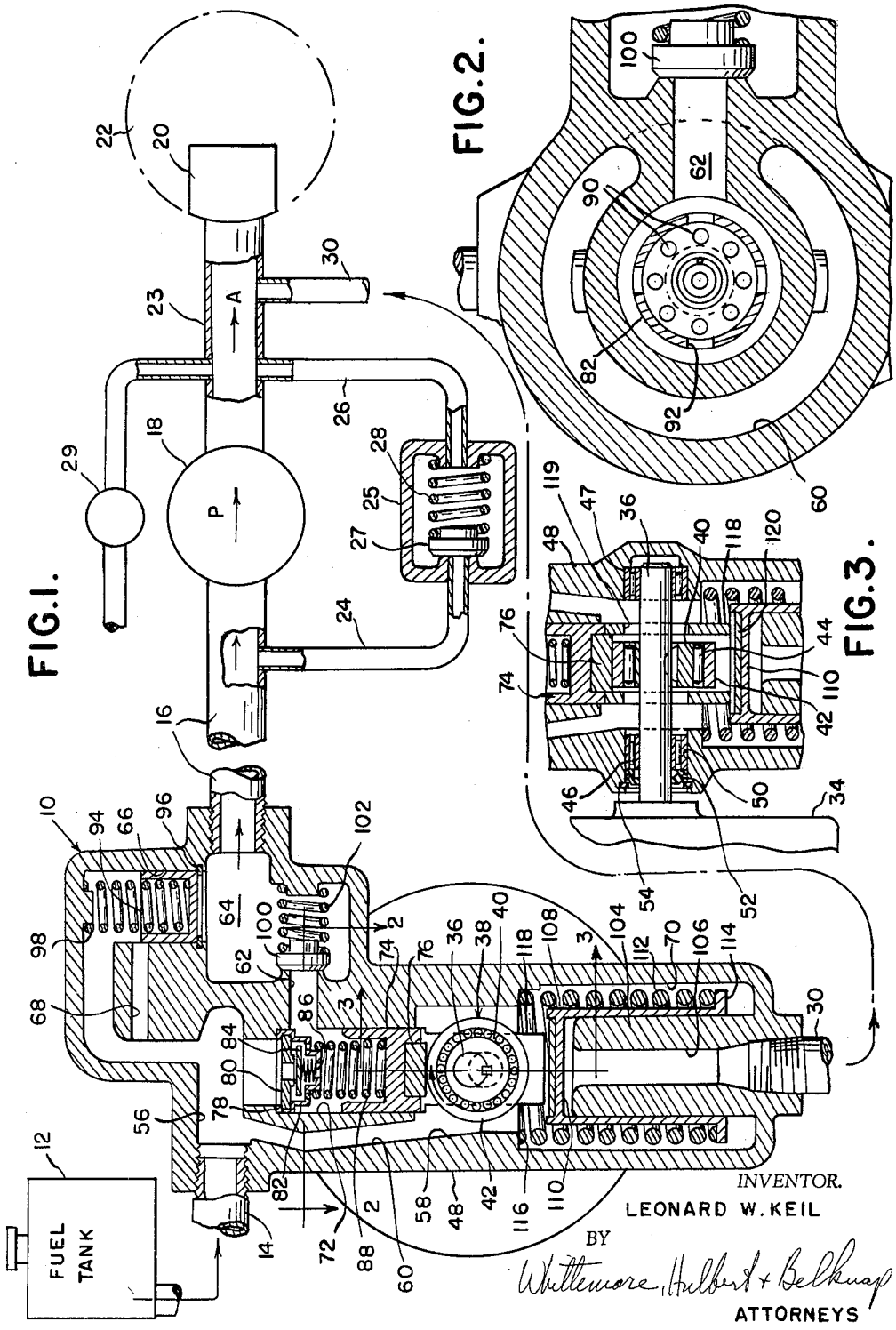
Nov. 17, 1964 L. W. KEIL 3,157,221

FLUID SUPPLY SYSTEM

Filed Aug. 7, 1961



United States Patent Office 3,157,221
Patented Nov. 17, 1964

3,157,221

FLUID SUPPLY SYSTEM

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Filed Aug. 7, 1961, Ser. No. 129,680
3 Claims. (Cl. 158—36.4)

The present invention relates to a fluid supply system and more particularly, to a system used to supply fluid at a constant pressure from a remotely controlled positive displacement booster pump designed to provide a variable volume output of fluid, the pump including a reciprocable piston, means for controlling the delivery rate of said pump, an accumulator, and a relief valve. The system may supply water, oil, or other liquids, but is particularly useful and supplying fuel to an internal combustion engine.

In the past, the supply of high pressure fuel to an engine by systems such as a shuttle piston fuel injection system, has required the use of two separate pumps, one pump being a booster pump usually mounted at the fuel reservoir tank and the second pump being a high pressure, engine driven pump adapted to supply fuel to the engine at a rate generally variable with engine speed. However, in prior systems, the two pumps have failed to supply a constant fuel pressure at the inlet of the pressure carburetor or other fuel control device.

It is an object of the present invention to provide a new and improved system including a booster pump including control means responsive to fuel pressure at or directly adjacent the point of use; namely, near the inlet of the carburetor or other fuel control.

More specifically, it is an object of the present invention to provide a system including a booster pump and an engine driven pump connected in series to supply fuel to an internal combustion engine, and control means for the booster pump responsive to fluid pressure intermediate the engine driven pump and the internal combustion engine.

It is a further object of the present invention to provide a fuel supply system including in combination a booster pump, an engine driven pump connected in series between a source of fuel and an internal combustion engine, and means responsive to fuel pressure adjacent the internal combustion engine to maintain fuel pressure constant in this area regardless of increase or losses of fuel pressure due to the faulty operation or complete failure of the engine driven pump or partial clogging of the fuel lines.

More specifically, it is an object of the present invention to provide a system including the booster pump and engine driven pump connected in series between a source of fuel and an internal combustion engine, including a bypass check valve in parallel with the engine driven pump so as to provide a predetermined but variable minimum flow of fuel at a constant pressure to speed-regulated engines of all kinds.

It is a further object of the present invention to provide a simple pump design, enabling the elimination of various well known components used in previous fuel systems, such as the usual electric relay, resistor and pressure switch, the final result being the elimination of "dead weight" on the airplane, for example, and the resultant savings of the costly eliminated parts.

It is a further object of the present invention to provide in a fuel system automatic means for controlling the fuel pressure remotely from the boost pump, said means being responsive to an automatic pressure regulator enclosed within the remotely controlled pump.

Other objects and features of the invention will become apparent as the description proceeds, especially

when taken in conjunction with the accompanying drawing, illustrating a preferred embodiment of the invention, wherein:

FIGURE 1 is a diagrammatic view partly in section, of a fuel supply system including a remotely controlled booster pump.

FIGURE 2 is an enlarged cross-sectional view of the inlet fuel valve taken in the plane of line 2—2, FIGURE 1.

FIGURE 3 is a fragmentary vertical sectional view of the pump taken in the plane of the line 3—3, FIGURE 1.

The invention as illustrated herein may be used with any internal combustion engine such for example as a reciprocating or gas turbine engine employing a pressure carburetor or fuel control for supplying fuel under pressure to the combustion chamber thereof. The system comprises a remotely controlled booster pump 10 which is supplied with fuel from a fuel tank 12 through inlet fuel conduit 14, the outlet from the pump 10 being the fuel conduit 16 leading to the engine driven pump 18. It will be understood that the pump 18 is driven at a speed variable in accordance with engine speed and hence, is adapted to deliver fuel to the point of use at a rate at least approximately variable in accordance with engine speed. Fuel from the engine driven pump 18 is supplied to a pressure carburetor or other fuel control device 20 associated with an engine, diagrammatically represented by the broken line circle 22. Fuel supply from the pump 18 to the fuel control device 20 is through a conduit 23, the interior of the conduit 23 adjacent the fuel control device 20 constituting a pressure area designated A whose function will be later described.

A conduit 24 connects the conduit 16 to a bypass valve assembly 25, the latter in turn being connected to the passage or conduit 23 by a conduit 26. The bypass valve assembly 25 includes a valve element 27 urged by a compression spring 28 in closing direction. If for any reason the pump 18 fails to function, fuel will continue to flow through by bypass valve 25 and allow fuel to flow to the conduit 23 and particularly to the pressure zone A therein.

A pressure regulating valve 29 is connected to the conduit 23 and is adapted to open when the pressure in the zone A exceeds a predetermined desired value. The fluid flowing through the valve 29 may be returned to the fuel tank or to the inlet side of the booster pump 10.

A conduit 30 is provided which connects the conduit 23 at the pressure zone A thereof to a control chamber of the booster pump 10.

The booster pump is adapted to be driven by suitable means such for example as an electric motor 34 driving a shaft 36. An eccentric cam assembly 38 is connected to the shaft 36, the assembly comprising an eccentric disc 40 keyed to the shaft and a bearing ring 42 spaced from the eccentric disc by roller bearings 44. The shaft 36 is mounted in bearings 46 and 47 provided in the pump housing 48. It will be understood that the illustration of the pump in FIGURE 1 is diagrammatic and that in practice the pump housing 48 may be made of a number of separable parts as is well understood in the art. The bearing 46 is mounted in an opening 50 extending through one wall of the pump housing 48 and the opening is closed by a seal 52 retained in place by a snap ring 54. The pump housing 48 is formed to provide an inlet passage 56, a chamber 58 within which the eccentric assembly 38 rotates, a passage 60 connecting the passage 56 and the chamber 58, a pump outlet passage 62, an outlet chamber 64, an accumulator and relief cylinder 66 and a relief conduit 68. The housing also includes an enlarged chamber 70 including control structure which will subsequently be described. Also, included within the housing is a pump cylinder 72.

Mounted within the pump cylinder is a piston 74 hav-

ing a hardened and polished wear plate **76** provided at its lower end in engagement with the bearing ring **42** of the eccentric assembly. Adjacent its upper end the cylinder **72** is reduced to provide a shoulder **78** against which is seated an inlet check valve assembly comprising a ported plate **80**, a cage **82**, a valve element **84**, and a light compression spring **86** positioned between the cage **82** and the valve element **84**. The check valve assembly is retained in position against the shoulder **78** of the housing by a compression spring **88**.

As best seen in FIGURE 2, the cage **82** contains ports **90** in the flange portion thereof below the valve element **84** and ports **92** in the sides thereof.

The arrangement is such that during the suction stroke of the piston **74** the valve **84** is forced off its seat against the relatively light compression spring **86**, and fuel flows into the cylinder **72** through the ports **90** and **92**. On continued rotation of the eccentric assembly the piston **74** is forced upwardly against the compression spring **88** and the increasing pressure closes the check valve **84**. The fluid is then caused to flow through the passage **62** and through the chamber **64** to the engine driven pump **18**. A relief valve is provided in the form of a piston **94** movable in the accumulator cylinder **66**, the piston being urged downwardly against a seat formed by a snap ring **96** by a compression spring **98**. If excessive pressure develops within the chamber **64** the piston valve **94** is urged upwardly to establish communication between the chamber **64** and the relief passage **68**. Piston valve **94** acts to maintain a ripple-free flow as long as the pressure in chamber **64** does not exceed a certain maximum value, not normally attained.

The outer end of the passage **62** is shaped to form a valve seat and associated therewith is a check valve **100** urged toward closed position by a compression spring **102**. The check valve **100** is of course opened by pressure developed during a pressure stroke of the piston **74**, but closes to prevent reverse flow during a suction stroke of this piston.

The lower end of the housing **48** is provided with a vertically extending tubular hub **104** having a passage **106** extending therethrough. The passage **106** is in communication, as illustrated, through conduit **30** with the fuel under pressure at pressure zone A.

Sleeved over the hub **104** is a cup-shaped control piston **108** having a closed end **110**. A calibrated compression spring **112** is engaged between a flange **114** formed at the lower end of the piston and a shoulder **116** formed in the housing and urges the piston downwardly at a predetermined force.

In order to regulate the output of the positive displacement pump comprising the cylinder **72** and piston **74**, the piston includes a pair of downwardly extending arms **118** slotted as indicated at **119** for the reception of the shaft **36**. The arms **118** are engageable with a plate **120** carried on the closed end **110** of the accumulator and regulator piston **108**. It will be observed that the suction or downward stroke of the piston **74** is under the influence of the spring **88** and that the extent of this downward movement is controlled or limited by engagement between the arms **118** and the plate **120**. When the piston **108** is held in its uppermost position the pumping piston **74** is prevented from moving on its suction stroke and hence, no fuel is delivered by the booster pump. On the other hand, when pressure at zone A falls below a required pressure the reduction in pressure within the piston **108** permits the spring **112** to move the piston downwardly, thus providing for a longer suction stroke of the pumping piston **74** to increase the rate of fuel delivery so as to restore pressure in pressure zone A to the required value.

It will thus be seen from the foregoing that the delivery of fuel in accordance with demand is accomplished by movement of the piston **108** which exerts a controlling influence on the booster pump in that it determines the length of the suction stroke. Accordingly, the accumulator and control piston serves a dual function. It regulates the stroke of pump piston **74** in accordance with pressure at remote point A, and serves as part of an accumulator to help maintain pressure at A at a constant value.

In a typical installation it may be desired to maintain the pressure at the zone A at a value of for example, approximately 25 p.s.i. The engine driven pump **18** may be of any suitable type such for example as a gear pump, and the booster pump **10** may operate to supply fuel to the engine driven pump **18** at a pressure which may be approximately 5 p.s.i. The bypass valve **25** is operable to open on a very small pressure difference as for example, ½ p.s.i. It may be noted that the springs **86** and **102** controlling the pump check vaves **84** and **100** respectively, are relatively light springs so that in the event of failure of the booster pump **10** the engine driven pump **18** may draw fuel directly from the fuel tank, the check valves **84** and **100** opening to provide for such flow of fuel. The conduit **30** has sufficient capacity to transmit pressure to the control piston **108** and to provide for a flow to render piston movement promptly responsive to variations in the pressure in the control zone A.

Assuming the system to be operating under the conditions described above, an increase in demand by the engine will result in a drop in pressure at the zone A. If the capacity of the engine driven pump **18** was such that at this time the pressure regulating relief valve **29** was partly open, this reduction in pressure in the zone A will result in partial closure of the valve **29**. After the valve **29** has fully closed, if the fuel demand still exceeds the discharge of fuel from the engine driven pump **18**, then the pressure at the zone A will decrease further with a correcting adjustment of the control piston **108**, lengthening the suction stroke of the pumping piston **74**. This will increase the discharge of the booster pump to a value exceeding the quantity of fuel being pumped by the engine driven pump **18** so that pressure at the intake side of the pump **18** will increase rapidly to a value such that the inlet pressure to pump **18** will exceed pressure existing in the zone A. At this time check valve **27** will open and a supplementary flow will take place through the check valve **25** to bring the pressure in the zone A to the required value. During this time of course the pump **18** will be pumping and when the discharge flow from the pump **18** is sufficient to satisfy or exceed the demand, the increase in pressure will open the pressure regulating valve **29**. At the same time, the increase in pressure will have decreased the output of the booster pump **10** to a required value.

Assuming that relief valve **29** was incorrectly set to open at too low a pressure or stuck open, the pressure at A would still regulate properly. A minute correcting adjustment of control piston **108** would move to increase the discharge of the booster pump causing an increase in pressure in lines **16** and **24** until it reaches that at point A, acting as though pump **18** did not exist, only the open line.

As previously mentioned, failure of the booster pump **10** will not cut off the supply of fuel as the engine driven pump **18** will draw fuel through the check valves of the booster pump from the fuel tank for delivery to the engine. At the same time, complete failure of the engine driven pump **18** will not terminate supply of fuel since at this time the booster pump will deliver the required quantity of fuel through the check valve **25** to the zone A to maintain pressure at the required value.

From the foregoing it will be observed that the control piston **108** functions as an automatic pressure regulator with the end result that a constant pressure is remotely controlled where most desired, such as at pressure point A adjacent the fuel control device **20**. In other words, the booster pump **10** not only maintains its own pressure constant, but it also corrects for any variations in pres-

sure at point A due to variations or faulty operation or complete failure of the engine driven pump **18**.

Due to the simplicity of design of the pump and the inner arrangement of the component parts, such as the inlet valve assembly including the cage **82**, the pumping piston **74**, the eccentric cam assembly **38**, and the accumulator and control piston **108**, all of which are in line in the housing **48**, the cost of machining, the weight factor, and the cost of final assembly of the parts is reduced. Furthermore, the pump **10** is easy to maintain and service, with an overall efficient use either in military or commercial applications where installation space is very limited.

While the invention has been illustrated and described as applied to an engine fuel system, it should be apparent that the remotely controlled positive displacement booster pump illustrated herein could be employed to supply any fluids, such as water, or oil, under a constant pressure to a remote discharge point.

The drawing and the foregoing specification constitute a description of the improved fluid supply system in such full, clear, concise and exact terms as to enable any person skilled in the art to practice the invention, the scope of which is indicated by the appended claims.

What I claim as my invention is:

1. A fuel control system for an internal combustion engine having a fuel control device requiring delivery of fuel at a predetermined pressure, said system comprising a tank, a booster pump connected to said tank, an engine driven pump connected between said booster pump and the fuel control device, said booster pump being a positive displacement variable stroke pump, pressure regulating bypass means connected between said engine driven pump and said fuel control device set to open at said predetermined pressure, a bypass around said engine driven pump having a check valve therein set to open whenever pressure at the inlet of said engine driven pump exceeds pressure at its outlet by a small amount, said booster pump having an accumulator chamber at the outlet side thereof, a relief valve in said accumulator chamber set to open only when pressure therein exceeds said predetermined pressure, and means responsive to pressure at the outlet of said engine driven pump for controlling the stroke of said booster pump.

2. A fuel control system for delivering fuel to an internal combustion engine at a selected pressure, comprising a booster pump, said booster pump being a positive displacement variable stroke pump, an engine driven pump connected to the outlet side of said booster pump, pressure regulating valve means connected to the outlet side of said engine driven pump and set to open at said selected pressure, a bypass around said engine driven pump set to open whenever pressure at the inlet side of said engine driven pump exceeds pressure at its outlet side by a small amount, and means responsive to pressure at the outlet side of said engine driven pump connected to said booster pump to control its output volume to maintain fuel pressure at the outlet side of said engine driven pump at said selected pressure, said means responsive to pressure at the outlet side of said engine driven pump comprising means in said booster pump operable to determine the stroke thereof.

3. A fuel control system in accordance with claim 2, in which said engine driven pump is a positive displacement pump driven at a speed variable in accordance with engine speed to deliver fuel at a rate at least approximately variable in accordance with engine speed.

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