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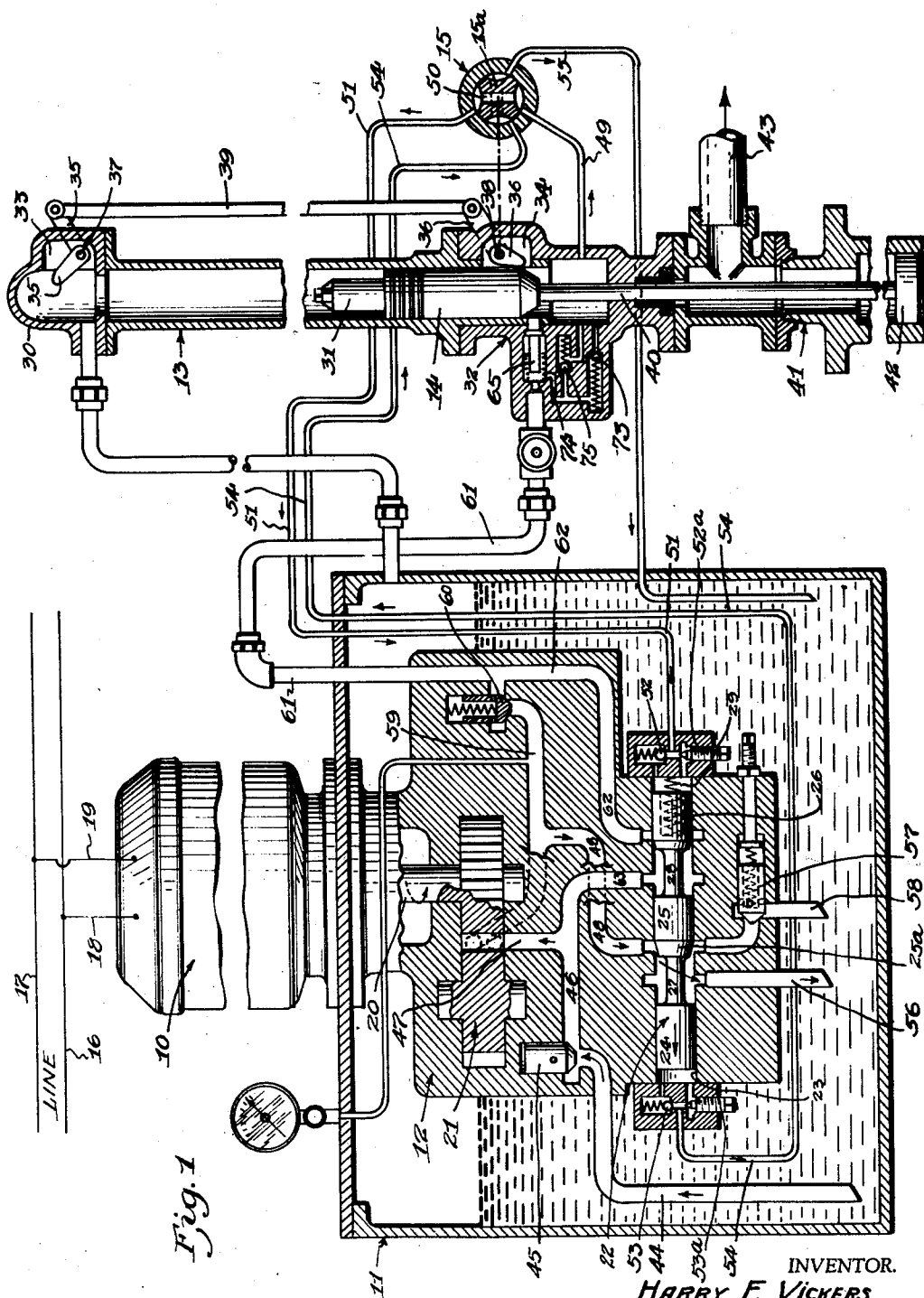
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2,276,358

POWER SAVING PUMP JACK

Filed Oct. 15, 1938

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

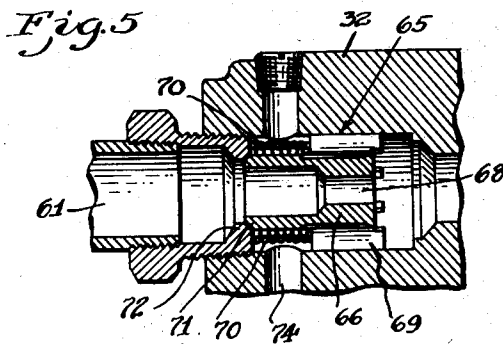
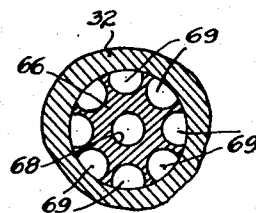
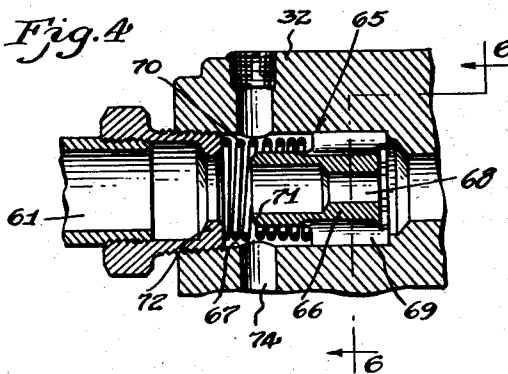
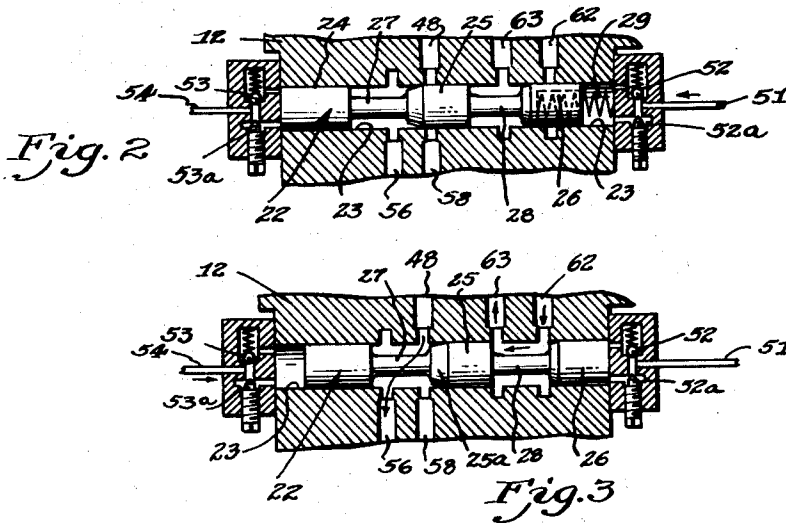


Fig. 6

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UNITED STATES PATENT OFFICE

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POWER SAVING PUMP JACK

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15 Claims. (Cl. 290—7)

This invention relates to a hydraulic pump jack unit and mechanism for actuating and controlling the same.

The mechanism contemplated by the present invention is adapted for use particularly with hydraulic pumping units used for pumping oil wells and the like. In the mechanism now used for these pumping units it is customary to provide a counterbalancing means consisting of an air accumulator or weight accumulator to control the downward motion of the piston in the pump cylinder. Without some such control, the weight of the column of oil and sucker-rods on the pumping piston will accelerate the same downwardly at too rapid a rate and cause damage to the pumping apparatus.

An object of the present invention is to provide a mechanism whereby the potential energy in the pumping system, as the piston reaches its top position, may be transferred to electrical energy through the same mechanism which normally furnishes the pressure liquid for the upstroke.

A further object of the invention is to provide a controlling and actuating mechanism for a pump jack which needs no counterbalancing means and which permits the recovery of a substantial portion of the electric current used in driving the pump jack during the upstroke. An additional object of the invention is to provide a pump jack which is self-starting and which has a safety deceleration valve to prevent the piston from getting out of control regardless of the condition of the driving motor, the failure of the coupling between pump and motor or an accident to the pipe line connecting the pump unit and the pump jack cylinder.

Another object of the invention has to do with an auxiliary control actuated by the pump jack piston and utilizing a pilot control pressure obtained from the base of the work cylinder to operate control valves in a remotely positioned unit.

Other objects and features of the invention have to do with details of construction and operation and with other safety features as will be set forth in the following specification and claims.

In the drawings:

Fig. 1 is a sectional view of the entire apparatus.

Fig. 2 is a partial section of the control unit of Fig. 1 showing a pilot operated valve in an up position.

Fig. 3 is a view similar to that of Fig. 2 showing the pilot operated valve in down position.

Figs. 4 and 5 are detail views of a deceleration valve for the pump jack.

Fig. 6 is a section taken on the lines 6—6 of Fig. 4.

Referring to Fig. 1, a motor 10 is shown mounted on top of a tank 11 in which is mounted a control unit housing generally designated as 12. An upright pump jack cylinder 13 is hydraulically connected to the control unit 12 in a manner which will be later referred to. A piston 14 is slidably mounted in the cylinder 13 and a control valve, to be actuated by the movement of piston 14, is shown at 15.

The motor 10 is either an alternating current induction motor or a direct current motor and is connected to power lines 16 and 17 by lines 18 and 19. Any conventional motor will generate electrical energy when mechanically driven but the two types above mentioned are the more efficient. The motor 10 is provided with a shaft 20 which is connected at one end to a gear pump 21. This gear pump 21 is housed in the control unit casing 12 as is also a pilot operated valve 22. The valve 22 is slidably retained in a cylindrical recess 23 and consists of three spools 24, 25 and 26, connected by narrowed portions 27 and 28. A spring 29, mounted at the right end of the valve 22, urges the valve toward the left. Various passageways and other details of the control unit 12 will be described in connection with the operation of the mechanism.

Considering now the cylinder 13, a dome 30 is provided at the top thereof and adapted to receive a projection 31 on the top of the piston 14. At the base of the cylinder 13 is a housing 32 for deceleration and safety valves which will later be described. In the housing 32 and the dome 30 are chambers 33 and 34 in which are mounted bell crank levers 35 and 36, respectively. These levers are pivoted respectively at 37 and 38 and the outer ends of each are connected by a rod 39. The inner ends of the levers are adapted to project into the cylinder 13. The levers being connected so that one of them may project into the cylinder at one time. Within the valve 15 is a rotating element 15a which is operatively connected to the lever 36, this connection being shown diagrammatically only.

A piston rod is shown at 40 extending from the piston 14 downwardly into the well pipe 41. A piston 42 is shown at the bottom of the rod 40 and represents diagrammatically the pumping unit for the oil well or other shaft. An outlet

conduit 43 is provided for the liquid which is pumped. It will be understood that the stroke of the piston 14, if used in an oil well, is normally about 10 feet and also the pumping unit 42 is located deep in the ground so that above it there is a high column of liquid.

Referring now to the operation: When the motor 10 is started, shaft 20 rotates in the direction as shown by the arrow and liquid from the tank 11 passes to the pump 21 through a conduit 44, past a check valve 45, and through conduits 46 and 47. Pressure fluid passes from the pump through conduit 46 to the valve recesses and is permitted to flow freely around the narrowed portion 27 of the valve 22 and to the tank 15 through drain line 56.

Assuming now that the piston 14 in the cylinder 13 has just reached its lowermost position and has actuated the lever 36 into the position shown in Fig. 1, the valve member 15a will be rotated into the position shown in Fig. 1 and valve 22 will be as shown in Fig. 3. With the valve 15a in this position, pilot pressure from the base of the cylinder 13 in the housing 32 causes the liquid to flow through a conduit 48 to the valve housing 15. Here it passes through a transverse opening 50 in the valve member 15a to a conduit 51 which directs the pilot pressure to the right end of the valve 22 in the housing 12. The pilot pressure passes through a check valve 52 and past a needle valve 52a, the function of which will later be described. The valve 22 is now urged to the left by the pilot pressure and this movement is resisted by reason of an adjustable needle valve 53a which restricts the flow of liquid from the chamber 23 to the left of valve 22 thereby controlling the rate of travel of said valve. Liquid from the end of the chamber 23 passes around the needle valve 53a to a conduit 54 which leads back to the valve member 15a and through a transverse passageway therein to a conduit 55 which leads to the tank. It will be seen that by reason of the needle valve 53a, the movement of the valve 22 to the left will be gradual. The final left-hand position of the valve is shown in Fig. 2.

In Fig. 1 the valve 22 is shown just as it has started its movement in the direction of the arrow. Liquid has been passing through the lines 48, as previously described, and past the valve portion 27 to a tank conduit 56. As the valve spool 25, with its tapered portion 25a, moves to the left, it gradually closes the passageway 48 from the passageway 56. Pressure then builds up in passageway 48 since a relief valve 57 blocks a tank passageway 58. Pressure also builds up in a supply passageway 59 against a check valve 60. When this pressure has reached a point such that the check valve 60 is overcome, liquid under pressure passes from the pump 21 through the passageway 59 to a main conduit 61 leading to the housing 32 and the lower portion of the cylinder 13. This pressure liquid raises the piston 14 to the top of the cylinder.

As the piston approaches the top of the cylinder the portion 31 contacts the lever 35 and actuates the rod 39 and therefore the valve rotor 15a. By this action the valve rotor 15a is moved to a position where the conduit 49 is connected to the conduit 54. Pilot pressure now passes from the lower portion of the cylinder 13 to the left end of the pilot operated valve 22 through a check valve 53. The valve 22 is moved to the right and the movement will again be gradual by reason of the restricted flow around the needle

valve 52a. It will be seen that as the valve 22 moves to the right, the passageway 48 is again open to the tank line 56 and the pressure which is moving the piston 14 upwardly is relieved.

Piston 14 then starts to descend and forces the liquid in the cylinder 13 back into the main conduit 61. The check valve 60 operates to prevent the liquid from entering conduit 59 and the liquid enters a return conduit 62 which leads to the valve 22. As the valve 22 is moved to its righthand position, as shown in Fig. 3, the conduit 62 is opened to a conduit 63 which leads to the pump inlet conduit 47, since the fluid is then permitted to flow around the narrowed portion 25 of valve 22. Consequently the fluid exhausting from the lower portion of the cylinder 13 passes directly through the pump 21 and tends to drive the same as a motor which in turn drives the electric motor 10. The electric motor, being connected to the power line, tends to maintain its normal rate of speed and, since the driving action thereon will tend to turn it at a rate faster than its normal rate, the current will be reversed and energy will be generated and passed into the power lines.

By using a special electric meter which will run backward as well as forward, only the net current used in the operation of the motor 10 will be recorded and the consumer will thereby get credit for the current put back in the line.

When the piston 14 reaches the end of its downward stroke, the lever 36 will be actuated by the piston and the element 15a of the valve 15 will be again moved to the position shown in Fig. 1. This will restart the cycle which has just been described by again moving the valve 22 to the left and directing pressure fluid from the pump to the cylinder 13.

The hoist unit is self-starting since spring 29 moves the control valve 22 to the left to the position shown in Fig. 2 when the system is not in operation; and, when the electric motor 10 is started, pressure is immediately developed in lines 48, 59 and 61, to cause the piston to move upward. As soon as pressure is developed, the pilot valve 15 becomes operative to control the movement of the control valve 22 and the piston 14.

A safety deceleration valve 65, found in the housing 32 will now be described. This valve is provided to prevent excessive downward speed of the piston 14 and is always available as a safety device in case electric current which is driving motor 10 is suddenly disconnected or in case of breakage of fluid line 61 or the coupling (not shown), between electric motor 10 and pump 21. The valve 65, which is shown in detail in Figs. 4, 5 and 6, consists of a shuttle 66 which is slidable in a cylindrical recess 67. This shuttle consists of a small piston-like member having an axial opening 68 and circumferentially spaced, longitudinal slots 69. A spring 70 tends to hold the valve to the right as shown in Fig. 4. Normally the shuttle 66 will permit liquid to pass to and from the cylinder 13 freely since the liquid may pass through the central opening 68 and also the longitudinal passageways or slots 69. In the event, however, of a failure in any portion of the pressure lines leading from the pump to the work cylinder, or in the event of a failure of the electric current, coupling or fluid line on the upstroke or downstroke of the piston 14, the piston 14 will immediately start to descend by force of gravity. The flow of liquid from the cylinder will, of course, be

through and around the shuttle 66. When the rate of flow of liquid through this valve increases to a certain velocity the resistance of the spring 70 is overcome and the shuttle will be moved to the position shown in Fig. 5. In this position, an end 71 of the shuttle seats at 72 in such a manner that liquid may no longer flow through the passageways 69 but only through the central aperture 68. This aperture 68 is proportioned in size for any given application of the apparatus so that the rate of the descent of the piston is reduced to a safe speed. After the piston 14 has descended to a point where it covers the opening to the valve 65 there will be a dash-pot action which is regulated by a relief valve 73 open on one side to the lower portion of the cylinder and on the other side to the pipe 61 through a passageway 74. A check valve 75 is provided to admit starting pressure from the pipe 61 to the lowermost portion of the cylinder 13 if the piston 14 has descended to a point below the deceleration valve port before stopping. The relief valve is so proportioned that it stops the piston with a gradual deceleration and prevents it from striking the bottom of the cylinder with sufficient velocity as to produce any detrimental stress in the piston rod 40.

What I claim is:

1. A self-reversing power driven hydraulic pump jack unit comprising a substantially vertical cylinder and pump jack, an electric motor, a pump driven by said motor, and hydraulic control valves for directing pressure to and from said pump and pump jack whereby said pump jack serves, in its downward stroke, to drive said pump and said motor and to effect return of electrical energy to the power lines by which the motor is usually driven.

2. An electric and hydraulic power apparatus for actuating a hydraulic piston, which comprises a mechanism operable as a pump and a motor, an electric motor operably connected to said mechanism adapted to drive said mechanism and be driven thereby, and means for controlling flow of fluid to and from said mechanism whereby during one portion of a stroke of said piston, said mechanism acts as a pump, and, during a second portion of the stroke of said piston, said mechanism acts as a motor for driving said electric motor whereby electrical energy may be furnished from said electric motor.

3. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system comprising a series of conduits and valves for directing pressure liquid from said pump to said cylinder during the upstroke of the piston and for directing pressure liquid from said cylinder to said motor during the downstroke of said pump whereby said pump is driven as a motor and said electric motor is actuated by said pump motor to return electrical energy to the power lines.

4. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably con-

nected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between said pump housing and said cylinder having pump end branches to the inlet and outlet of said pump respectively, and valves for opening said main conduit to one or the other of said branches, whereby liquid under pressure may be furnished from said pump to said cylinder during the upstroke of said piston and from said cylinder to the inlet of said pump during the gravity downstroke of said piston.

5. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between said pump housing and said cylinder, said conduit being composed of two branch conduits at the pump end, one branch being a return conduit open to the pump inlet and one branch being a supply conduit open to the pump outlet, whereby pressure liquid may be furnished from said pump to said main conduit and cylinder during the upstroke of said piston, and from said main conduit and cylinder to said pump during a downstroke of said piston.

6. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operated in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between said pump housing and said cylinder, said conduit being composed of two branch conduits at the pump end, one branch being a return conduit open to the pump inlet and one branch being a supply conduit open to the pump outlet, a control valve for opening and closing said return branch conduit, and a check valve in said supply branch conduit, whereby pressure liquid may be furnished from said pump to said main conduit and cylinder during the upstroke of said piston, and from said main conduit and cylinder to said pump during a downstroke of said piston.

7. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between said pump housing and said cylinder, said conduit being composed of two branch conduits at the pump end, one branch being a supply conduit open to the pump outlet and one branch being a return conduit open to the pump inlet, a control valve for opening and closing said latter branch conduit, and a check valve in said former branch conduit, whereby pressure liquid may be furnished from said pump to said main conduit and cylinder during the upstroke of said

piston, and from said main conduit and cylinder to said pump during a downstroke of said piston, and means responsive to the movement of said piston for actuating said control valve to direct liquid from said cylinder and main conduit through said return branch to the inlet of said pump.

8. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between said pump housing and said cylinder, said conduit being composed of two branch conduits at the pump end, one branch being a supply conduit open to the pump outlet and one branch being a return conduit open to the pump inlet, a control valve for opening and closing said latter branch conduit, and a check valve in said former branch conduit, whereby pressure liquid may be furnished from said pump to said main conduit and cylinder during the upstroke of said piston, and from said main conduit and cylinder to said pump during a downstroke of said piston, and a pilot valve means responsive to the movement of said piston for directing pilot liquid from said cylinder to one end or the other of said control valve to actuate the same.

9. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between the lower end of said cylinder and said pump housing, said conduit being composed of two branch conduits at the pump end, one branch being a supply conduit open to the pump outlet and one branch being a return conduit open to the pump inlet, a tank, a tank opening leading to each of said branches, and a control valve adapted when shifted to open and close said supply branch tank opening and said return branch, whereby pressure liquid may be furnished from said pump to said supply conduit, main conduit and cylinder to effect the upstroke of said piston, and from said cylinder, main conduit and return conduit to said pump during a downstroke of said piston, the latter flow serving to drive said pump as a motor to effect rotation of said electric motor and return of energy to power lines.

10. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between the lower end of said cylinder and said pump housing, said conduit being composed of two branch conduits at the pump end, one branch being a supply conduit open to the pump outlet

and one branch being a return conduit open to the pump inlet, a tank, a tank opening leading to each of said branches, and a pilot operated control valve adapted when shifted to open and close said supply branch tank opening and said return branch, whereby pressure liquid may be furnished from said pump to said supply conduit, main conduit and cylinder to effect the upstroke of said piston, and from said cylinder, main conduit and return conduit to said pump during a downstroke of said piston, the latter flow serving to drive said pump as a motor to effect rotation of said electric motor and return of energy to power lines, and a pilot valve means responsive to the movement of said piston for directing pilot liquid to said control valve to actuate the same.

11. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between the lower end of said cylinder and said pump housing, said conduit being composed of two branch conduits at the pump end, one branch being a return conduit open to the pump inlet and one branch being a supply conduit open to the pump outlet, a tank, a tank opening leading to each of said branches, and a control valve adapted when shifted to open and close said supply branch tank opening and said return branch, means cooperating with said control valve to restrict the rate of movement thereof, and a check valve in said return branch tank opening and in said supply branch, whereby pressure may be furnished through said main conduit to effect the upstroke of said piston, and directed from said cylinder to the inlet of said pump during a downstroke of said piston.

12. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between the lower end of said cylinder and said pump housing, said conduit being composed of two branch conduits at the pump end, one branch being a return conduit open to the pump inlet and one branch being a supply conduit open to the pump outlet, a tank, a tank opening leading to each of said branches, and a control valve adapted when shifted to open and close said supply branch tank opening and said return branch, means cooperating with said control valve to restrict the rate of movement thereof, and a check valve in said return branch tank opening and in said supply branch, whereby pressure may be furnished through said main conduit to effect the upstroke of said piston, and directed from said cylinder to the inlet of said pump during a downstroke of said piston, and a pilot valve means responsive to the movement of said piston for directing pilot liquid to said control valve to actuate the same.

13. A self-reversing hydraulically actuated

pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between said pump housing and said cylinder having pump end branches to the inlet and outlet of said pump respectively, valves for opening said main conduit to one or the other of said branches, and a safety deceleration valve for controlling flow from said cylinder to said pump whereby said flow is automatically restricted to a predetermined volume.

14. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between said pump housing and said cylinder having pump end branches to the inlet and outlet of said pump respectively, valves for opening said main conduit to one or the other of said branches, and a safety deceleration valve for controlling flow from said cylinder to said pump comprising a spring biased shuttle normally positioned to present a relatively large flow orifice to said main conduit and adapted to be closed to present a smaller flow orifice to said main conduit whereby the flow from

said cylinder is limited to a predetermined volume.

15. A self-reversing hydraulically actuated pump jack unit comprising a substantially vertical cylinder, a piston operable in said cylinder, an electric motor, power lines for furnishing electrical energy to said motor, a pump housing, a hydraulic pump in said housing adapted to be driven as a hydraulic motor and operably connected with said electric motor, and a hydraulic system for directing liquid to and from said pump and cylinder comprising a main conduit between said pump housing and said cylinder having pump end branches to the inlet and outlet of said pump respectively, a bypass conduit leading from said outlet branch, a control valve connected to said bypass and inlet branch shiftable to a starting position to close said bypass conduit and block said inlet branch and shiftable to a downstroke position to open said bypass and said inlet branch, a valve in said inlet branch to permit flow only away from said outlet, whereby during starting and upstroke of the piston, pressure liquid may flow from said pump to said main conduit through said outlet branch, and during the downstroke of said piston, pressure liquid may flow from said main conduit to said inlet branch, a pilot valve means responsive to the movement of said piston for directing pilot liquid to one end or the other of said control valve to shift the same from one position to another during operation of said piston to permit said operation to be continuous, and means normally urging said control valve to starting and upstroke position in the absence of pilot pressure whereby said unit is self-starting upon the starting of the electric motor.

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