pump is preferably a positive displacement piston pump of several stages, in the present instance two stages, and it is also of the valved variety. For that reason I mount on the crank case 44 a cylinder block 63 fastened thereto by suitable securing devices 64. The block incorporates a first stage cylinder 66, sometimes called a low pressure cylinder, and a second stage or high pressure cylinder 67. Adapted to operate in the cylinder 66 is a low pressure or first stage piston 68 connected to the eccentric 61 by a connecting rod 69. Similarly, in the second stage cylinder 67 a piston 71 is joined to the eccentric 62 by a connecting rod 72.

As shown especially in Figures 3 and 4, the oil or other fluid which is let into the crank case 44 can rise to any desired height therein until it approaches the entrance to a cored passageway 73 leading from a point slightly above the pinion gear 51 to a passage 74 in the cylinder block and extending into a similar passageway 76 in a detachable cylinder head 77. Disposed in the head at a convenient location is an inwardly opening poppet inlet valve 78 seated in the head to control a port 79 and normally restrained by a spring 81. As the piston 68 descends, the resulting vacuum opens the valve 78 permitting fluid to flow from the crank case 44 through the passages 73 and 74 and the passage 76 into the interior of the cylinder 66.

Material in the cylinder is expelled from the cylinder as the piston 68 rises by flowing through an outlet poppet valve 82 shown in Figure 2. This valve is normally urged toward its seat by a spring 83 and controls flow from the cylinder 66 through a passageway 84 to an inlet valve 86 leading to the cylinder 67. The valve 86 is also

of the poppet type and is usually held seated by a spring 87. Material drawn into the cylinder 67 through the opening provided when the valve 86 is unseated is subsequently expelled from that cylinder through a port 88 controlled by a valve 89 pressed on its seat by a spring 91 and giving access to a passageway 92. An outlet conduit 93 extends from the opening 92 to a suitable point of entry 94 into the tank 12.

In general, fluid flows from the pipe 33 and the conduit 38 into the sump pipe 34 then into the crank case 44 of the scavenge pump, then into the first stage cylinder 66 of such pump then to the second stage cylinder 67 of the scavenge pump and finally through the outlet pipe 93 to the tank 12. In accordance with my invention, I provide means for supplying make-up air along with the scavenge oil and for affording preliminary compression of the make-up air even before it gets to the first stage of the scavenge pump. The chamber 37 around the main cylinder 8 is especially provided with an air inlet check valve 96. In actual operation, atmospheric air is drawn in to the cylinder 8 during the descent of the piston 6 the weight or head of the fluid in the long vertical pipe 38 being sufficient to prevent substantial back flow or a check valve 97 precludes backflow.

During the subsequent ascent of the piston 6 the valve 96 closes and the then trapped air is expelled through the passages 36 and through the pipe 38 toward the scavenge pump 41. Leakage oil from the cylinder 8 also travels through the pipe 38 to the scavenge pump, in the sump pipe 34 joining released and leakage oil coming through the duct 33. There is consequently supplied to the crank case 44 of the scavenge pump both non-compressible oil and compressible air and in various mixed amounts and relative quantities at random. That is, there may be a very large amount of oil arriving at the scavenge pump one particular moment, a very small amount at a following moment and perhaps a moderate intermixture at other times.

This mixture of air and oil, air individually or oil alone is retained partly in the crank case 44 at least no higher than the entrance level of the conduit 73. If the oil tends to go much higher than that it is readily drawn into the conduit 73 whereas if the level sinks well below the inlet to the conduit 73 its induction to the remaining part of the scavenge pump is not readily accomplished. There is consequently an automatic oil level regulation at a point sufficiently high to lubricate the gears and revolving parts of the pump and at a point to provide ready induction to the cylinders of the pumping mechanism.

The fluid flowing into the first stage cylinder 66 is expelled from that cylinder under varying conditions. If air alone is involved, the air is compressed to an amount dependent upon the resistance to flow partly regulated by the spring 83 incorporated with the outlet valve 82. The air so compressed is then transferred to the smaller volume second stage cylinder 67, is again compressed in that cylinder and is restored to the balancing tank 12 at a pressure equivalent to the pressure inside that tank. If air so pumped tends to increase the pressure in the balancing tank (both as to air and oil) above the desired amount, the excess air is bled off or permitted to escape through a regulating valve 102 blowing to the atmosphere and adjustable to the precise pressure desired.

If, instead of air, oil alone enters the scavenge pump cylinder 66; the oil when expelled would travel into the volumetrically smaller second stage cylinder 67. The first stage volume will not fit the smaller volume of the second stage cylinder. It is possible, by permitting the loads on the piston 68 to run up quite high, to force the solid oil entirely through the outlet valve 82, through the passage 84, through the inlet valve 86 and through the outlet valve 89 to the outlet conduit 93. The pressure on the oil at the first stage therefore becomes substantially that within the balancing tank 12. It is preferred not to permit the pressure on piston 68 to run up to that extent. As shown in Figure 4, I provide a special relief valve 103 urged into a port 104 in the cylinder 66 by a closure spring 106. The port 104 opens into the passageway 76 in communication with the interior of the crank case 44. Depending upon the setting of the spring 106, when the piston 68 ascends liquid leaves the cylinder 66 through the valve 82 or if the pressure is great through the relief valve 103 also.

Sufficient oil to charge fully the cylinder 67 travels through the passage 84 whereas the excess represented by the greater size of cylinder 66 is bypassed through the passage 76 back to the interior of the crank case 44. In this way the maximum pressure on the piston 68 is limited. While the operation has been described with oil, air too, can by-pass if for any reason the pressure becomes high enough to open the relief valve. According to this arrangement the maximum quantity of oil alone that can be pumped is regulated by the volume of the second stage cylinder 67 whereas the maximum amount of air that can be pumped is dependent upon the volume of the first stage cylinder 66. This relationship is maintained at about the expected ratio for operation of the balancing tank 12.

Preferably the ratio between the pinion 51 and the ring gear 52 is such with regard to the speed of the motor 18 and the main pump 17 that the scavenge pump 41 operates at a relatively slow rate. This is primarily for the reason that the oil and air mixture most often pumped may possibly be of an explosive character if its temperature is high. While oil alone in the absence of air will not explode and air alone in the absence of oil is not combustible, still an oil-air mixture in proper proportions will burn if it is sufficiently hot. By operating the scavenge pump at a relatively slow rate (in one instance 75 R. P. M.) the temperature rise due to pumping and compression of air and displacement of oil is relatively slight, the heat dissipation from the pump alone being sufficient to keep the temperature well within a safe margin.

Very seldom does the scavenge pump pump oil alone. Most of the time it operates on a mixture so that there is some compressibility and some cushioning effect to alleviate what otherwise might be a "water hammer" symptom in the hydraulic piping. Furthermore the pumping of oil with the air through the entire scavenge pump is effective to lubricate all of the parts even those without substantial lubrication if air alone were pumped. It has been found in practice that a scavenge pump of this sort has a life many times that of an oil pump operating alone or of an air pump operating alone so that by combining both fluids and handling them in one positive displacement multi-stage pump considerable improvement has been made.

The volume of oil in the system is substantially constant and little or no oil is lost from the system as a whole during normal operation. It is not necessary in this environment to provide any

oil make-up valve or any oil release valve if fluctuations in oil volume due to changes in temperature (both seasonal and due to operation of the mechanism) can be compensated for. These are absorbed by changes in volume of the air body 13 in the balancing tank. The air system is operated with a variable volume and so provides compensation for the slight fluctuations in the oil system. That is, when the pressure gets too high rather than bleed oil from the system, extra air is let out from the relief valve 102. When the pressure gets low the relief valve 102 closes until sufficient air has been added through the inlet valve 96. The quantity of air which enters the valve 96 is approximately constant for any given jack stroke because the speed of operation of the main jack piston 6 and of the scavenge pump 41 is always substantially constant. This quantity is sufficiently great so that by varying the amount of air bled off or released through the valve 102, the pressure within the balancing tank 12 both on the oil body 11 and the air volume 13 is maintained at the selected value.

It is to be especially understood that the showing herein although representative of a practical embodiment is especially in Figure 1, a diagrammatic showing intended to illustrate the most pertinent features of the scavenge pump arrangement. The conduit 33 for example, is intended to represent various conduits normally present and which supply oil to the sump line 34 and the line 33 is intended to represent numerous lines in practice carrying leakage oil. Furthermore, the pilot valve 28, reversing valve 16, and the main pump 17 are preferably as shown in the mentioned application and patent but various different systems of valving can be utilized without adversely affecting the operation of the scavenge pump 41 and its appurtenances.

What is claimed is:

1. A hydraulic pumping jack comprising a jack cylinder, a jack piston reciprocable in said cylinder, a balancing tank for containing oil and air, mechanism for transferring oil between said tank and said cylinder to reciprocate said piston, some of said oil escaping from said transferring mechanism, a pump adapted to pump an air and oil mixture, a conductor for conducting said escaped oil from said cylinder to said pump, a port communicating with the atmosphere for admitting air to said conductor, and a conduit for conducting oil and air discharged by said pump to said balancing tank.

2. A hydraulic pumping jack comprising a jack cylinder, a jack piston reciprocable in said cylinder, a balancing tank for containing oil and air, mechanism for transferring oil between said cylinder and said tank to reciprocate said piston, some of said oil leaking past said piston, a pump having an inlet communicating with the atmosphere and an outlet, a conduit connecting said pump outlet and said balancing tank, and a connector for conducting said leakage oil to said pump to be forced with said air into said balancing tank.

3. A hydraulic pumping jack comprising a jack cylinder, a jack piston reciprocable in said cylinder, a balancing tank for containing oil and air, mechanism having oil releasing openings for transferring oil between said tank and said cylinder to reciprocate said piston, some of said oil being released from said transferring mechanism through said releasing openings, a pump having an inlet communicating with the atmosphere and an outlet, a conduit connecting said pump outlet and said balancing tank, and a connector for conducting said released oil to said pump to be forced with said air into said balancing tank.

4. A hydraulic pumping jack comprising a jack cylinder, a jack piston reciprocable in said cylinder, a balancing tank for containing oil and air, mechanism for transferring oil between said tank and said cylinder to reciprocate said piston, some of said oil leaking past said piston and some of said oil being released from said transferring mechanism, a pump having an inlet communicating with the atmosphere and having an outlet communicating with said balancing tank, and connector for conducting said leakage oil and said released oil to said pump to be forced with said air into said balancing tank.

5. A hydraulic pumping jack comprising a jack cylinder, a jack piston reciprocable in said cylinder, a balancing tank for containing oil and air, mechanism for transferring oil between said tank and said cylinder to reciprocate said piston, a pump having an inlet and an outlet, a conduit for connecting said outlet to said tank, and a connector communicating with the atmosphere and with said transferring mechanism for conducting to said inlet both oil from said transferring mechanism and air.

6. A hydraulic pumping jack comprising a jack cylinder, a jack piston reciprocable in said cylinder, a balancing tank for containing oil and air, mechanism for transferring oil between said tank and said cylinder to reciprocate said piston, a positive displacement pump having an outlet connected to said tank and having an inlet, and a connector communicating with the atmosphere and with said transferring mechanism for conducting to said inlet both oil from said transferring mechanism and air.

7. A hydraulic pumping jack comprising a jack cylinder, a balancing tank for containing oil and air, a hydraulic system for transferring oil under a relatively high pressure between said tank and said cylinder, a scavenger system, some of said oil being released from a relatively high pressure in said hydraulic system to a relatively low pressure in said scavenger system, and a single pump communicating with the atmosphere and with said scavenger system for forcing said oil from said scavenger system and air into said balancing tank.

8. A hydraulic pumping jack comprising a jack cylinder closed at its upper end, a jack piston reciprocable in said cylinder, a balancing tank for containing oil and air, mechanism for transferring oil between said tank and said cylinder below said piston to reciprocate said piston, some of said oil leaking past said piston, a check-valved air inlet to said cylinder above said piston, a valved pump having an inlet and an outlet, a connector extending from said cylinder above said piston to said inlet, and a conduit extending from said pump to said balancing tank.

9. A hydraulic pumping jack comprising a jack cylinder, a jack piston reciprocable in said cylinder, a balancing tank for containing oil and air, mechanism for transferring oil between said tank and said cylinder to reciprocate said piston, and a single pump communicating with the atmosphere and with said transferring mechanism for simultaneously supplying said balancing tank with oil and air.

10. A hydraulic pumping jack comprising a jack cylinder, a jack piston reciprocable in said cylinder, a balancing tank for containing oil and

air, a main pumping mechanism for transferring oil between said tank and said cylinder to reciprocate said piston, and a secondary pumping mechanism communicating with the atmosphere and with said main pumping mechanism for simultaneously supplying said balancing tank with oil and air.

11. In a pumping jack mechanism having a balancing tank for containing a body of oil and air, a positive displacement pump having an inlet and an outlet, a conduit for connecting said outlet to said tank, and a connector communicating with the atmosphere and with said body of oil for supplying both oil and air to said inlet.

12. In a pumping jack mechanism having a balancing tank for containing a body of oil and air, a multi-stage piston pump having an inlet and an outlet, a conduit for connecting said outlet to said tank, and a connector communicating with the atmosphere and with said body of oil for concurrently supplying both non-compressible oil and compressible air to said inlet.

13. In a pumping jack mechanism having a balancing tank for containing a body of oil and air, a multi-stage piston pump having an inlet and an outlet, a pressure conduit connecting said

outlet to said tank, a connector communicating with the atmosphere and with said body of oil for supplying said inlet with air and oil, and a fluid pressure responsive by-pass connected between successive stages of said pump and said inlet.

14. In a pumping jack mechanism having a balancing tank for containing a body of oil and air, a pump having cylinders and pistons of different sizes, a connector communicating with the atmosphere and with said body of oil and then connected to one of said cylinders then to another of said cylinders and then to said tank, and a valved conduit joined to said connector between said cylinders for releasing fluid from said connector between said cylinders.

IRA MORGAN WHITE.

REFERENCES CITED

The following references are of record in the file of this patent:

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Number	Name	Date
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