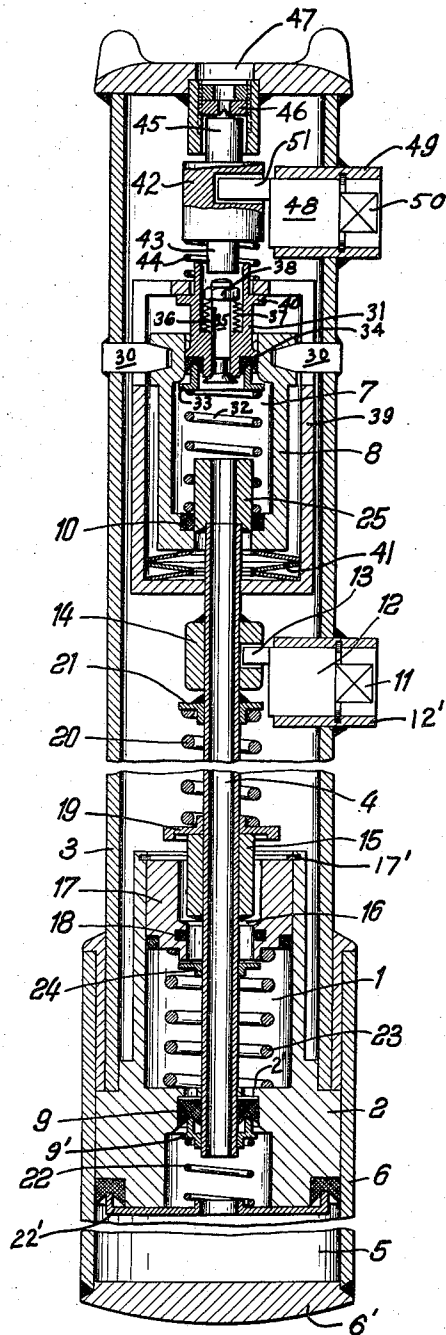


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W. WILKENLOH ET AL
PUMP MEANS FOR HYDRAULIC JACKS

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Inventors:

WILHELM WILKENLOH
AND ERICH JÄGER

BY
Michael S. Stuber
att.

1

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PUMP MEANS FOR HYDRAULIC JACKS

Wilhelm Wilkenloh, Duisburg-Buchholz, and Erich Jäger,
Duisburg-Wanheim, Germany, assignors to Rhein Stahl
Wanheim Gesellschaft mit beschränkter Haftung

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The present invention relates to hydraulic arrangements adapted to be used as props or jacks. For example, the structure of the present invention may be used as a prop extending between the floor and roof of a mine. It is often desirable with such hydraulic arrangements to provide very large forces which are difficult to obtain with known hydraulic arrangements which are used as jacks or props, and where a rapid movement of such a jack or prop into an expanded position is required it is necessary to use undesirably large pistons. Furthermore, with the known hydraulic arrangements a great deal of energy used in operating pumps of such arrangements is wasted.

One of the objects of the present invention is to provide a hydraulic jack or prop with a pump which enables energy applied to the pump during one of its strokes but not used for that stroke to be stored in the pump and automatically used as part of the force for effecting the succeeding stroke of the pump.

Another object of the present invention is to provide a hydraulic jack or prop with a pump which requires substantially equal forces for its suction and pressure strokes.

A further object of the present invention is to provide a hydraulic jack or prop capable of being rapidly expanded without having undesirably large pistons.

An additional object of the present invention is to provide in an arrangement of the above type a pump structure capable of being manually operated and being made up of simple and ruggedly constructed parts many of which perform multiple functions.

With the above objects in view the present invention mainly consists of an expandable and collapsible hydraulic arrangement to be used as a jack or a prop, this arrangement including a plurality of telescoped tubes and pump means in the tubes for expanding the same. An operating means is connected to the pump means for moving the same through operating cycles each of which includes a pressure stroke and a suction stroke, and a means, forming part of the pump means, is provided for storing energy applied to the pump means through the operating means during one of the strokes and applying the stored energy to the pump means during the other of the strokes.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantage thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

The drawing is a longitudinal, central section through a hydraulic arrangement constructed in accordance with

2

the present invention, part of the structure being schematically illustrated, and parts of the elongated tubes being broken away so as to enable the structure to be conveniently illustrated.

5 Referring now to the drawing, it will be seen that an outer tube 6 has an inner tube 3 telescopically slidable therein. The outer tube 6 is provided at its bottom end with an end wall 6'. The inner tube 3 is provided within the tube 6 with an end wall in the form of a piston 2 which 10 slidably engages the inner surface of the tube 6. The end wall 6' and end wall 2 form between themselves within the tube 6 a chamber 5.

A pair of pins 30 are fixed to the inner tube 3 and extend into the interior thereof where they support an enclosure 8 having a bottom end wall formed with a bore 15 passing therethrough. A hollow shaft 4 extends through a bore of piston 2 and through the bore of the end wall of enclosure 8 so that the interior 7 of enclosure 8 communicates through the shaft 4 with the chamber 5. The 20 chambers 5 and 7 together with the interior of shaft 4 form a high pressure chamber, as will be apparent from the description which follows. The lower end portion of the hollow shaft 4 extends slidably through a sealing ring 9 located in the bore of piston 2, and the top end of the shaft 4 is fixed to a tubular piston 25 which extends slidably through a sealing ring 10 carried by the enclosure 8 at the bore thereof. This enclosure 8 also forms a housing for a valve, as will be apparent from the description which follows.

30 A crank 12 is turnable within a tubular member 12' extending through and carried by the wall of the inner tube 3, and this crank 12 has at its outer end face a non-circular projection 11 to which a crank handle may be fixed so that crank 12 may be manually rotated. A crank pin 35 13 is fixed eccentrically to the inner face of crank 12, and this pin 13 extends into a recess within a block 14 fixed to the shaft 4 at the exterior thereof. The recess of block 14 into which the pin 13 extends is large enough to permit rotation of the crank 12 while retaining the pin 13 in engagement with the block 14. Thus, during rotation 40 of the crank 12 the shaft 4 will be raised and lowered.

A piston 15 is fixed to the shaft 4 and thus moves therewith. A second piston 17 is located about the shaft 4 and is formed with a bore 16 into which the piston 15 slidably 45 extends when the piston 15 is moved with respect to piston 17 downwardly beyond the position shown in the drawing. The bore 16 is a suction bore, and the piston 17 is located slidably within a cylindrical extension 1 of the piston 2. A sealing ring 18 is located on piston 17 at bore 16 to 50 seal the engagement between pistons 15 and 17. Thus, when the crank 12 is turned to move the shaft 4 downwardly, as viewed in the drawing, the piston 15 will move down and close the bore 16 so as to shut the interior of the cylindrical extension 1.

55 A ring 19 is located freely about the shaft 4 for movement with respect to the same and rests against the piston 15 in the position of the parts shown in the drawing. A spring 20 located about the shaft 4 has one end in engagement with a ring 21 which is fixed rigidly to the shaft 4 as 60 by welding or the like. Upon downward movement of the piston 15 with the shaft 4, the ring 19 will engage the piston 17 and there will be sufficient force in the spring 20 to urge the piston 17 downwardly together with the piston 15 as long as the pressure of the fluid medium within the extension 1 is below a given value.

65 A plate 22' is retained against the bottom face of

3

piston 2 and is formed with a central bore about which a coil spring 22 is located on the upper face of the plate 22'. This coil spring 22 bears against a ring 9' which in turn bears against the sealing ring 9 to maintain the latter against the bottom face of the inner circular portion 2' of piston 2 which directly surrounds the shaft 4 and which is formed with bores passing therethrough, as shown in the drawing. Upon movement of pistons 15 and 17 toward the piston 2, the pressure of the fluid in the extension 1 increases sufficiently to shift the sealing ring 9 downwardly against the force of spring 22 so as to open the passage between chamber 5 and extension 1 and the fluid in extension 1 thus flows into the chamber 5 during the downward pressure stroke of pistons 15 and 17 to effect upward displacement of piston 2 and tube 3. Because of the large volume displaced by pistons 15 and 17 during their downward pressure stroke, as described above, a considerable quantity of fluid will flow into the chamber 5 to effect a rapid expansion of the tubes, so that when the structure is used as a mine prop the top of tube 3 may be quickly moved into engagement with the roof. Up to the present time extremely large pistons have been used in order to obtain the necessary rapid expansion of such a prop.

During the upward movement of shaft 4 caused by continued rotation of crank 12, the suction stroke of the pump takes place, and pistons 15 and 17 move upwardly together, piston 17 being moved up by the spring 23 which acts through the ring 24 on the piston 17. Of course, the spring 20 is stronger than the spring 23 so as to be capable of moving the piston 17 downwardly during its pressure stroke. During the upward movement of the shaft 4, the piston 17 moves up under the influence of spring 23 until it engages the snap ring 17' located in a groove formed in the inner face of the extension 1. The upward movement of the pistons 15 and 17 creates a partial vacuum within the cylindrical extension 1, and after piston 17 engages the ring 17' the continued upward movement of piston 15 together with the shaft 4 opens the bore 16 so that fluid will flow from the interior of tube 3 through the bore 16 into the extension 1.

It will be noted that because the chamber 5 communicates through shaft 4 with the chamber 7, the pressure in these chambers is the same, and the upward movement of the shaft 4 moves the piston 25 into the chamber 7 so as to increase the pressure of the fluid therein, and this increased pressure acts to store energy which urges the piston 25 downwardly to contribute to the force required for the succeeding pressure stroke. Thus, during the succeeding pressure stroke the force required by the operator is diminished by the force of the fluid in the chamber 7 acting on the piston 25.

This operation will continue until the pressure required to move fluid from extension 1 into chamber 5 is so great that the spring 20 can no longer move the piston 17 together with the piston 15 during the downward stroke of the latter. At this time the smaller piston 15 works by itself since the piston 17 remains in its upper position shown in the drawing.

It will be noted that because the piston 17 no longer moves downwardly with the piston 15, the continued downward movement of the latter with the shaft 4 results in further compression of the spring 20 without movement of the piston 17. However, this energy which is stored into the spring 20 is not wasted since it is expended in the succeeding suction stroke by contributing to the force required for moving the shaft 4 together with the piston 25 upwardly. Thus, with the above-described arrangement by proper choice of the sizes of pistons 25, 15, and 17 not only is it possible to store during one stroke of the pump energy which is used in the succeeding stroke of the pump, but also it is possible to make the force required for the suction strokes substantially equal to that required for the pressure strokes. Since the force required to move the piston 25 into the

4

chamber 7 is used in the succeeding pressure stroke the output of the pump is almost double so that with proper choice of the diameters of the pistons this advantage may be applied either toward obtaining a very large force with the hydraulic arrangement of the invention or toward obtaining a very large speed of operation.

The enclosure 8 is formed in its top wall with a bore through which a valve body 31 slidably extends. A spring 32 in the enclosure 8 urges a ring 33 against a sealing ring 34 which engages the valve body 31 and seals the engagement between the valve body 31 and the enclosure 8. The valve body 31 is itself axially bored and a valve member 35 formed with an outer axially extending groove 36 is slidable in the bore of valve body 31. The bottom end of valve member 35 is enlarged and bears against the bottom end of the bore of body 31 to close this bore. A plurality of ring-shaped dish springs 37 engage a nut 38 to urge the bottom end of valve 35 against its seat. A cylindrical member 39 is freely located about the enclosure 8 and is formed with elongated cutouts through which the pins 30 freely extend. The cylindrical member 39 has a top wall formed with a bore through which the body 31 extends, and this body 31 is formed with an outer annular projection 40 against which the top wall of the member 39 is urged by the ring-shaped dish springs 41 located about shaft 4 and between enclosure 8 and the bottom wall of the cylindrical member 39. A block 42 is located within the tube 3 above the valve body 31 and is provided with a bottom extension 43 located in alignment with the valve 35. A spring 44 engages the top face of member 39 and block 42 to urge the latter upwardly, and the top end of block 42 is formed as a valve 45 which engages the annular member 46 located in the interior of tube 3 to close the interior of tube 3, this annular member 46 having its central opening in communication with a bore 47 formed in the top wall of the tube 3. A crank 48 is turnably carried in a tube 49 fixed to and extending through the wall of the tube 3, and the crank 48 has a non-circular extension 50 to which a handle is adapted to be connected. An eccentric crank pin 51 is fixed to and extends from the inner face of crank 48 and extends into a recess of block 42, this recess having sufficient clearance to permit turning of crank 48 through an angle sufficient to open the passage through the annular member 46 as well as to move the valve 35 downwardly and open the passage through the valve body 31.

The interior of the tube 3 is filled with any suitable hydraulic fluid such as oil by turning the crank 48 so as to open the passage through the ring 46. Upon release of the crank 48, the spring 44 closes this passage by moving the valve 45 into engagement with the ring 46. Also, during filling of the interior of tube 3 the crank 48 is turned sufficiently to cause extension 43 to open the valve 35 and the oil flows into chamber 7 and down the shaft 4 into chamber 5, the valve 35 being returned to its closed position by springs 37 when the crank 48 is released.

During operation of the pump oil flows from the interior of tube 3 into the extension 1 and from the latter into the chamber 5. Thus, in this way oil becomes displaced from the interior of tube 3 to the interior of the tube 6 and the tubes thus expand whereby, when the prop is used in a mine the top plate of the inner tube 3 is pressed with increasing pressure against the roof of the mineshaft.

To prevent increase of this pressure over a predetermined maximum amount, which would cause the tube 3 to buckle, the valve 31, 35 will act as a safety valve when the predetermined maximum pressure is surpassed. In this case the increased pressure in chamber 7 will lift the valve body 31. Since this valve body 31 contacts with its flange 40 the member 39, this member will be also lifted against the force of the spring plates 41. The action will take place only when the pressure in the

5

chamber 7 is increased so that this pressure will overcome the force of spring plates 41. When the valve body 31 is thus lifted the upper end of the valve stem 35 will abut against the extension 43 of the block 42 and the valve will open so that compressed fluid may pass from the chamber 7 into the tube 3. Thereby the pressure in the chamber 7 and the chamber 5 connected thereto is reduced to the permissible maximum pressure.

When it is desired to move tube 3 back into the tube 6, the crank 48 is again turned so as to move the block 42 downwardly, as viewed in the drawing, and this results on the one hand in opening of the passage through ring 46 so that the interior of tube 3 communicates with the atmosphere, and on the other hand in the opening of the valve 35 so that fluid in the chamber 5 may flow upwardly through the tube 4 into the chamber 7 and from the latter through the valve body 31 into the tube 3. The valve 31, 35 has therefore two purposes. It will serve as outlet valve whenever it is desired to collapse the expanded prop, in which case the valve is operated by the crank 48. Secondly, the valve 31, 35 will act as safety valve to prevent increase of the pressure fluid in the chamber 7 above a predetermined maximum amount.

The hydraulic prop as described above operates as follows:

During the first part of the operation of the prop in which the fluid serves only to lift the deadweight of the inner tube 3 and the part of the mechanism connected thereto the piston 15 fixedly attached to the hollow shaft 4 will, during the downward movement of the shaft 4, close the bore 16 in the larger piston 17 and compress the fluid in the chamber 1. Thereupon the valve 9 opens against the pressure of the spring 22 and the fluid will pass from the chamber 1 into the expansion chamber 5 and from there through the hollow shaft 4 also in the upper chamber 7. During the further downward stroke of the shaft 4 the plate 19 pressed by the spring 20 against the upper surface of the piston 15 will contact the upper surface of the piston 17 so that the two pistons are coupled together and moved together downwardly, whereby a greater volume of fluid is moved from the chamber 1 into the chambers 5 and 7. During the upward or suction stroke of the shaft 4 the pistons 15 and 17 will move first together in upward direction under the action of the spring 23 until the upper surface of the piston 17 strikes the snap ring 17'. Thereupon the upward movement of the piston 17 stops and the piston 15 will therefore move relative to the piston 17 further in upward direction opening again the bore 16 so that the fluid in the tube 3 may communicate with the chamber 1. It is understood that the spring 22 will close the valve 9 during the upward movement of the pistons 17 and 15 so that the compressed fluid in chambers 5 and 7 cannot pass into the chamber 1 during the upward suction stroke of the pump.

During this first part of the operation in which the prop is not under pressure the pistons 15 and 17 act together to displace a large amount of fluid during the pumping stroke and to provide thereby for a rapid expansion of the prop.

When the top plate of the inner tube 3 abuts against the roof of mineshaft, or against any other object to be supported, the rapid expansion of the prop will stop and the fluid pressure in the chambers 5 and 7 will increase with every pump stroke. During this part of the operation the action of the mechanism will differ from the action as described above. During the downward movement of the shaft 4, that is during the pumping stroke, the piston 15 will again close the bore in the piston 17, compress the fluid in the chamber 1, the valve 9 will open and the fluid compressed in the chamber 1 will pass therefrom into the chambers 5 and 7. When the valve 9 opens, the pressure in the chamber 1 is of course the same as in the chambers 5 and 7 and this pressure will increase rapidly when the end plates of the tubes 3 and 6 re-

6

spectively are in engagement with the faces of the mineshaft. When the built-up pressure is greater than the force necessary to compress the spring 20, and when the plate 19 contacts during the downward stroke of the shaft 4 the upper surface of the piston 17, the piston 17 will due to the increased pressure in the chambers 1, 5 and 7 remain stationary and the spring 20 will be compressed between the plate 19 resting on the stationary piston 17 and the plate 21 fixed to the shaft 4. During this compression of the spring 20 energy will be stored in this spring, which will be released on the return stroke or suction stroke of the shaft 4.

It should be noted that during the downward pumping stroke the fluid pressure in the chambers 5 and 7 acts on the top surface of the piston 25 and this force acts therefore during the downward stroke in the same direction as the force on the crank 12. During the pumping stroke the piston 15, after closing the bore in the piston 17 and opening the valve 9 has to overcome the full pressure in the chamber 1. The force acting on the piston during this period is equal to the force exerted by the crank 12 and the force of the compressed fluid acting on the piston 25 minus the force with which the spring 20 resists its compression.

During the upward suction stroke the piston 25 works against the full pressure in the chamber 7. The force acting during this period on the piston 25 is equal to the sum of the forces from the crank 12 and the force which the spring 20 returns during its expansion, minus the negligible small force of the atmospheric pressure acting on the piston 15 during its movement out of the chamber 1.

By properly dimensioning the spring 20 and the diameters of pistons 15 and 25 it is possible to reduce the difference between the necessary crank forces during the pumping and the suction stroke to a minimum. An increase of the diameter of piston 25 relative to the diameter of piston 15 will reduce the necessary crank force during the downstroke and will require an increased crank force during the up stroke.

A pump action is always assured by the two pistons 15 and 25. At the end of the up stroke the chamber 1 communicates with the interior of tube 3 and fluid will enter from the tube 3 into the chamber 1. During the down stroke the piston 15 enters into the chamber 1 and displaces fluid therefrom into the chambers 5 and 7. Every down stroke therefore increases the amount of fluid in the pressure chambers 5 and 7. During the up stroke the amount of liquid in the chambers 5 and 7 remains constant and the pressure increases as the piston 25 displaces liquid from the chamber 7 into the chamber 5 whereby the top plate of tube 3 will be pressed with increased force against the wall it abuts. It should be noted that the energy accumulated by and returned to the piston 25 is increased with increasing pressure of the fluid in the chambers 5 and 7. The accumulation of energy therefore increases as the necessary force for the pumping action becomes greater. A compensation of the crank forces during the up and down strokes therefore takes place during all pressure conditions in the chambers 5 and 7.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of hydraulic props or jacks differing from the types described above.

While the invention has been illustrated and described as embodied in pump arrangements for hydraulic props or jacks, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential char-

acteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a pump and pressure chamber unit, in combination, a first pressure chamber; a second pressure chamber; reciprocating pump means having a pressure stroke and a suction stroke for pumping pressure fluid into said first pressure chamber during said pressure stroke thereof and including a hollow shaft communicating at opposite ends thereof with said first and said second pressure chamber, respectively; a piston fixedly mounted on said hollow shaft for movement in and out of said second pressure chamber for increasing the volume of said second pressure chamber during the pressure stroke of said pump means and for decreasing the volume of said second pressure chamber during the suction stroke of said pump means; and operating means operatively connected to said hollow shaft for reciprocating said pump means and for moving said piston out of said second pressure chamber during the pressure stroke of said pump means and into said second pressure chamber during the suction stroke of said pump means.

2. In a pump and pressure chamber unit, in combination, a first pressure chamber; a second pressure chamber; reciprocating pump means having a pressure stroke and a suction stroke for pumping pressure fluid into said first pressure chamber during said pressure stroke thereof and including a cylinder having an end wall, piston means arranged in said cylinder movable towards and away from said end wall, inlet valve means formed in said piston means, outlet valve means in said end wall, and a hollow shaft communicating at opposite ends thereof with said first and second pressure chamber, respectively, and operatively connected to said piston means; a piston fixedly mounted on said hollow shaft for movement in and out of said second pressure chamber for increasing the volume of said second pressure chamber during the pressure strokes of said pump means and for decreasing the volume of said second pressure chamber during the suction stroke of said pump means; and operating means operatively connected to said hollow shaft for reciprocating said pump means and for moving said piston out of said second pressure chamber during the pressure stroke of said pump means and into said second pressure chamber during the suction stroke of said pump means.

3. In a pump and pressure chamber unit, in combination, a first pressure chamber; a second pressure chamber; reciprocating pump means having a pressure stroke and a suction stroke for pumping pressure fluid into said first pressure chamber during said pressure stroke thereof and including a cylinder having an end wall, piston means arranged in said cylinder movable towards and away from said end wall, inlet valve means formed in said piston means, outlet valve means in said end wall, and a hollow shaft communicating at opposite ends thereof with said first and second pressure chamber, respectively, and operatively connected to said piston means, said hollow shaft being concentrically arranged with said outlet valve means and being guided therein; a piston fixedly mounted on said hollow shaft for movement in and out of said second pressure chamber for increasing the volume of said second pressure chamber during the pressure stroke of said pump means and for decreasing the volume of said second pressure chamber during the suction stroke of said pump means; and operating means operatively connected to said hollow shaft for reciprocating said pump means and for moving said piston out of said second pressure chamber during the pressure stroke of said pump means and into said second pressure chamber during the suction stroke of said pump means.

4. In a pump and pressure chamber unit, in combination, a first pressure chamber; a second pressure chamber;

reciprocating pump means having a pressure stroke and a suction stroke for pumping pressure fluid into said first pressure chamber during said pressure stroke thereof and including a cylinder having an end wall formed with a bore therethrough communicating at one end thereof with said first pressure chamber, a hollow shaft communicating at opposite ends thereof with said first and second pressure chamber, respectively, and extending with clearance through said bore, combined seal and non-return valve means located in said bore about said shaft for preventing fluid from flowing from said first pressure chamber into said cylinder and permitting fluid to flow through said bore from said cylinder into said first pressure chamber, a first piston slidable in said cylinder and formed with a second bore through which said shaft passes with clearance, a second piston fixed to said shaft and slidable into and out of said second bore, and spring means operatively connected to said shaft and engaging said pistons for moving said first piston together with said second piston when pressure in said cylinder is below a predetermined value; a third piston fixedly mounted on said hollow shaft for movement in and out of said second pressure chamber for increasing the volume of said second pressure chamber during the pressure stroke of said pump means and for decreasing the volume of said second pressure chamber during the suction stroke of said pump means; and operating means operatively connected to said hollow shaft for reciprocating said pump means and for moving said third piston out of said second pressure chamber during the pressure stroke of said pump means and into said second pressure chamber during the suction stroke of said pump means.

5. In a pump and pressure chamber unit, in combination, a first pressure chamber; a second pressure chamber; reciprocating pump means having a pressure stroke and a suction stroke for pumping pressure fluid into said first pressure chamber during said pressure stroke thereof and including a cylinder having an end wall formed with a bore therethrough communicating at one end thereof with said first pressure chamber, a hollow shaft communicating at opposite ends thereof with said first and second pressure chamber, respectively, and extending with clearance through said bore, combined seal and nonreturn valve means located in said bore about said shaft for preventing fluid from flowing from said first pressure chamber into said cylinder and permitting fluid to flow through said bore from said cylinder into said first pressure chamber, a first piston slidable in said cylinder and formed with a stepped bore having a smaller diameter at the end of the bore directed toward said cylinder through which said shaft passes with clearance, a second piston fixed to said shaft and having an outside diameter equal to said smaller diameter of said bore, said second piston being movable from a position in which it is located outside said smaller diameter of said bore so that fluid may pass between said first and second piston into said cylinder and a position in which said second cylinder is at least partly located within said smaller diameter of said stepped bore thereby preventing passage of fluid through said stepped bore, and spring means fixedly connected at one end thereof to said shaft and engaging said first piston with the other end thereof, for moving, during the pressure stroke, said first piston together with said second piston when pressure in said cylinder is below a predetermined value, while said first cylinder remains stationary during the pressure stroke when said predetermined value is surpassed, said spring means being stressed during said pressure stroke when said first piston remains stationary so that energy is stored in said spring means and this stored energy is returned during the suction stroke of said pump means; a third piston fixedly mounted on said hollow shaft for movement in and out of said second pressure chamber for increasing the volume of said second pressure chamber during the pressure stroke of said pump means and for decreasing the volume of said

second pressure chamber during the suction stroke of said pump means; and operating means operatively connected to said hollow shaft for reciprocating said pump means and for moving said third piston out of said second pressure chamber during the pressure stroke of said pump means and into said second pressure chamber during the suction stroke of said pump means.

References Cited in the file of this patent

UNITED STATES PATENTS

430,251 Kendall ----- June 17, 1890

945,648
947,613
1,170,139
1,579,913
1,829,451
2,048,098
2,435,326
2,440,060
2,550,163

10

Wakefield ----- Jan. 4, 1910
Gathmann ----- Jan. 25, 1910
Briau ----- Feb. 1, 1916
Bronson ----- Apr. 6, 1926
McNab ----- Oct. 27, 1931
Bohnenblust ----- July 21, 1936
Schwerin ----- Feb. 3, 1948
Page ----- Apr. 20, 1948
Phenning ----- Apr. 24, 1951