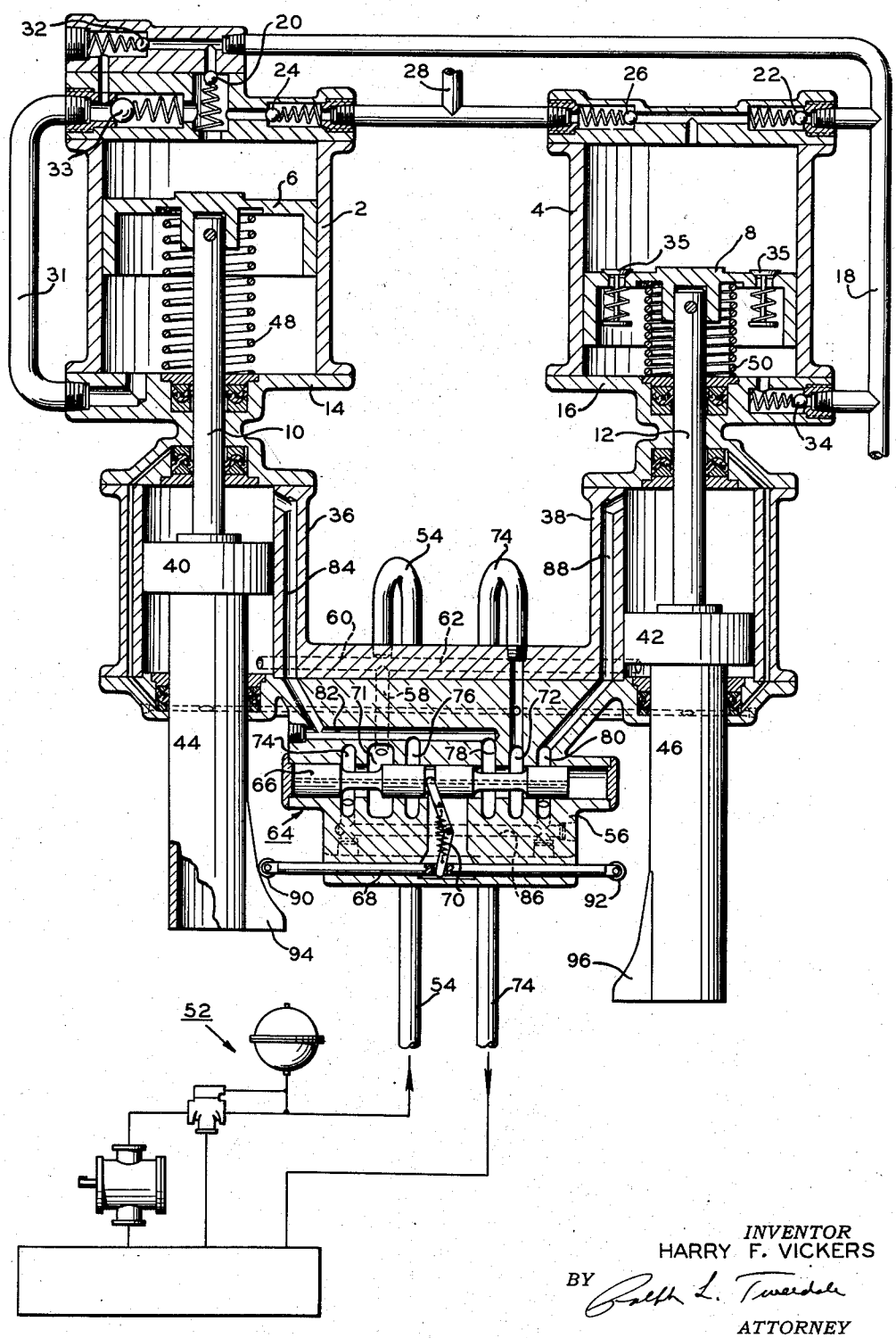
Feb. 24, 1942. H. F. VICKERS 2,274,224

PUMPING SYSTEM

Filed July 24, 1940



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Patented Feb. 24, 1942 2,274,224

UNITED STATES PATENT OFFICE

2,274,224

PUMPING SYSTEM

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Application July 24, 1940, Serial No. 347,240

3 Claims. (Cl. 103—49)

This invention relates to power transmissions, particularly to those of the type comprising two or more fluid pressure energy translating devices one of which may function as a pump and another as a fluid motor.

The invention is more particularly concerned with a liquid fuel pumping system for use with internal combustion engines. In many engine installations, particularly those on aircraft, the fuel supply tanks are located at a considerable distance from the engines and below the level thereof, and, where highly volatile fuels are used, vapor-lock trouble is frequently encountered with systems in which the fuel pumping means is located adjacent the entrance and must draw fuel from the tank by suction through a long suction conduit. The vapor-lock difficulties may be avoided by placing the pump close to or in the tank, but this complicates the problem of transmitting power from the remotely located engine to the pump.

It is an object of the present invention to provide an improved fuel supply system adapted for installations of this character wherein the pump may be located closely adjacent to the tank and may be operated from the engine by hydraulic transmission of power.

More particularly, it is an object of the invention to provide an improved fuel supply system having a pair of independently operable pumping elements, each of which is normally biased by a substantially constant force to deliver fuel into the delivery line, together with intimately operable hydraulic means for retracting the pumping element of each pump individually.

It is a further object to provide in an apparatus of this character a control system for the hydraulic operating means which is automatically controlled by movement of the pumping elements and which provides a more rapid retraction stroke than the pumping stroke under all normal conditions and which further insures that the pumping strokes of the two pumping elements will overlap in point of time so that at all times at least one of the pumping elements will be effective to deliver fuel.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred form of the present invention is clearly shown.

In the drawing:

The single figure is a diagrammatic view of a fuel supply system incorporating a preferred form of the present invention.

Such a system may comprise a pair of individual pumping elements comprising cylinders 2 and 4 within which pistons 6 and 8 are reciprocably mounted. Rods 10 and 12 extend through the bottom end caps 14 and 16 to form operating means for the respective pistons. There is thus provided a pair of differential-area cylinders constituting the fuel pumping elements. Fuel may be conducted to the pumping elements from the tank by a short line 18 which extends through inlet check valves 20 and 22 to the upper or large end of the cylinders 2 and 4. Outlet check valves 24 and 26 permit outflow from the upper end of the cylinders to a fuel supply conduit 28. The inlet conduit 18 also connects through check valves 32 and 34 with the small end of cylinders 2 and 4. A bypass conduit 31 of large capacity extends from the small end of cylinder 2 to the large end thereof through a check valve 33. As an equivalent arrangement for cylinder 4, the piston 8 is shown as provided with two or more check valves 35 therein.

For the purpose of operating the pumping pistons 6 and 8, a pair of fluid motors are provided beneath the pumping cylinders. These may comprise a pair of cylinders 36 and 38 having pistons 40 and 42 therein. The latter are connected to the piston rods 10 and 12 and have tail rods 44 and 46 of larger diameter extending through the bottom ends of the cylinders 36 and 38.

The pistons 6 and 8 are each biased upwardly by a spring 48 and 50 and also by hydraulic pressure constantly exerted over the small area at the bottom of pistons 40 and 42. For this purpose pressure fluid is conducted from a source of constant pressure, such as an accumulator system, generally designated as 52, by means of a conduit 54 to a valve block 56 which forms part of the bottom end closure member for the cylinders 36 and 38. The conduit 54 communicates with a passage 58 having branches 60 and 62 extending to the bottom end of the cylinders 36 and 38.

Fluid may be admitted alternately to the upper ends of the cylinders from the pressure source 52 under the control of a shiftable four-way valve 64. The spool 66 of the valve is adapted to be shifted to the left or right by means of a rod 68 having an over-center linkage connection 70 with the spool 66. The latter is of the type which permits the rod 68 to shift almost to its extreme position before the spool 66 begins to shift. The valve 64 is of the customary four-way type and has a pressure port 71 in communication with

the supply conduit 54. The valve also has a return port 72 which communicates by means of a conduit 74 with a suitable reservoir. On opposite sides of the pressure port 71 there is provided a pair of cylinder ports 74 and 76 while a similar pair of cylinder ports 78 and 80 are provided on opposite sides of the return port 72. Ports 76 and 78 are connected together by a duct 82 and communicate with the upper end of cylinder 36 through a passage 84. Likewise ports 74 and 80 are connected together by a duct 86 and communicate with the upper end of cylinder 38 by a passage 88.

For the purpose of shifting the rod 68 and the valve 66, the former is provided with rollers 90 and 92 on its opposite ends which are adapted to contact with cams 94 and 96 carried by the tail rods 44 and 46.

In operation, assuming the parts to lie in the position illustrated, it will be seen that pressure fluid is admitted through conduit 54, conduit 58, port 71 and branches 60 and 62 to the lower end of both cylinders 36 and 38. This together with a portion of the springs 48 and 50 exerts a substantially constant bias tending to drive both the pistons 6 and 8 upwardly.

With the valve spool 66 in the position shown, the upper end of cylinder 36 is connected to the return line through passage 84, duct 82, ports 78 and 72 and conduit 74. Thus the piston 6 is free to move upwardly under its bias and exerts a substantially constant pressure on the fuel in discharge line 28 moving upwardly to discharge fuel as fast as it is consumed at the far end of the line 28. At the same time fuel is drawn into the lower end of cylinder 2 from the fuel supply conduit 18 through the check valve 32 and conduit 31. Normally the upward movement of either piston takes place at a relatively slow speed so that the same size conduit at the inlet and outlet lines of the cylinder 2 permits unrestricted flow to and from the two ends of the cylinder.

It will be noted that the cam 94 in the position of the piston 6 shown in the drawing has already started to move the rod 68 to the right but not far enough to cause the over-center mechanism to shift the spool 66. Preferably the curvature of the cam 94 may be such that the mechanical advantage between tail rod 44 and shifter rod 68 progressively decreases in the same proportion that the force required to shift the over-center mechanism decreases. Thus a constant force will be exerted on the tail rod 44 by the roller 90. As the piston 6 moves upwardly a predetermined farther distance, the rod 68 is shifted rightwardly to the point where the over-center mechanism snaps shifting the valve 66 also to the right.

It will be noted that due to the different lengths of the two grooves in the valve spool cooperating with the ports 71 and 72 that the supply pressure will be cut off from the cylinder 38 before it is opened to cylinder 36. On the other hand, at port 72 the cylinder 36 is not cut off from the return line until after cylinder 38 has been opened up thereto. Thus there is an appreciable interval while both pistons are free to move upwardly under their constant bias.

As the spool 66 continues its movement to the right the port 76 is opened to the port 71, and pressure fluid is thus admitted to the upper end of cylinder 36. Due to the larger area at the top of piston 40, this pressure fluid overcomes the bias on the piston and moves the latter downwardly at a relatively rapid rate compared with its upward movement. Fluid discharged from the lower end of cylinder 36 flows outwardly to branch 60 and duct 58 to join with the incoming fluid from pipe 54 thus increasing the speed of downward movement.

As soon as the upper end of cylinder 38 was connected to the return conduit by the opening up of port 80 to port 72, the piston 8 started moving upwardly under its constant bias and took over the duty of delivering fuel to the discharge conduit 28. This upward movement continues until the cam 96 shifts the rod 68 to the left again thus restoring the spool 66 and rod 68 to the position shown on the drawing and again permitting the piston 6 to move upwardly. During the shifting of the spool 66 there was, of course, the same interval during which both pistons were relieved of downward pressure on their respective heads thus insuring that there is no instant during which at least one piston is free to exert its constant pressure on the fuel in the supply line.

It will be noted that during the downward movement of either piston the fuel in the lower end of the cylinder 2 or 4, as the case may be, is discharged out through the conduit 31 and check valve 33 or through check vales 35 to the head end of its respective cylinder. In this way the more rapid movement of the piston on its suction stroke is permitted to occur without substantially increasing the rate of flow through the suction conduit 18. In other words, on the slow upward stroke of each piston it fills the chamber at the lower end of the cylinder, and during the rapid retraction stroke this volume is utilized to help fill the upper end of the cylinder by direct transfer from one end to the other through the inlet valve 20 or 22, as the case may be. The quantity thus transferred is, of course, not quite sufficient to fill the upper cylinder chambers, due to the smaller area of the lower cylinder chambers. The difference required, however, may be drawn from the suction line 18 through the inlet check valves 20 and 22 without creating excessive suction in the line 18.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a fuel supply system for an internal combustion engine the combination of a pair of expansible chamber pumps having valved connection with a source of fuel and with a fuel delivery conduit, a source of hydraulic power fluid, independent fluid motors for operating said expansible chamber pumps on their intake strokes, biasing means for operating said pumps on their outlet strokes to exert a substantially constant pressure on the fuel delivery line independently of the rate of fuel consumption, and valve means operated by each fluid motor near the end of its pumping stroke for first relieving pressure in the other motor to start the latter on a pumping stroke and later admitting pressure to the former motor to start it on an intake stroke.

2. In a fuel supply system for an internal combustion engine the combination of a pair of expansible chamber pumps having valved connection with a source of fuel and with a fuel delivery conduit, means biasing said pumps in the direction of a pumping stroke, and hydraulically operated means for alternately retracting said pumps on a suction stroke, said last means in-

cluding a valve shiftable by operation of the pumps and timed to provide a shorter suction stroke at each motor through the pumping stroke thereof, said pumping strokes overlapping each other in respect to duration.

3. In a fuel supply system for an internal combustion engine the combustion of a differential-area cylinder-and-piston pump, means biasing the piston toward the large end of the cylinder, intermittently operating means for operating said piston in the opposite direction against said biasing means, valved inlet and outlet connections to the large end of the cylinder, and a permanently open passage from the small end of the cylinder to the incoming side of the inlet valve, whereby the piston when rapidly retracted by said operating means displaces from the small end of the cylinder a substantial portion of the volume of fuel required to fill the large end thereof.

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