April 7, 1942. W. B. REED 2,279,057

HYDROPNEUMATIC POWER UNIT

Filed April 16, 1938

Fig. 1.

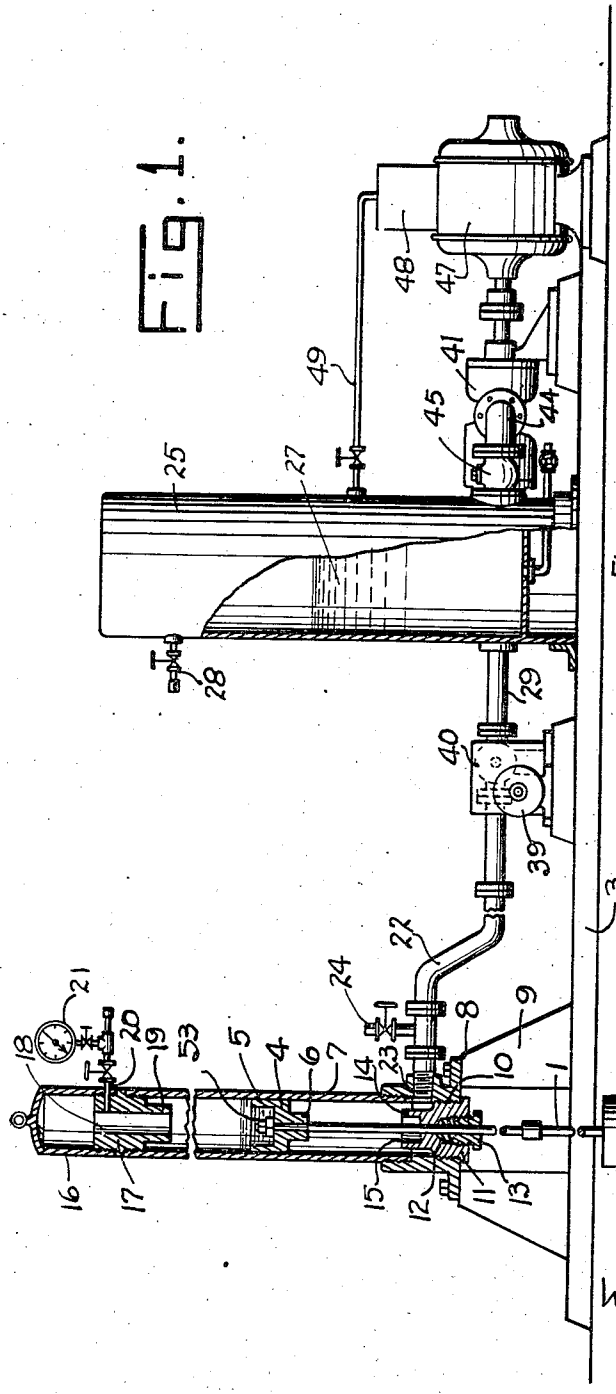
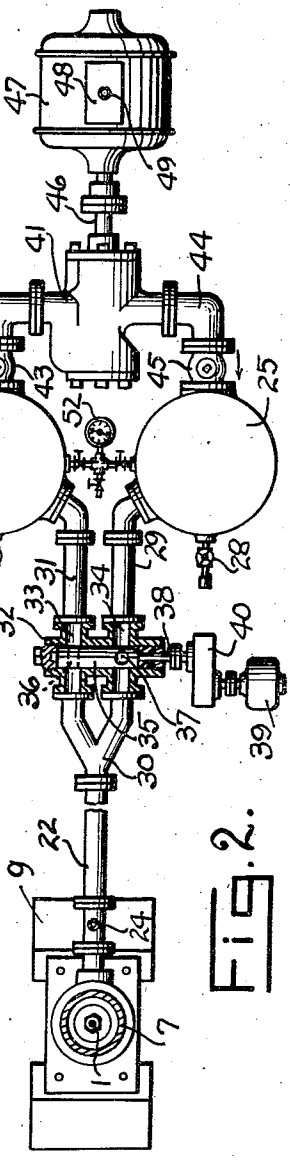


Fig. 2.



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HYDROPNEUMATIC POWER UNIT

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6 Claims. (Cl. 60—52)

My invention relates to a process for operating deep well reciprocating pumps.

It is an object of the invention to provide a process of pumping deep wells whereby the energy employed in operating the devices therefor may be conserved and economized.

It is a further object to provide a device of maximum flexibility whereby the variation of the length of stroke may be changed by varying the relative gas pressures used in the system.

It is a further object to provide a process whereby a pump unit may be operated by hydropneumatic means and the force of the falling pump rod and plunger may be employed in generating and storing pressure to be returned to the operating system.

It is another object to provide a flexible means of operating the pump rod whereby the moving parts are pressure controlled at all times and thereby the wear and tear on the rod string be reduced to a minimum.

In the drawing herewith, Fig. 1 is a side view partly in elevation and partly in central longitudinal section illustrating a preferred form of my invention.

Fig. 2 is a top plan view partly in section.

In carrying out my invention I desire to operate the pump rod or other load reciprocating means through the use of hydraulic means, supplemented by pneumatic pressure employed therewith. In accomplishing this inventive idea I have provided a pump rod 1 which reciprocates within the well casing 2 and may be understood as having connected to it at the lower end thereof the usual oil pump plunger and valve equipment.

The pump rod which is connected to the piston rod carries at its upper end projecting above the platform 3 of the power unit a piston 4. Said piston is formed with an outer cup shaped rim 5 projecting upwardly above the body of the piston. On the lower end of said piston is a downwardly extending hub 6 spaced somewhat from the walls of the cylinder 7 in which it reciprocates.

The power unit cylinder 7 is mounted within a base member 8 which is mounted upon a supporting post or pedestal 9. Said base has a central opening as a continuation of the power unit cylinder which is threaded at 10 to receive a threaded bushing 11. This bushing has an axial opening therein through which the piston rod may reciprocate. A stuffing box comprising packing 12 and a gland 13 thereon forms a seal around the moving rod. At the upper end of the bushing and spaced slightly from the walls of the cylinder is an upwardly extending rim or cup 14. The interior of said cup provides a space 15 about the rod into which fits the hub 6 upon the plunger.

The upper end of the cylinder has a closed extension 16 thereon which forms a compression chamber closing the upper end of the cylinder Said extension is connected with the cylinder by a special coupling member 17 which has a central passage 18 therethrough, the lower end of which has a downwardly extending flange 19 which is shaped and formed to fit within the upper cup shaped end 5 of the piston. I have further provided in connection with the coupling 17 and extension 16, a laterally extending pipe 20 through which the charge of gas under pressure and also oil may be injected into the cylinder and which may have thereon a pressure gauge 21. A quantity of oil 53 is injected into the cylinder through extending pipe 20 to ride above the piston to act as a lubricant also to facilitate the seal about the piston, but specifically to provide fluid for a retarding action when the piston extension 5 enters the space between the extending flange 19 of the stop member 17 and the cylinder wall to provide an hydraulic cushion and stop at the upward extremity of the piston travel.

The piston is adapted to be forced upwardly to operate the power unit and further compress the air volume above the piston through liquid forced into the cylinder below the piston through a pipe 22. Said pipe is connected to the side of the base member at 23.

I have also shown an upwardly extending vent member, having therein a hand operated valve 24, this vent to be used when the conductor pipes are being initially filled with oil.

My apparatus includes a pair of tanks or containers 25 and 26. The tank 25 may be called a power reservoir and the tank 26 a recovery reservoir. Each of said tanks has its interior partly filled with liquid such as oil, said liquid being indicated as 27 in Fig. 1. The upper portion of each container is filled with gas or air under a determined individual pressure. Each tank has a laterally extending pipe thereon controlled by means of a hand valve 28 to be used when charging the tanks with air or gas under pressure. From the power reservoir 25 a pipe 29 is extended toward the power unit for connection beyond the valve units at 30 with the pipe 22. A similar pipe 31 connects the reservoir 26 with said pipe 22. This pipe 22 may be only a few feet as when the installation is at the derrick side or it may be at any economic distance as in the case of central control.

In the two pipes 29 and 31 I have placed a valve unit including a housing 32 with a passage 33 connected with the pipe 31 and a similar passage 34 connected with the pipe 29. A valve member 35 of the rotating type extends across the housing 32 and has an opening 36 to be brought into registration with the passage 33 and an opening 37 to be brought into registration with the passage 34. These two openings 36 and 37 form two valves at right angles to each other so that when one valve is open the other will be closed. Said valve member 35 is shown with extended rod 38 which may be operated by a motor 39 through a gear reduction means 40. Through this operating means the valve member is caused to rotate with a predetermined, uniform, continuous and slow speed which times and controls the number of strokes per minute of the power unit.

The valve unit control of the power unit operation, its timing per stroke and number of strokes per minute is actuated independently of any other function of the process.

The valve unit is so operated that one valve opens and closes at a uniform speed with or without a closed interval of determined length before the other valve opens and then closes with the same uniformity followed by an optional closed interval. The uniform speed of the valves in opening and closing causes the gradual enlargement from a small beginning to full orifice and then with gradually decreasing orifice to complete closure prevents the sudden jerk and jar due to an instantly applied and cut-off force, as is the case when quick opening and closing valves are used, and forms an important feature of control in conjunction with the gas pressure operation of my invention. These closed intervals may be of the same length or the intervals may be varied by design of the valve opening so that at the top of the stroke the interval may be short and at the bottom of the stroke it may have a longer interval. This closed interval or dwell in the stroke allows time for the stretch in the rods to be taken up at the end of the up-stroke before the down stroke begins, and also allows for the stretch of the rod as the upstroke begins.

The valve design may be of the slide valve, piston valve, rotary valve or other variation and the valves may be actuated in many ways and by varied power means without departing from the principles of my invention.

The recovery reservoir and the power reservoir are connected to each other through a pump 41. An outlet pipe 42 from the recovery reservoir 26 is connected to the inlet side or suction of said pump. In the pipe 42 is placed a check valve 43 allowing the passage of liquid in the direction of the arrow. Between the pump 41 and the power reservoir 25 is the pump discharge pipe 44 having therein a check valve 45 opening in the direction of the reservoir

The pump 41 is shown operated from the power shaft 46 of the electric motor 47. Said motor is governed through a rheostat and control switch 48 operated by pressure from the power reservoir 25 through a connecting pipe 49. It will be understood that changing pressure in the reservoir 25 will regulate the motor speed within set limits and will further actuate a switch in the control chamber 48 to start and stop the motor when the pressure rises above or falls below established limits. In this manner the amount of liquid pumped can be controlled and the determined gas pressure maintained. This type of regulator is part of the motor equipment and can be purchased in the market. If gas, gasoline or Diesel type engine be used as motive power the regulation thereof will be controlled by changing pressures in power reservoir 25 through means of diaphragm regulators.

Supply of oil for the circuit is introduced and adjusted through the inlet pipe 50 having thereon a hand operated valve 51. The introduction of oil into the pipes, tank system and the motor driven pump is completed without air pockets by operating the vent 24. The oil circuit is self contained and complete. There should be no loss therefrom except by accident when adjustments can be made through valve 51.

A pressure gauge 52 is shown connected to both the recovery reservoir and the power reservoir and may be used to indicate the pressure in either of said reservoirs by the proper manipulation of valves in the pressure line in which the gauge is set.

To introduce the various air pressures the valve units are closed and through valve 28 air is injected into the power reservoir 25 of a determined initial pressure P1. This pressure will be exerted from check valve 45, tank 25, pipe 29, to the closed valve 37 in the valve unit. In the power unit cylinder with the piston in down position an initial pressure C1 is introduced through pipe 20. This pressure extends through pipe 22 to the closed valves 36 and 37 in the valve unit. In like manner an initial pressure R1 is introduced into the recovery tank and extends from closed valve 36 in the valve unit, the recovery reservoir and thence through pump 41 to check valve 45. These three determined individual air pressures are of such relation and difference that by operating the valve unit which puts them in motion and the power driven pump which restores the pressure in the power reservoir the system functions as designed.

With the initial air pressures as described, the detail of a complete cycle will be as follows:

A part revolution of valve member 35 would open valve 37 (with valve 36 closed). The pressure P1 of the power reservoir would then extend to the power unit, forcing the piston therein to its up position, lifting the load on the piston rod and compressing the initial air pressure C1 into the chamber 16 with a resulting increased pressure C2. During this upstroke a volume of oil V1 has been forced by the expanding pressure P1 into and filling the power unit cylinder from the base to the piston in the up position. The expansion by the transfer of this volume V1 from power reservoir to power unit cylinder has reduced the pressure of P1 to P2 and increased the pressure of C1 to C2. The up position is therefore reached at the point of equilibrium of the resultant of pressure P_2 and C_2. It is obvious that this point of equilibrium and stop may be varied by adjusting initial pressures P_1 and/or C_1 and determined for any desired point of stop below the hydraulic stop at top of the cylinder. The pressure P2 is now extended from power reservoir through valve unit, pipe 22, to the piston in the power unit cylinder. The valve unit 37 then closes and the pressure P2 is separated by the closed valve. A further movement of the valve member 35 opens valve 36 (valve 37 remains closed) and permits the down stroke actuated by the down pull of the weight of the pump rod and the expanding pressure of C2 above the piston, forcing the oil volume V1 below the piston through pipe 22, valve 36, pipe 31 into the

recovery reservoir 26 and compressing its pressure R1 by the amount of oil V1 to an increased pressure R2. This increasing compression of R1 to R2 during the down progress of the piston tends to retard the down velocity of the piston and back pressure R2 which is so determined that it equalizes the gravity load on the piston plus the expanding pressure C_2 increasingly retarding the piston travel until brought to a stop at some determined point above the lower hydraulic stop provided in the base member. At the end of the down stroke the pressure R2 extends from the piston through the valve unit into the recovery tank until valve 36 is closed when this pressure R2 is separated by the closing of said valve. We then have the cylinder pressure C2 reduced to C1 and recovery reservoir with pressure R2 and a power reservoir with pressure P2.

It is now the function of the power driven pump 41 to pump oil volume V1 at pressure R2 from recovery reservoir into the power reservoir, returning to it oil volume V1 to recompress this pressure P2 back to the initial pressure P1, thus completing one cycle. This detail with the modification that the power driven pump action is continuous describes one complete cycle.

In the operation of my power unit equipped with fluid under determined initial pressure within the power reservoir 25 which will be sufficient to raise the rod load attached to the piston 4, the pump plunger and the load of liquid above it are raised against the initial pressure of air compressed in the cylinder above the piston. When the back pressure exerted by the air compressed in the cylinder and extension reaches an equilibrium with the upward pressure the upward movement of the piston is stopped and the piston will remain in that position until the valve 35 is rotated sufficiently to close the passage 34 and then open the passage 33. The weight of the piston and its load plus the expanding pressure of the gas in the upper end of the cylinder and extension 16 will cause the piston to move downwardly, and the oil below the piston will be forced out through the pipe 22 and through the valve member 35 into the recovery cylinder 26. It will there build up a back pressure sufficient to slow down the dropping of the piston until equilibrium and stop is reached at some determined point, where it will remain until the valve member 35 is rotated sufficiently to close passage 33 and open passage 34. The force of the falling piston and its load will compress the gas or air within the recovery cylinder and thus store up pressure. The energy of this stored up pressure is conserved by assisting the pump 41 to move the liquid therein back to the power reservoir 25 to maintain the pressure in said reservoir at the predetermined amount.

Another advantage of my process which is now obvious is that the stroke of the plunger may be lengthened or shortened as desired by the increase or decrease of the coordinated gas pressures. An increase in the initial pressure in the power unit cylinder will decrease the length of the upstroke. An increase in the initial pressure of the power reservoir would increase the length of the upstroke. An increase in the initial pressure of the recovery reservoir will shorten the downstroke while a decrease in this pressure would permit a longer downstroke before an equilibrium and stop is reached. It is also obvious that the determined initial pressures in power and recovery reservoirs are more than a lifting and counter compression means, as their individual values are so fixed and utilized in relation to the determined initial pressure in the cylinder in the power unit that the length of both the up and down stroke is controlled and determined thereby. Under normal operative conditions the speed of piston travel is adjusted to coincide with the opening and closing of the valves. When, however, the normal adjustments are thrown out of balance the valves may close and stop the piston travel before the normal stroke is ended, or the piston may have completed its stroke to await the closing of its valve.

It is also obvious that a change in the gravity load on the piston will change an established equilibrium thereby affecting the length of stroke. The well gassing or starting to flow, or a break in the rod string will all lighten the load and extend the length of stroke upward probably beyond pressure control. On the other hand an undue loss of pressure in the recovery reservoir will lengthen the down stroke. It is to take care of such abnormal changes, sudden or otherwise, that the hydraulic stops at the upper and lower end of the cylinder are provided to decrease shock and bring the ascending or descending piston to a safe hydraulically emergency cushioned stop. By variation of the speed of rotation of the valve member 35 the time between the upward and downward stroke may also be controlled to accomplish the speed of operation which is adapted to any particular pumping installation. The operation of the power driven pump is continuous at almost fixed load and uniform speed with consequent high efficiency for both pump and motive power and with minimum wear. Further advantages of the invention will be obvious to those skilled in the art.

What I claim is new is:

1. A reciprocating motor including a cylinder, a piston therein, a tubular stop member in said cylinder to positively limit the upward movement of said piston therein, a cup shaped upper end on said piston adapted to contain a liquid, a sleeve-like projection extending downwardly from said stop member adapted to engage in said piston when said piston exceeds its normal upward travel and thus act as a shock absorber, a chamber for air under pressure above said stop member, means alternately to introduce into and exhaust pressure fluid from said cylinder below said piston, and means whereby the pressure of fluid in said chamber may be varied to oppose and stop the upward movement of said piston in said cylinder.

2. In a power unit of the character described for wells, a power reservoir, a recovery reservoir, said reservoirs having gas and liquid under individual pressures therein, a pump to transfer liquid from said recovery reservoir to said power reservoir to maintain the desired pressure in said power reservoir, a pipe connection between said reservoirs and a pressure fluid operated motor device, and a valve unit constantly operating at a determined speed in said pipe connections to periodically open and close one valve in the connection from the power reservoir to said device and after a determined time interval to open and close the other valve in the connection between said device and said recovery reservoir with a determined time interval thereafter, before repeating the cycle.

3. In a power unit of the character described for wells, a power reservoir, a recovery reservoir, said reservoirs having gas and liquid under individual pressures therein, a pump to transfer a

sufficient amount of liquid from said recovery reservoir to said power reservoir to maintain the desired pressure in said power reservoir, means to operate said pump in response to a fluid pressure in said power reservoir, a pipe connection between said reservoirs and a pump operating device, and means to operate a valve in each of said pipe connections to control the flow of fluid pressure to said device to periodically open and close one valve from said power reservoir to said device and after a determined time interval to open and close the other with a determined time interval thereafter before repeating the cycle.

4. In a power unit of the character described, a hydraulically operated motor for a well pump, a fluid pressure power reservoir, a recovery reservoir, said reservoirs having gas and liquid under individual pressures therein, a pump to transfer liquid from said recovery reservoir to said power reservoir to maintain a predetermined pressure in said power reservoir, pipe connections between said reservoirs and the intake of said pump motor, a valve member in said pipe connections, a power means to continuously operate said valve member to periodically open and close one valve in the line from said power reservoir to said motor and then open and close the other in the exhaust from said motor with a time interval between the opening and closing of each valve.

5. In combination, a motor cylinder, a load engaging piston therein, a reservoir for liquid under a determined gas pressure to raise said piston and its load, a recovery reservoir to receive the exhaust liquid from said cylinder, said recovery reservoir having gas under determined pressure therein to oppose and finally stop the descent of said piston at a determined point in said cylinder, a gas containing extension on said cylinder having gas under pressure therein sufficient to oppose and finally stop the power stroke at a determined point in said cylinder, and means to control the passage of fluid to and from said cylinder.

6. In a hydro-pneumatic power unit, a cylinder, a piston therein adapted to reciprocate an attached gravity load, said cylinder having a gas volume under determined initial pressure above said piston, means to admit liquid under a determined expanding gas pressure below said piston to force the piston upward thereby compressing the said gas volume above said piston to increasingly retard the upward travel of said piston to a point of balance and stop at a determined point in said cylinder, means in turn to discharge the liquid under said piston with its descending load and expanding pressure, said discharge liquid compressing a gas volume under initial determined pressure to increasingly retard the downward piston travel to a determined point of balance and stop, and means to maintain the said individual gas volumes and pressure at their determined relative values.

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