

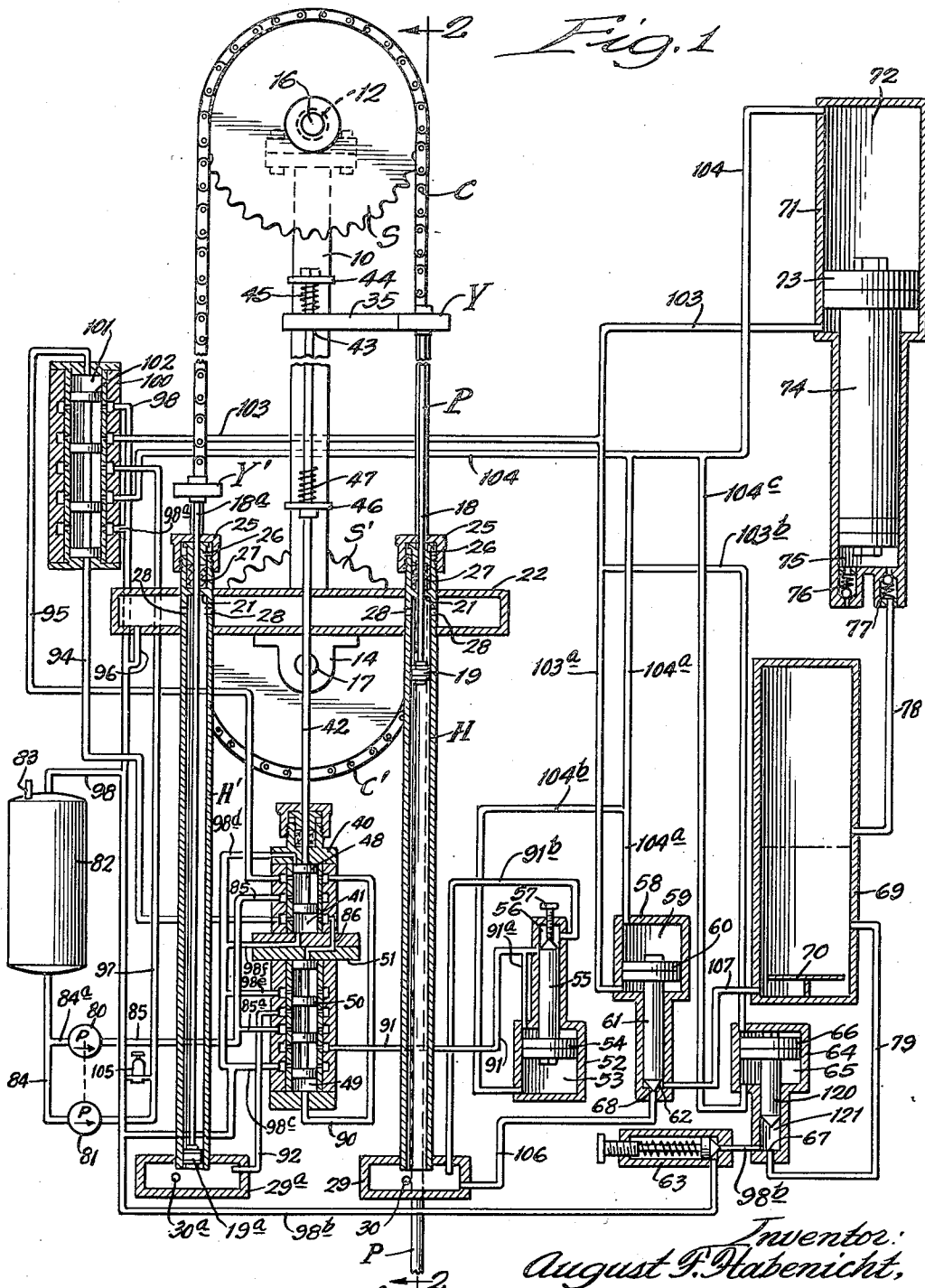
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A. F. HABENICHT
HYDRAULIC POWER UNIT

2,560,285

Filed July 15, 1948

2 Sheets-Sheet 1



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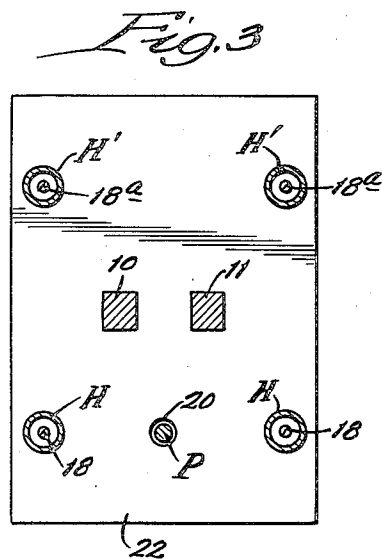
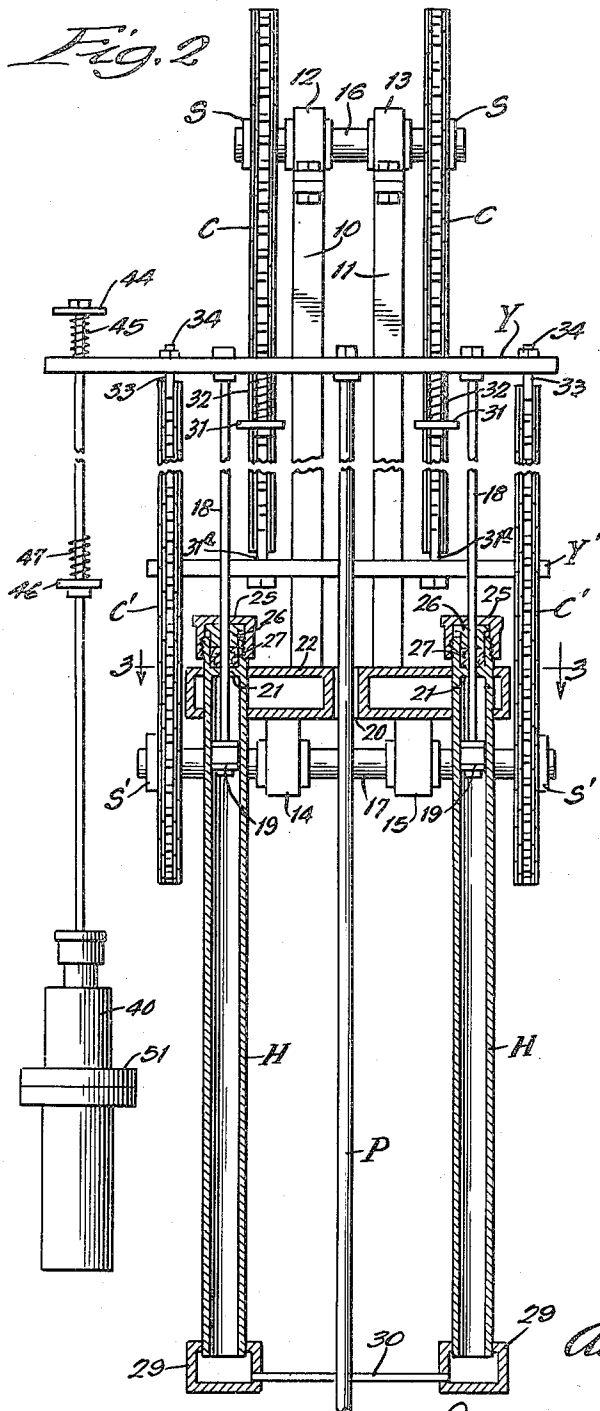
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UNITED STATES PATENT OFFICE

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HYDRAULIC POWER UNIT

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Application July 15, 1948, Serial No. 38,812

4 Claims. (Cl. 60—51)

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This invention relates to hydraulic power devices, and in particular to a reciprocating-piston hydraulic engine adapted to operate a deep-well pump or other load having great inertia.

In the design of power means for starting and reciprocating the shafts of deep-well pumps the inertia of the pump shaft and its associated piston presents a very serious difficulty. A typical deep-well pump may have a shaft several hundred feet or more in length, with a piston at the lower end thereof. The overall weight of the shaft and piston may be very great, and starting it upward against the force of gravity can, in general, be accomplished only by the application of a relatively tremendous thrust. If the power plant at the top of the well is made large enough to provide the required initial thrust without overloading, then its capacity is largely unused throughout the major part of the stroke, since the thrust required for raising the shaft after it is once in motion is very much less than the thrust required to start it. On the other hand, if a power plant be provided whose steady out-put is appropriate for the movement of the shaft, then it is likely to be overloaded to the breaking point when the pump shaft is started upward.

An object of this invention is to provide a hydraulic power unit having means adapted to receive energy during the power cycle and to store it for use in assisting the power unit during that portion of the cycle when a heavy mass must be started in motion. Another object of this invention is to provide a hydraulic power unit having a cushion chamber into which hydraulic fluid can pass and store energy by compressing the air therein, such stored energy being made available for the assistance of the power unit during the portion of its stroke wherein abnormally great thrust is required.

Still another object of this invention is to provide, in a hydraulic power unit having a cushion chamber for the storage of energy by air compression, a novel means for insuring that the air content of the chamber is held at an adequate level to insure proper operation. A further object of this invention is to provide, in such a hydraulic power unit, means insuring that the energy stored in the cushion chamber is released, at the proper time and in the proper magnitude, to assist the power unit in starting a load having great inertia. Other specific objects and advantages will appear as the specification proceeds.

The invention is illustrated, in a preferred embodiment, by the accompanying drawings, of which Figure 1 is a view in front elevation of a

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hydraulic power unit made according to this invention; the figure is partly in section, and connecting pipes and certain other components are represented diagrammatically. Fig. 2 is a vertical view, partly in section, taken along the line 2—2 in Fig. 1; and Fig. 3 is a horizontal sectional view of the power unit, taken along the line 3—3 of Fig. 2.

In the illustrations, a hollow rectangular box or chamber 22 is supported in a horizontal position by any suitable means (not shown). A pair of hydraulic power cylinders H pass through and are rigidly affixed, as by welding, to box 22 near one end thereof; a corresponding pair of power cylinders H' are carried by box 22 near its opposite end, as best shown in Fig. 3. A pair of ports 28 in the sides of each of the cylinders H and H' communicate with the interior of box 22. Each of the power cylinders H carries a piston 19 and a piston rod 18; at their upper ends piston rods 18 are affixed to a yoke Y. Each of power cylinders H' has a piston 19a and a piston rod 18a; piston rods 18a are affixed at their upper ends to a yoke Y'.

Each of the cylinders H and H' is equipped at its upper end with a stuffing box, comprising an annular internal shoulder 21 formed integrally with or welded into the cylinder, packing material 27 positioned around the piston rod and seated on shoulder 21, a gland 26 adapted to compress packing material 27, and a cap 25 threaded onto the top of the cylinder and adapted to force gland 26 downward to compress packing material 27. Annular shoulder 21, gland 26, and cap 25 all have central apertures machined to provide a snug sliding fit with the piston rod 18 or 18a.

A shaft P, which may be the shaft of a deep-well pump, passes through aperture 20 in box 22 and is affixed to yoke Y at a point midway between piston rods 18. Aperture 20 is sufficiently large to provide ample clearance for shaft P, and the annular wall of aperture 20 is integrally formed with or welded to the top and bottom of box 22.

The bottom of each of the cylinders H is fitted tightly into and welded respectively to one of a pair of closed tanks 29; tanks 29 are connected together by a communicating pipe 30. Similarly, the bottom of each of the cylinders H' is fitted into a tank 29a, the tanks 29a being connected together by a communicating pipe 30a.

A pair of upright supporting arms or standards 10 and 11 are affixed, as by welding, to the upper side of box 22. Arms 10 and 11 carry at their tops journal bearings 12 and 13 respec-

tively; journaled into said bearings is an axle 16. At its opposite ends axle 16 carries a pair of sprocket wheels S. Chains C pass over wheels S and connect yoke Y to yoke Y'. Chains C are secured to yoke Y' by bolts 31a and to yoke Y by yieldable couplings comprising bolts 31 and coil springs 32. Springs 32 operate to maintain at all times a slight tension on chains C.

Journal bearings 14 and 15 are welded, or otherwise affixed, to the lower side of box 22; journaled therein is an axle 17 carrying at its opposite ends sprocket wheels S'. Chains C' pass around wheels S' and connect yoke Y to yoke Y', chains C' being secured to yokes Y and Y' by suitable bolts 33 and cooperating nuts 34. Nuts 34 are adjusted to maintain chains C' under slight tension.

Control valve 40 is mounted vertically in rigid relationship to cylinders H and H' by any suitable means (not shown). Valve 40 includes an upper section containing a cylinder 41 and a two-section piston 48 slidable therein. A piston rod 42 is affixed to the upper end of piston 48; it extends above valve 40 to a level slightly higher than the highest point attained by yoke Y when pistons 19 are at the top of their stroke in power cylinders H. Piston rod 42 passes slidably through apertures 43 in the arm 35 which extends laterally from yoke Y. Flange members 44 and 46 are affixed rigidly to rod 42. Member 44 is positioned near the top of piston rod 42, where it is engaged by arm 35 when pistons 19 reach the topmost portion of their stroke, such engagement causing piston 48 to rise to its upper position as shown in the drawing. Flange member 46 is positioned on rod 42 at a point near the level reached by yoke Y when pistons 19 are at the lowest portion of their stroke, member 46 being engaged by arm 35 and piston 48 moved thereby to its lower position at the time pistons 19 attain the lowest portion of their stroke. Coil spring 45 is affixed to flange member 44 and extends downward therebelow around rod 42; coil spring 47 is affixed to member 46 and surrounds rod 42 thereabove.

The lower part of valve 40 comprises a cylinder 49 and a four-section piston 50 reciprocable therein. The upper and lower parts of valve 40 are separated by a bulkhead 51 containing a passage 86 which connects the upper end of cylinder 49 with a port on the side of cylinder 41 near the lower end thereof.

Valve 100, mounted on the structure of the hydraulic power unit by any suitable means, comprises cylinder 101 and a four-section piston 102 reciprocable therein.

A hydraulically-actuated adjustable valve 52 comprises a valve cylinder 56, a sliding valve member 55 machined to fit snugly within cylinder 56, a hydraulic cylinder 53, and a piston 54 slidable within cylinder 53 and carried by the lower end of valve member 55. An adjustable thumb-screw 57 is threaded through the top of the housing of valve 52 and is positioned to engage the upper end of valve member 55, so that its position of maximum upward movement may be varied by turning thumb-screw 57.

Hydraulically-actuated valve 58 comprises a valve cylinder 62 having a valve seat 68 centered at the lower end thereof, a slidable valve member 61 positioned within cylinder 62, a hydraulic cylinder 59, and a piston 60 slidable within cylinder 59 and carried by the upper end of valve member 61.

Compression chamber 69 is a closed, air-tight

tank having a baffle plate 70 mounted on the floor thereof. Hydraulically-actuated valve 64 is similar in structure to valve 58; it comprises hydraulic cylinder 65, piston 66 reciprocable therein, valve member 120, valve cylinder 121, and valve seat 67.

Hydraulically-actuated air pump 71 comprises a pump chamber 75, a pump piston 74 reciprocable therein, a power cylinder 72, a piston 73, carried by the upper end of pump piston 74 and reciprocable in cylinder 72, a ball-check valve 76 connecting the interior of cylinder 75 to atmosphere, and a ball-check valve 77 connecting the interior of cylinder 75 to pipe 78, which in turn communicates with the interior of compression cylinder 69. Ball-check valve 76 is spring-biased so as to permit flow of air, under pressure differential, from the atmosphere to the interior of cylinder 75 but to prevent any flow in the opposite direction. Ball-check valve 77 is spring-biased to permit flow of air under pressure from cylinder 75 into pipe 78 but to prevent any flow of gas in the opposite direction.

Hydraulic pressure for the operation of the power cylinders and other hydraulically-actuated devices is provided by pumps 80 and 81, which are indicated diagrammatically on the drawing. These may be conventional rotary hydraulic fluid pumps, driven by an electric motor or any other suitable source of energy, capable of generating hydraulic pressures of considerable magnitude. In a typical deep-well pump installation, the pressures required of pumps 80 and 81 might be of the order of 700 to 800 pounds per square inch.

Tank 82, which has a conventional air vent 83, is represented diagrammatically on the drawing; it may be any suitable storage tank for hydraulic fluid. The hydraulic fluid employed in the operation of this invention may be any stable liquid; I prefer to use a light oil.

Pipe 84 and its branch 84a connect tank 82 to pumps 81 and 80 respectively; the direction of flow of liquid in pumps 80 and 81 is as indicated by arrows on the drawing.

From pump 80 pipe 85 carries fluid to a port located midway up the wall of cylinder 41 and through branch pipe 85a to a port midway up the wall of cylinder 49. Pipe 90 connects a port near the upper end of cylinder 41 to a port at the bottom of cylinder 49. Pipe 91 connects a port on the wall of cylinder 49 about one-third of the distance up from the bottom thereof, to a port in valve 52 opening into chamber 56. A branch pipe 91a connects pipe 91 to the upper end of hydraulic power cylinder 53 in valve 52. Another port communicating with valve cylinder 56 is connected by pipe 91b to one of the tanks 29. Pipe 92 connects a port on the wall of cylinder 49, about two-thirds of the distance up from the bottom thereof, to one of the tanks 29a. Pipe 98 connects tank 82 to a port near the top of cylinder 101 in valve 100; branch pipe 98a connects pipe 98 to a port near the bottom of cylinder 101; branch pipe 98b connects pipe 98, through spring-biased safety valve 63, to a port in the side of valve cylinder 121 in valve 64. Branch pipe 98c connects a port near the bottom of cylinder 49 with pipe 98b; branch pipe 98d connects a port at the top of cylinder 41 to pipe 98c; branch pipe 98e connects a port near the top of cylinder 49 to pipe 98d; and branch pipe 98f connects the bottom of cylinder 41 with pipe 98d.

Pipe 95 connects a port near the top of cylinder

der 41 with a port on the top of cylinder 101; pipe 94 connects a port on the bottom of cylinder 101 with a port near the lower end of cylinder 41.

Pipe 97 connects pump 81 to a port midway up the side of cylinder 101; a spring-biased safety valve 105, similar in structure to valve 63, is indicated diagrammatically on the drawing as connected between pipes 97 and 98b. This valve may be adjusted to permit liquid to pass from pipe 97 into pipe 98b and thence back to tank 82 at a predetermined pressure, the magnitude of which may vary according to the particular application. The functional result of valve 105 is to maintain a constant source of pressure for the actuation of the various power cylinders operated by pump 81; in practice, this constant pressure might be of the order of 500 pounds per square inch.

Pipe 103 connects a port on the side of cylinder 101, about two-thirds of the distance up from the bottom thereof, to the lower end of hydraulic cylinder 72, in compressor pump 71. Branch pipe 103a connects pipe 103 to a port at the lower end of hydraulic cylinder 59 in valve 58. Branch pipes 103b connects pipe 103a with a port at the top of hydraulic power cylinder 65 in valve 64.

Pipe 104 connects a port on the side of cylinder 101, about one-third of the distance up from the bottom thereof, to a port at the top of hydraulic cylinder 72 in compressor pump 71. Branch pipe 104a connects pipe 104 to a port at the top of power cylinder 59 in valve 58. Branch pipe 104b connects pipe 104a to a port near the bottom of power cylinder 53 in valve 52. Branch pipe 104c connects pipe 104 to a port on the bottom of power cylinder 65 in valve 64. Pipe 96 connects a port on the under side of rectangular box 22 to pipe 98.

A pipe 106 provides communication between one of the tanks 29 and valve seat 68 in valve 58; pipe 107 runs from a port opening into cylinder 62 of valve 58 to a port opening into the lower end of compression chamber 69. Pipe 79 connects a port on the side of chamber 69, about one-fourth of the distance up from the bottom thereof, to valve seat 67 in valve 64.

Operation

The drawing shows the hydraulic power unit of the invention at that point in its operation wherein pistons 19 have just completed their upward stroke and are ready to start downward. As yoke Y reached its maximum upward displacement, arm 35 engaged spring 45 and caused piston 48 to move to its upward position as shown. Thereupon liquid under pressure from pump 80 flowed from pipe 85 through pipe 90 to the lower end of cylinder 49 and caused piston 50 to rise to its upward position, as shown. At the same time, liquid under pressure from pump 80 flowed from pipe 85 through cylinder 41 and pipe 95 to the upper end of cylinder 101, causing piston 102 to assume its lower position, as shown.

At the stage of operation illustrated in the drawings, liquid under pressure is flowing from pump 80 through pipes 85 and 85a, cylinder 49, and pipe 92 into tank 29a, and as pressure is built up in the tanks 29a pistons 19a will rise, carrying with them yoke Y'.

As pistons 19a begin to rise, pistons 19, in hydraulic cylinders H, will start to drop and yoke Y will be lowered, carrying with it shaft P.

Shaft P, as has been pointed out, will normally be carrying a very heavy mass, and as a result

it is most important that it be prevented from dropping precipitately and thereby damaging the deep-well pump or other device associated with it. Before describing in detail the means whereby rapid descent of shaft P is prevented, however, actions resulting from the shift in position of piston 102 will be described.

When piston 102 is moved to its lowered position, as shown, liquid under pressure from pump 81 flows through pipe 97 and pipe 104 and its various branches, resulting in the raising of valve member 55 in valve 52, the closing of valve 58, the opening of valve 64, and the lowering of piston 74 in compressor pump 71. As the various pistons 60, 66, and 73 are caused to shift position, the hydraulic fluid thereby vented from the respective power cylinders is free to flow through pipe 103 and its various branches back to cylinder 101 and thence through pipe 98 to storage tank 82. As piston 54 is raised by pressure from fluid introduced through pipe 104b, the liquid above piston 54 is vented through pipe 91a, pipe 91, cylinder 49, and pipe 98c back to tank 82.

Now, to return to the operation of power cylinders H, it will be seen that as yoke Y is lowered, the hydraulic fluid in power cylinders H will be forced out of tanks 29 through pipe 91b, valve cylinder 56, pipe 91, cylinder 49, and pipe 98c back to tank 82. The rate of flow of this liquid can be controlled by appropriate adjustment of thumb-screw 57 so as to permit shaft P to be lowered at any desired rate. In this stage of the power unit's operation, none of the fluid in power cylinder H can flow into compression tank 69, since valve 58 is closed.

While pistons 19 are completing their downward movement, compressor pump 71 compresses the air in cylinder 75 and, when piston 74 reaches the bottom of its stroke, compressor pump 71 injects, by way of ball-check valve 77 and pipe 78, a charge of compressed air into tank 69.

When pistons 19 in power cylinders H reach the bottom of their stroke, arm 35 engages spring 47 and causes piston 48 to shift to its lower position. Thereupon, fluid under pressure from pump 80 flows through pipe 85, cylinder 41, and passage 86 into the top of cylinder 49, causing piston 50 to assume its lower position. At the same time, liquid flows from cylinder 41 through pipe 94 into the lower end of cylinder 101, causing piston 102 to assume its upper position. The liquid displaced by the movement of pistons 48, 50, and 102 is free to flow back to tank 82 by way of the upper portion of cylinder 41 and pipe 98d.

With the re-orientation of the valves 40 and 100, liquid under pressure from pump 81 flows through pipe 97, cylinder 101, and pipe 103 and its various branches, to reverse the positions of piston 60 in valve 58, piston 66 in valve 64, and piston 73 in compressor pump 71. At the same time, liquid under pressure from pump 80 flows through pipe 85, pipe 85a, cylinder 49, and pipe 91 to valve 52. The fluid from pump 80 flows down pipe 91a and causes piston 54 to be lowered, thereby opening valve 52 and permitting free passage of liquid from pipe 91 into tanks 29. The liquid displaced by the shift in position of pistons 54, 60, 66, and 73 can flow back to tank 82 by way of pipe 104 and its various branches, the lower portion of cylinder 101, pipe 98a, and pipe 98.

When liquid from pump 80 begins to flow into the tanks 29 it imposes a hydraulic pressure on pistons 19, tending to force them upward and accordingly to raise pump shaft P. When the power unit is first placed in operation, the initial pres-

sure on pistons 19 will be insufficient to overcome the inertia of shaft P, and but for the "cushion chamber" feature of this invention, a "move-or-break" situation would be created wherein pump 80 would be severely overloaded and probably stalled or broken. In this invention, however, no such result can occur; the hydraulic fluid pumped into tank 29 by pump 80 can flow through pipes 106 and 107, past the now-open valve 58, into compression chamber 69. As the hydraulic fluid rises in chamber 69 it compresses the air therein before it and produces an increasing pressure in the upper end of tank 69. This flow, and consequent compression, continues until the pressure in tank 29 is great enough to overcome the inertia of pump shaft P to cause it to start upward. Thereupon, the further advance of hydraulic fluid into power cylinders H is assisted by the compressed air in the top of tank 69, and as pistons 19 rise to the top of their stroke, some of the oil in tank 69 is discharged through pipes 107 and 106 into tanks 29 and cylinders H.

After the pump has been in operation for several cycles, a state of equilibrium is reached whereby the pressure remaining in tank 69 between successive up-strokes of pistons 19 is approximately equal to the pressure necessary to raise pump shaft P after its inertia has been overcome. As pistons 19 reach the upper limit of their stroke, arm 35 again engages spring 45 and causes the valves to re-assume the positions shown in the drawing. Thereupon, valve 52 closes, so as to afford only a restricted passage for the outflow of liquid from cylinders H back to tank 82, as is required to prevent precipitate lowering of shaft P. Valve 58 closes and thereby stores within tank 69 the potential energy represented by the air compressed therein. Valve 64 opens, and compression pump 73, which during the previous half-cycle has charged cylinder 75 with air from the atmosphere through valve 76, now compresses it and forces it under pressure into tank 69.

The functions and purposes of compressor pump 71, baffle plate 70, and valve 64 are related to the maintenance of smooth, dependable operation of compression tank 69. As will be understood from the foregoing descriptions, it is desirable that tank 69 provide, at each time the pistons 19 begin an up-stroke, a substantial supply of hydraulic pressure to supplement and assist pump 80 in its task of overcoming the inertia of shaft P and starting it on its upward course. It has been found that, if tank 69 is employed alone, in course of time the air originally trapped in the upper portion of the tank becomes mixed with the hydraulic fluid and passed off to tank 82, where it escapes to the atmosphere through vent 83. As the air is thus removed from tank 69, its effectiveness as a cushion is reduced. This condition can be considerably lessened by the use of baffle plate 70, which minimizes the turbulence of the hydraulic fluid within tank 69 and thus reduces the tendency of the fluid to absorb air. Nonetheless, a certain amount of air escapes from tank 69 despite the action of baffle plate 70, and if the power unit is to be employed for a long period of continuous operation a means must be provided for restoring air to tank 69 during operation. Compressor pump 71 performs that function.

Compressor pump 71, valve 64, and safety valve 63 cooperate to maintain the air and liquid content of tank 69 within the upper and lower limits required for efficient performance of its function. During the up-strokes of pistons

19, valve 64 is closed and the liquid level in tank 69 is free to rise as far as may be necessary to build up the hydraulic pressure required to start and raise pump shaft P. During the down-strokes of pistons 19, valve 64 is opened and any excess of pressure which may have been built up in tank 69 is relieved through safety valve 63. Valve 63 should be set to pass fluid at a pressure slightly below that required within power cylinders H to raise shaft P. For example, should a pressure of 500 pounds per square inch within cylinders H be required to raise shaft P after it has been started, valve 63 should be set to pass fluid at a pressure of about 490 pounds per square inch. Then, at the beginning of each up-stroke of pistons 19, the pump 80 will build up within tank 29 and tank 69 a pressure sufficient to start shaft P; thereafter, during the remainder of the up-stroke of pistons 19, liquid will flow out of tank 69 and into power cylinders H until the pressure within tank 69 has dropped to 500 pounds per square inch. When this point has been reached, the pressure in tank 69 will remain substantially constant until pistons 19 complete their up-stroke. During this portion of the cycle valve 64 is closed and valve 63 is thus out of the circuit. When the down-stroke of pistons 19 commences, compressor pump 71 injects a charge of compressed air into tank 69, valve 58 closes, and valve 64 opens. After the charge of air from compressor pump 71 is discharged into tank 69, any excess fluid pressure over 490 pounds per square inch is relieved by discharge of fluid through valve 63 back to storage tank 82. If the air provided by compressor pump 71 is greater than that required to replace the air lost by absorption in the hydraulic fluid, the liquid level in tank 71 will gradually drop until it reaches the port communicating with pipe 79. It cannot drop below that level, however, since excess air thereafter provided by compressor pump 71 will be vented directly through valve 63. The net result of the combined action of compressor pump 71, valve 64, and valve 63 is thus to maintain the air and liquid contents of tank 69 always within limits which will give good performance.

The ports 28, the interior of box 22, and pipe 96 connecting box 22 to storage tank 82 provide the important advantage in this invention of maintaining atmospheric pressure on both sides of the stuffing box at the upper ends of power cylinders H and H', since any leakage of hydraulic fluid past pistons 19 and 19a is simply returned to tank 82, and can never build up a hydraulic pressure on the stuffing box. This feature, which is of very great importance is providing dependable and trouble-free operation, is disclosed and claimed in my earlier co-pending application, Serial No. 35,100, entitled "Fluid Pump," filed June 25, 1948.

In the drawing, for illustrative purposes, power cylinders H and H' have been shown as having equal cross-sectional areas. In many instances it may be preferable to make power cylinders H larger in cross-sectional area than power cylinders H'. Any desired proportions may be adopted for these power cylinders without affecting the sequence of operations, since the valve actions in this invention are controlled solely by the position of yoke Y.

While a particular embodiment of the invention has been shown and described in this specification in considerable detail for purposes of illustration, it will be understood that the struc-

tural details may be varied widely by those skilled in the art without departing from the spirit of my invention.

I claim:

1. In a hydraulic engine adapted to move in vertical reciprocating motion a load having substantial mass, a power cylinder, a piston reciprocable therein, inlet means for introducing hydraulic fluid into the cylinder comprising a valve having an open position and a closed position, said valve when in the closed position providing a restricted passage for the flow of fluid, a closed chamber communicating with the cylinder adapted to receive hydraulic fluid until the pressure on said fluid exerted by the gas in the chamber is sufficient to start the piston, and control means automatically responsive to the movement of the piston operative to open the valve when the load is to be moved against the force of gravity and to close the same when the load is being moved in a direction wherein its motion is aided by the pull of gravity.

2. In a hydraulic engine adapted to move in vertical reciprocating motion a load having substantial mass, a power cylinder, a piston reciprocable therein, inlet means for introducing hydraulic fluid into the cylinder comprising a valve having an open position and a closed position, said valve when in the closed position providing a restricted passage for flow of fluid, a closed chamber, means including a second valve providing a passageway for hydraulic fluid from the cylinder to the chamber, and control means automatically responsive to movement of the piston operative to open both valves when the

load is to be moved against the force of gravity and to close both valves when the load is being moved in a direction wherein movement is aided by the pull of gravity.

3. Apparatus according to claim 1 wherein a hydraulically actuated air pump is connected to the closed chamber and operative, responsively to the control means, to inject a quantity of gas into the closed chamber during each cycle of piston movement.

4. Apparatus according to claim 2 wherein a hydraulically actuated air pump is connected to the closed chamber and operative, responsively to the control means, to inject a quantity of gas into the closed chamber during each cycle of piston movement.

AUGUST F. HABENICHT.

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