

Jan. 28, 1947.

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2,414,979

HYDROPNEUMATIC WELL PUMPING SYSTEM

Filed Oct. 24, 1941

2 Sheets-Sheet 1

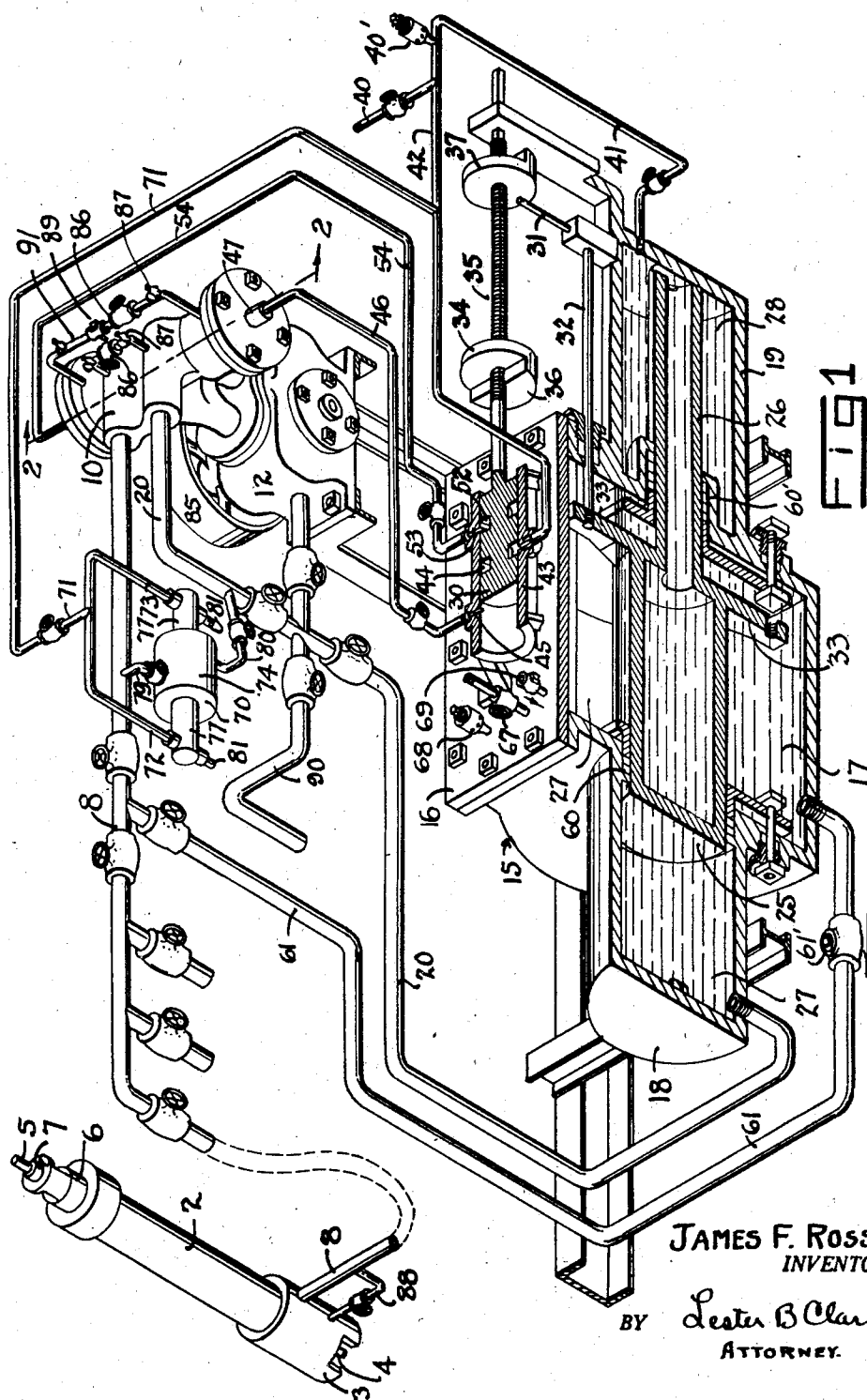


FIG 1

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2 Sheets-Sheet 2

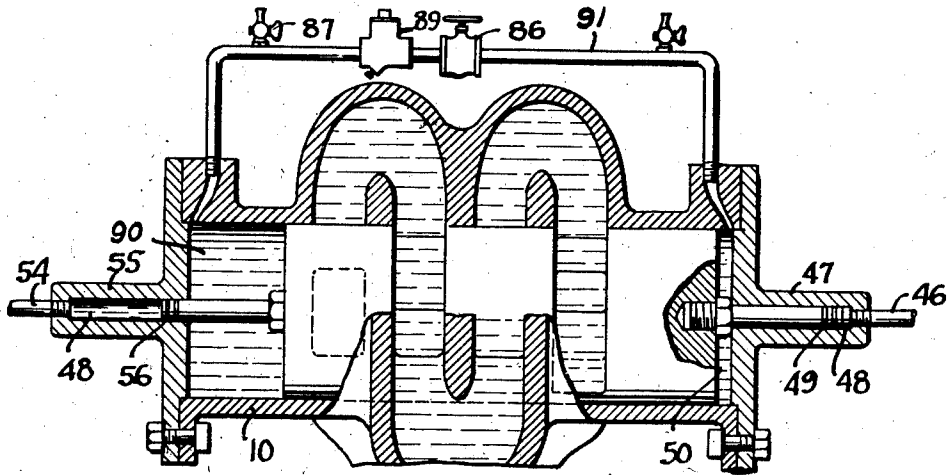


Fig 2

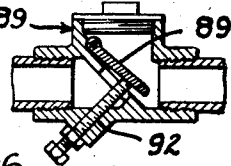
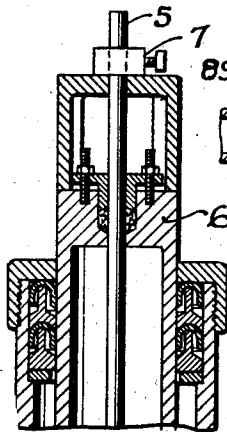


Fig. 6

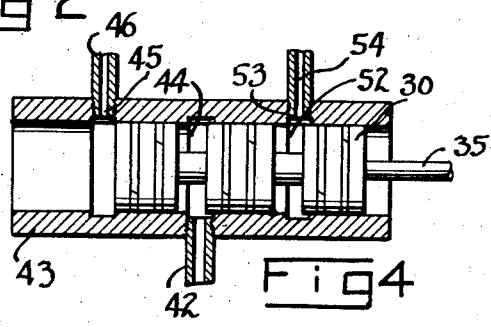


Fig 4

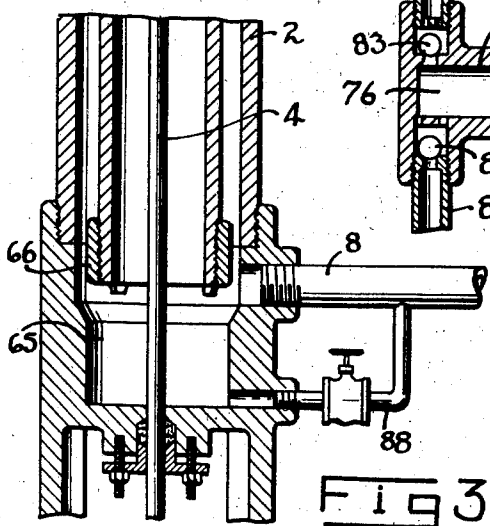


Fig 3

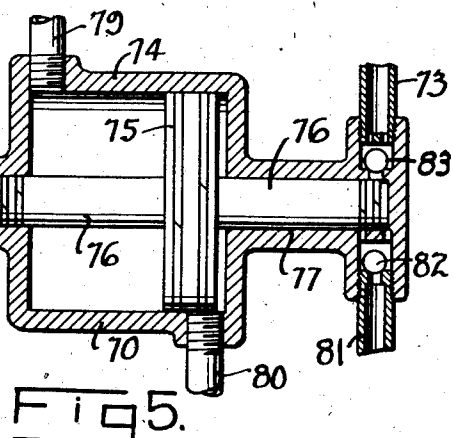


Fig 5.

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UNITED STATES PATENT OFFICE

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HYDROPNEUMATIC WELL PUMPING
SYSTEM

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Application October 24, 1941, Serial No. 416,303

7 Claims. (Cl. 138—30)

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The invention relates to a hydropneumatic well pumping system and particularly to the control of counterbalancing and fluid storage features thereof.

In my prior copending application, Serial No. 216,093, filed June 27, 1938, for a System of pumping wells, there is a detailed disclosure of an entire hydropneumatic pumping system, and in my copending application, Serial No. 308,334, filed December 9, 1939, there are disclosed various forms of different modifications of the control valves and fluid storage assembly.

The present invention contemplates that considerable increase in efficiency of the power pump may be effected by providing a mechanism or assembly by which the actuating liquid and the pneumatic pressure fluid are excluded from each other.

Another difficulty has been encountered in hydropneumatic units where a pneumatic fluid is utilized to maintain a balance or counterbalancing pressure on the actuating liquid because the fluid and the liquid have a connecting interface which permits contamination of the liquid by the gaseous fluid. This difficulty is enlarged upon where higher pressure is utilized because it has been found that air or gas will be more rapidly absorbed by the actuating liquid and in such quantities that the actuating liquid being circulated cannot be efficiently handled by a power pump because such actuating liquid contains compressible gaseous fluids.

With the foregoing difficulty in mind, the present invention contemplates an assembly wherein the actuating liquid is confined in one chamber, the pneumatic fluid in another chamber, and a reciprocable pressure plunger arranged for a floating movement between and within both such chambers.

The term "fluid" will be employed to designate the gaseous pressure fluid used to load the actuating liquid, and the term "liquid" will be employed to designate the actuating liquid used to operate the pumping jack.

One of the objects of the invention is to provide a fluid chamber and an actuating liquid chamber with a pressure plunger floating within and between the two chambers so that the actuating liquid may be loaded with a predetermined pressure.

Another object of the invention is to load the actuating liquid in a hydropneumatic pumping system for wells with a predetermined pressure to effect the balance and counterbalance where such pressure is applied by a differential pressure plunger subjected to relatively high pneumatic pressure.

Another object of the invention is to provide a hydropneumatic pumping system for wells with a differential pressure plunger which will move

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with the flow of the actuating liquid and the movement of such differential pressure plunger actuates the reversing valve.

Still another object of the invention is to provide a reversing valve for hydropneumatic well pumping systems which will have a delayed action at one end of the stroke and a more rapid action at the opposite end of the stroke.

Still another object of the invention is to provide a control system for hydropneumatic well pumping systems wherein leakage of actuating liquid will be returned either manually or automatically during operation to the system whenever the volume of actuating liquid in the system is depleted to a predetermined extent.

Still another object of the invention is to provide a device in a hydropneumatic well pumping system which will either manually or automatically replenish during operations the supply of actuating liquid whenever the volume of the liquid falls below a predetermined amount.

It is also an object of the invention to reduce the size and cost of the fluid chamber by storing the loading gaseous fluid under high pressure in a smaller chamber than heretofore used with lower pressures.

It is also an object to utilize a hollow plunger to separate the liquid and fluid so that the capacity of the hollow plunger may augment the fluid chamber in storing fluid pressure.

Another object of the invention is to utilize high pressures in a hydropneumatic well pumping system so as to employ smaller and more efficient equipment and apparatus.

Another object is to provide a simple, efficient and compact pilot valve to control the operation of the reversing valve.

Another object of the invention is to provide an auxiliary reservoir of actuating liquid to be supplied to the system, which reservoir is maintained at a pressure slightly under or lower than the pressure coming from the jack so that the supply of liquid to the system may be replenished from said pressure source when the supply of pressure liquid from the pumping jack is restricted.

Another object is to so locate the auxiliary reservoir of actuating liquid that the pressure to be maintained thereon will be provided by the action of the floating plunger supplemented by leakage of fluid or liquid into said reservoir from the fluid chamber and from the main liquid chamber.

A still further object is to provide a pump jack construction and operation which will cause the supply of actuating liquid to be automatically replenished.

Other and further objects of the invention will be readily apparent when the following descrip-

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tion is considered in connection with the accompanying drawings, wherein:

Fig. 1 is a perspective diagrammatic assembly of the control mechanism and pumping system with certain of the parts shown in section to illustrate the pilot valve, differential pressure plunger, and housing construction.

Fig. 2 is a section taken on the line 2—2 of Fig. 1, looking in the direction of the arrows.

Fig. 3 is a vertical sectional view of the pump jack cylinder and ram illustrating the mechanism for causing the replenishing of the actuating liquid.

Fig. 4 is a vertical sectional view of the pilot valve construction used to actuate the reversing valve.

Fig. 5 is a vertical sectional view through the compressor device used to compensate for loss of pneumatic fluid.

Fig. 6 is a vertical sectional view of a fluid flow retarding valve for delaying the action of the reversing valve in one direction.

In Fig. 1 the diagrammatic view illustrates the control mechanism for the pump jack ram. The jack cylinder 2 is mounted on the well head 3 and is arranged to receive the sucker rod 4 which extends upwardly from the reciprocating pump in the bottom of the well. This jack cylinder is best seen in section in Fig. 3 wherein the sucker rod 4 extends upwardly into the cylinder and projects at 5 through the top thereof. This cylinder carries a ram 6 which supports the rod by the adjustment clamp 7. The details of this pump jack will be later described.

In order to elevate the ram 6 and the string of rods 4 so as to elevate the oil in the well, a pipe 8 is connected into the base of the cylinder 2 to conduct an actuating liquid to and from the cylinder in effecting the pumping operation. This pipe extends for any desired distance to a point where it is connected with the reversing valve 10. This reversing valve is disposed in the system and controls the flow of liquid to and from the pump jack. This valve 10 is in turn shown in detail in Fig. 2 and will be described in detail hereafter.

An actuating liquid pump 12 has its inlet and discharge connected to the valve housing 10 so that in operation the valve 10 may be used to reverse the direction of flow by either directing liquid from the pump through the pipe 8 into the pump jack cylinder to elevate the ram and sucker rods, or upon reversal of the valve 10 the intake of the pump is connected to the pump jack cylinder. The valve 10 has therefore been designated as a reversing valve.

In order to avoid placing the entire load on the upstroke of the jack upon the pump 12 and the motor which operates it, and to, in turn, take advantage of the force of gravity on the downstroke of the jack which tends to force the actuating liquid out of the pump jack cylinder 2, a balance and counterbalance unit has been provided. This unit is shown generally at 15. The unit includes a housing 16 which has a central chamber 17 therein. The housing 16 has an actuating liquid cylinder 18, or reservoir, on one end, while on the opposite end a pneumatic fluid pressure cylinder 19 has been shown. These cylinders are in axial alignment with each other.

A pipeline 20 is shown as leading from the reversing valve housing 10 to the actuating liquid cylinder 18 and it seems obvious that actuating liquid will be forced into the cylinder 18 when the valve 10 connects the discharge of the pump 12

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to the pipe 20, whereas, the actuating liquid will be forced by fluid pressure out of the cylinder 18 when the valve 10 is reversed and the suction of the pump is connected to the pipe 20.

In other words, the pump 12 will run continuously to discharge the actuating liquid coming from the jack into the cylinder 18 and to receive such liquid from the cylinder 18, depending upon the position of the valve 10. The chamber 18, therefore, serves as a reservoir or source of actuating liquid for the pump.

If the pump 12 were compelled to provide all the power for the elevating of the rod and fluid load of the well, it would be subjected to a maximum power demand on the upstroke and the motor would run idle on the downstroke. It is most efficient for the motor and pump to run continuously and be loaded uniformly because a smaller motor and pump may be used. To accomplish this it is desirable to store not only the energy of the pump during the downstroke, but to also utilize the energy of the actuating liquid due to the gravitational force of the load in the well. It therefore seems apparent that the operation of the pump and the pumping action of the pump jack can be balanced and counterbalanced by applying a predetermined and desired pressure to a plunger such as 25. This pressure on the plunger 25 will assist in the discharge of liquid from the chamber 18 and, in turn, retard the introduction of liquid to the chamber 18. With this in mind the plunger 25 is provided with an extension or shank 26 which extends into the pneumatic chamber 19, and it will be noted that the extension 26 is of considerably lesser diameter than the head 25. The relative sizes or proportions of the head 25 and the extension or plunger 26 can be so adjusted that any desired differential pressure may be maintained upon this extension, or said head and extension may be of equal cross sectional area as is sometimes desirable under certain pumping conditions.

For instance, if a ratio of 10 to 1 is desired, the area of the head 25 will be ten times that of the cross sectional area of the extension 26. Thus, a relatively high pressure of the pneumatic fluid in the chamber 19 can be utilized. This plunger 25 is thus disposed in a floating position between the actuating liquid 27 in the chamber 18 and the pressure fluid 28 in the chamber 19 but the plunger will be urged against the liquid 27 in the chamber 18 by a predetermined and substantially constant pneumatic pressure fluid 28.

In order to control the operation of the entire device in accordance with the flow of actuating liquid, a pilot valve 30 is arranged to be actuated by the arm 31 which is, in turn, connected thru the rod 32 to the projection 33 on the plunger in the chamber 17. Thus, when a predetermined volume of actuating liquid 27 has been drawn from the cylinder 18, due to the suction of the pump 12 and the differential pressure on the plunger 25, the pilot valve 30 will be moved from the position shown in Fig. 1 to its alternate position. The movement of this pilot valve is accomplished when the arm 31 engages an adjustable stop 34 carried by the valve rod 35. The adjustable member 34 is weighted on one side at 36 so that its adjustment will not be inadvertently changed. A similar adjustable member 37 is also positioned on the rod 35 so as to be engaged by the finger 31 on the reverse stroke of the plunger 25 when the pump jack moves to its lowermost position. In other words, when a pre-

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determined volume of liquid is forced from the actuating chamber 18, the pilot valve will be moved and on the other hand, when a predetermined volume of liquid has been introduced into the actuating liquid chamber 18, the pilot valve 30 will again be moved.

In order to supply a pneumatic pressure in the chamber 19, a fitting 40 has been arranged on a pipe 41 which leads into the chamber 19. A piping 42 connected to 41 leads into the housing 43 of the pilot valve 30 and introduces a pressure fluid into the recess 44 of the pilot valve.

This recess 44 is therefore filled with an air, gas or other compressible fluid under pressure when it is in the position shown. When, however, the plunger 25 causes the pilot valve to be moved to the left, the recess 44 will move into alignment with the port 45 in the housing 43 and this will allow the fluid under pressure to discharge into the pipe 46 leading to the sleeve 47 on the end of the reversing valve 10.

In this manner a fluid under pressure will be introduced into the passage 48, (see Fig. 2) in the sleeve 47 which will act upon a piston 49 therein, tending to move the valve member 50 of the reversing valve.

Another recess 52 in the pilot valve member will, at this time, move into alignment with the pipe 42 and in turn be charged with a fluid under high pressure. When the plunger 25 reverses its movement and contacts the adjustable member 37 to move the pilot valve to the right, then the recess 52 will be moved to the position shown in Fig. 1, whereupon the fluid under pressure in the recess 52 will discharge into the port 53 and a pipe 54 leading to the sleeve 55 on the other end of the reversing valve 10. This fluid will, in turn, act upon the piston 56, (see Fig. 2) which is similar to the piston 49, and cause the reversing of the valve member 50 to its opposite position. It will be noted that the ports 45 and 53 are uncovered as the pilot valve makes its stroke, so as to allow for the discharge of any pressure remaining in the pipes 46 and 54. Thus, it will be apparent that by the reciprocating movement of the pilot valve 30 that the reversing valve is alternately moved in accordance with the floating movement of the plunger 25.

It seems obvious that due to pressures in the chambers 18 and 19 there may be some leakage therefrom into the central area or chamber 17 through the stuffing boxes 60 and 60' respectively because of the lower pressure therein. Chamber 17 which entirely surrounds the plunger 25 and the extension 26 is utilized as an auxiliary pressure retaining storage reservoir in which to trap and conserve the leakage from said chambers. Said reservoir is also employed for storing an additional reserve supply of actuating liquid which reserve should be maintained therein in sufficient volume to compensate for all liquid leakage occurring around the pump jack or elsewhere from the system and to automatically lubricate the plunger 25 and the extension 26.

Liquid in said auxiliary reservoir will naturally gravitate into the lower portion thereof as shown in the drawings while the pressure fluid collecting therein will accumulate above the liquid level which pressure fluid however is not specifically indicated in the drawings. Pressure is also generated in said reservoir by reciprocation of the plunger 25 which displaces a certain amount of the liquid and fluid in said chamber during each downstroke of the pump jack. The reservoir 17 may be maintained at any desired pressure below

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that coming from the pump jack during its downstroke which maintained pressure facilitates the passage of liquid from said reservoir through pipes 61 and 8 and aids the motor unit and pump in injecting said liquid into the chamber 18, as is more fully described in the following paragraph:

Inasmuch as the system will operate upon a predetermined volume of actuating liquid it seems obvious that if liquid leaks from the chamber 18 or from around the jack or elsewhere from the system in sufficient quantity to permit the end of the ram 66 to descend into the dash pot construction 65 on the lower end of the jack cylinder, there will then be a reduced pressure in the pipes 8 and 61, due to the fact that said dash pot is provided with a by-pass 88 which restricts, and may be regulated as desired to limit the escape of liquid from under the descending ram. Restricting the flow of liquid from the dash pot increases the pressure therein and gradually checks the momentive and gravitational descent of the ram while at the same time such restriction decreases the pressure in the pipes 8 and 61 to a point below the fluid pressure maintained in the auxiliary reservoir 17, whereupon liquid is automatically forced from the bottom of said reservoir through the pipes 61 and 8 to the pump 12 and thence into chamber 18 without interruption of continuous pumping operations.

The pressure in the reservoir 17 can be increased by applying a source of pressure to the pipe 67 on top of the housing, and a popoff valve 68 may be used to insure the release of any pressure accumulating above a predetermined amount for which this valve may be set. On the other hand, still another valve 69 may be provided to allow the inlet of air from the atmosphere if the pressure in the chamber falls below a predetermined amount. A one way valve 61' is provided in the pipe 61 to prevent high pressure liquid in the closed system from entering said auxiliary reservoir 17.

A double action air compressor arrangement is shown at 70 in Fig. 1 and in section in Fig. 5. This compressor is utilized for the purpose of maintaining a predetermined fluid pressure on the system. The compressor embodies a housing 74, an actuating piston 75 and two compression plungers 76 on the opposite ends thereof which reciprocate in the cylinders 77. Pressure actuating liquid for reciprocating the piston 75 and the plungers 76 is supplied through pipe 79 on one stroke of the pump jack and through pipe 80 on the alternate stroke of the pump jack. During the upstroke of the pump jack, pressure in the liquid pipes 8 and 79 is sufficiently high to overcome the pressures then existing in pipes 20 and 80 and to cause movement of the piston 75 to the right as shown in Fig. 5 and such movement causes the right hand plunger 76 to compress and discharge air from the right hand cylinder 77, through check valve 83 and pipe 73 into the high pressure air line 71 which leads through pipes 42 and 41 to the fluid storage chamber 19. The left hand plunger 76 during said stroke likewise moves to the right thus causing a partial vacuum in the left hand cylinder 77 whereby said cylinder is filled with air entering through the left hand pipe 81 and inlet valve 82.

During the alternate or downstroke of the pump jack the differential pressures in said actuating liquid pipes are reversed and the piston and plungers will move to the opposite or left hand end of their stroke and in like manner com-

press and discharge air from the left hand cylinder through pipe 72 and thence into the storage chamber 19. Said movement to the left meanwhile causes the right hand cylinder to refill with air available for compression during the next succeeding upstroke which completes the compression cycle. As the air compression plungers 76 are constantly immersed in liquid it is therefore possible to generate high pressures without undue heating and thus automatically maintain any desired high pressure in the chamber 19. A pop valve 40' may be set as desired to release any excess pressure existing in the system.

In pumping modern deep oil wells, especially when operating at high speed, a too rapid checking of the momentive and gravitational forces generated by the weight of the descending rods will cause very destructive shocks and stresses to the sucker rods and pumping equipment. This damage is eliminated or nullified by employment of the fluid flow retarding valve 88', Fig. 6 which acts to slow down as desired the action of the reverse valve 10 at one end of its stroke. The valve 88' has a hinged disc 89 therein which permits a free flow of fluid past said disc in one direction but which may be regulated by the adjusting screw 92 to check or limit the flow of fluid in the opposite direction thereby slowing down the operation of the reversing valve 10 as desired.

A modification of the application of said fluid retarding valve 88' consists in introducing a similar or substitute flow retarding valve in one of the lines 46 or 54 which supply air to actuate the reverse valve 10 thus slowing the movement of said reverse valve at one end of its stroke. A further modification of such mechanism consists of eliminating the adjusting screw, 92 and providing or boring a hole or passageway through the disc 89 of proper size to limit the fluid flow past said disc, to the proper amount to slow down the action of the reversing valve 10 as desired.

It is to be understood that under normal operating conditions a sufficient volume of liquid should be maintained in the system to prevent the lower end of the ram 66 from entering the dash pot 65. In other words, the downstroke of the ram is preferably terminated approximately as shown in Fig. 3.

The pump 12 is operated by means of a drive wheel 85 which may be driven by a belt or a suitable motor.

The reversing valve 10 may have suitable control valves, such as 86 and 88' thereon to control the action thereof because it is desirable that it be operated so as to avoid any shock to the system. Suitable vent valves 87 may also be provided if desired.

It is to be understood of course, that all the pipe connections have suitable valves and vents therein as may be desired to maintain and control the pressures.

A pipe 90 is shown in Fig. 1 which may serve as a drain or filler for the system or the pump 12.

Broadly, the invention contemplates a hydro-pneumatic pumping system wherein the pressures are automatically maintained for actuating liquid and replenishing the actuating liquid and wherein the pressure fluids are excluded from each other so as to provide an economic and successful pumping system.

What is claimed is:

1. In a hydropneumatic pumping system for wells wherein a flow of actuating liquid is controlled to effect the pumping action, an accumulator including a housing, an actuating liquid

chamber thereon, a pneumatic fluid chamber thereon, a differential pressure plunger freely supported to float between said chambers to maintain a predetermined pressure on the liquid in the liquid chamber due to the pressure of the fluid in the pneumatic chamber, means in said housing to receive the leakage from each of said chambers, and means to exhaust the pressure fluid and to return the liquid to the system.

2. In a hydropneumatic well pumping system where an actuating liquid is loaded with a pneumatic fluid, a plunger disposed between the liquid and fluid, said plunger being disposed to float between the liquid and fluid to transmit movement to one or the other depending on the predominant force, said plunger having different sized exposed surfaces in said liquid and fluid so as to obtain a differential in pressures, said plunger being hollow and open to the pneumatic fluid end to provide a storage chamber for a quantity of such pneumatic fluid.

3. In a hydropneumatic pumping system for wells wherein a flow of actuating liquid is controlled to effect the pumping action, an accumulator including a pneumatic pressure chamber, an actuating liquid chamber, an intermediate closed reservoir receiving fluids including actuating fluid and pneumatic fluid from their respective chambers, a pressure plunger freely supported to float between and within said chambers to maintain a predetermined pressure on the liquid within the liquid chamber due to the pressure of the fluid in the pneumatic chamber, means to conduct the actuating fluid from the intermediate reservoir to the pumping system and means for establishing a maximum fluid pressure which may be attained within the intermediate reservoir.

4. A device of the character set forth in claim 3 including means permitting the free entry of atmospheric air to the intermediate reservoir.

5. In a hydropneumatic pumping system for wells wherein a flow actuating liquid is controlled to effect the pumping action, an accumulator including a pneumatic fluid chamber, an actuating liquid chamber spaced therefrom, an intermediate closed reservoir between and connecting said chambers to receive fluid leakage from both of said chambers, a pressure plunger having longitudinal aligned lengths of different diameters said plunger extending across the intermediate reservoir with one of its ends reciprocally mounted within the actuating liquid chamber and the other of its ends reciprocally mounted within the pneumatic fluid chamber whereby movement of the plunger length of largest diameter from its chamber into the intermediate reservoir will increase the pressure of fluid within said reservoir by fluid displacement, means to conduct the actuating fluid from the intermediate reservoir to the pumping system and means acting to prevent a counterflow of said fluid through the conducting means.

6. In a device of the character set forth in claim 5 including means for limiting the pressure of fluid occurring within the intermediate reservoir.

7. In a device of the character set forth in claim 5 including means for limiting the pressure of fluid occurring within the intermediate reservoir and means permitting the entry of air into said reservoir when the fluid pressure within the reservoir is lower than atmospheric pressure.

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