

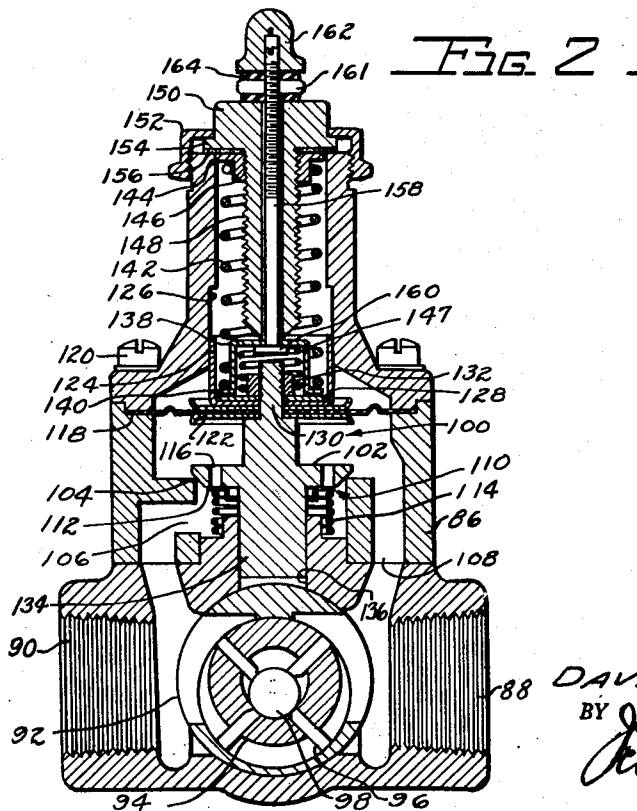
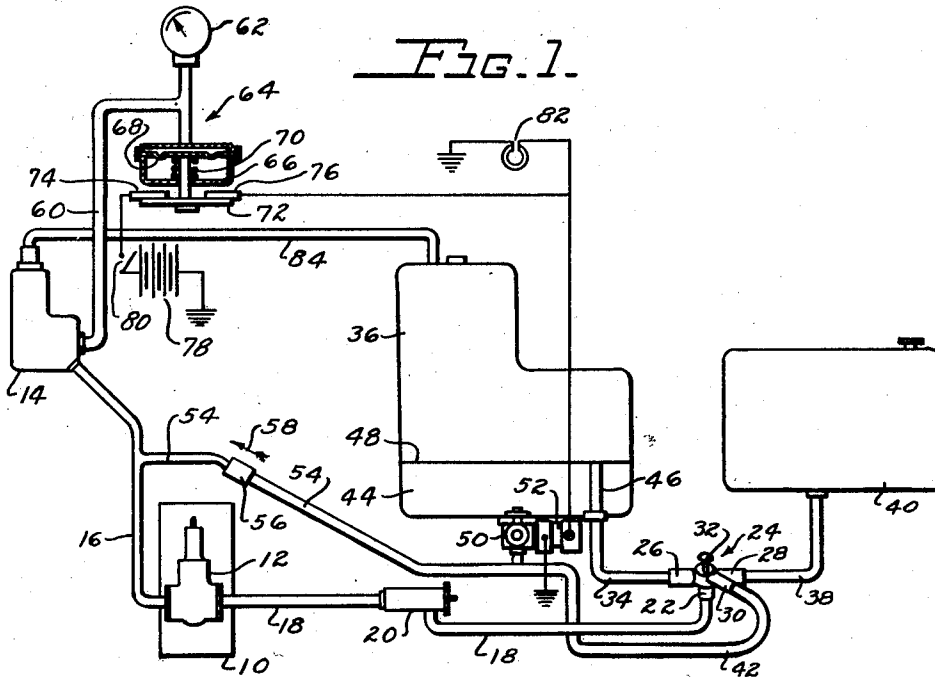
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AIRCRAFT FUEL SYSTEM

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AIRCRAFT FUEL SYSTEM

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to fuel systems having a plurality of fuel supply tanks and is particularly applicable to aircraft.

One of the advantages gained in a system of this kind by carrying the fuel supply in a number of separate tanks is that it makes for better weight distribution. Moreover, in combat craft there is the further advantage that if one tank becomes so punctured as to lose its fuel, the loss will be proportionately less as the number of tanks is greater.

There is, however, a slight disadvantage in a plural tank arrangement, in that when one tank becomes empty it frequently happens that, before a shift in connections may be made to another tank, a considerable volume of air has been drawn by the pump from the emptied tank and discharged into the fuel lines and carburetor. This disadvantage has given rise to the practice of supplementing the usual engine driven pump with an electrically driven auxiliary pump and with means which responds to a small drop in carburetor pressure to operate the electric pump until the engine driven pump may be reconnected to a full tank.

A system having an electric auxiliary pump and a fuel-pressure responsive electric switch for the pump is shown, described and claimed in my copending application Serial No. 475,683, filed February 12, 1943, now Patent No. 2,406,854, September 3, 1946. In the system shown in this copending application, by way of illustration, both the engine driven pump and the electric auxiliary pump are of the type which have an inbuilt relief valve for returning fuel from the discharge side back to the suction side upon a predetermined pump discharge pressure being exceeded, the relief valve of the engine pump being set, in the embodiment shown, at fifteen pounds, that of the electric auxiliary pump at ten pounds and the pressure responsive switch for operating the electric auxiliary pump being adjusted to start the electric pump when the discharge pressure from the engine pump falls below twelve pounds.

These relief valve pressures are, of course, arbitrarily selected for purposes of illustration. It is, however, desirable that the relief valve pressure of the engine pump be higher than that of the auxiliary pump and that the pressure at which the pressure responsive switch becomes operative be between the two pump pressures.

In the operation of the system of the copending application, the engine pump takes fuel from a given tank until it is empty, then momentarily takes air from the tank and transfers it to the carburetor. The substitution of air for liquid in the discharge pipe and carburetor causes the pressure therein to drop considerably. The pressure responsive switch, also subject to carburetor pressure, senses the drop and starts the electric pump. The relief valve of the electric pump being set for ten p. s. i. pressure, cannot open the pressure responsive switch which is set at twelve p. s. i. so it normally continues to maintain the fuel at the carburetor at ten p. s. i. until the engine pump may be reconnected to a full tank whereupon it picks up the fuel and builds up, in the discharge pipe and carburetor, the fifteen p. s. i. to which it is set, whereupon the pressure responsive switch is actuated and the electric pump stops until the next emergency arises.

The foregoing operation of the system of the copending application will maintain only if the engine pump is immediately connected to a full tank, so that solid fuel at ten p. s. i. will be maintained at the carburetor until the engine pump regains full pumping capacity and operates the pressure responsive switch to stop the electric pump. However, if there is any delay in selecting a full tank, as, for instance, when the selector cock is operated manually, the engine pump may, during the delay, build up an air pressure in the discharge pipe and carburetor which exceeds the pressure to which the electric pump is set, and thus override the electric pump and prevent its discharging any fuel into the system. This may result in a stalled engine.

It is therefore an object of this invention to provide an engine pump having air eliminating characteristics in the form of an inbuilt relief valve so constructed and arranged that it will not return any considerable liquid fuel from the discharge side back to the suction side until a relatively high pressure, say fifteen p. s. i., is exceeded but will return air or vapor from the discharge side back to the suction side when a pressure as low as several p. s. i. is exceeded.

Other objects and advantages will be evident as the invention is further described and reference is made to the drawings, wherein:

Fig. 1 is a schematic view of a system employing an engine driven pump to which my improved construction is adaptable.

Fig. 2 is a vertical axial section through a pump which embodies the principles of my invention.

Referring more particularly to the schematic

view Fig. 1, an engine 10 carries a main fuel pump 12, the pump being operatively connected to the engine to be rotated thereby, and adapted to supply liquid fuel under pressure to the carburetor 14 through the engine pump discharge pipe 16.

The suction pipe 18 of the engine pump 12 is connected through a strainer 20 to the common outlet 22 of a selector cock 24, which, in the embodiment shown, has three inlet branches 26, 28, and 30, either of which may be placed in flow communication with the outlet 22 by turning the selector knob 32 to the selected position.

Outlet branch 26 is connected by a pipe 34 to the outlet opening of a main fuel tank 36, outlet branch 28 is connected by a pipe 38 to the outlet opening of an auxiliary fuel tank 40, and outlet branch 30 is connected by a pipe 42 to the outlet opening of a reserve fuel supply 44.

By providing a standpipe 46 on the upper end of the pipe 34, the fuel in the main tank 36 cannot be drawn below the line 48 by the pipe 34. The reserve supply 44 is therefore maintained in the main tank, although the reserve supply may be kept equally well in a separate tank, if so desired.

The auxiliary pump 50 is driven by an electric motor 52 and has its suction side connected to the bottom of the reserve supply 44, the discharge side being connected around the engine pump 12 and into its discharge pipe 16 by way of the pipe 54. A check valve 56 is biased for flow in the direction of the arrow 58. The discharge side of the auxiliary pump 50 may also be connected by way of the pipe 42, selector cock 24, and pipe 18, to the suction side of the engine pump 12.

Connected into the carburetor 14 by a pipe 60 is a gage 62 for visible indication of the pressure being pumped, and a pressure responsive switch 64 which comprises a body 66 divided into two compartments by a diaphragm 68 which is movable downward by the pressure in the pipe 60 but is urged upward by the spring 70, whereby, at a sufficient drop in pressure in the pipe 60, the spring moves the contact bar 72 into engagement with the contacts 74 and 76, thereby keeping the switch 64 closed as shown in Fig. 1 until the pressure in pipe 60 is restored. The spring 70 in the embodiment shown is so proportioned that the switch 64 closes upon a drop in pressure in the pipe 60 to about twelve pounds. A battery 78 is connectible to the contact 74 through a manual switch 80. The motor 52 and a signal light 82 receive current from the contact 76 when the switch 64 is closed. A small pipe 84 connects the air eliminating portion of the carburetor 14 to the top of the main fuel tank 36. The engine pump 12 and the mechanism which provides it with air eliminating characteristics will now be described.

Referring particularly to Fig. 2, the pump 12 comprises a body 86 with inlet opening 88 and discharge opening 90. The liner 92 has an offset bore. The rotor 94 is offset with the bore but concentric with its outside. The rotor 94 is radially slotted for the blades 96. A follower 98 keeps the outer ends of the blades against the bore of the liner.

The relief valve 100 comprises a valve head 102 which is spring loaded to keep it against a seat 104 in the body. When the pressure in the discharge space 106 exceeds the force of the loading springs, the valve head rises and part or all of the fluid being pumped returns to the

suction space 108. The usual bypass valve 110 consists of a disc 112 held by a spring 114 over a series of holes 116 and is provided for bypassing fuel from the suction side 108 to the discharge side 106 when the pump is inoperative.

The valve 100 is of the balanced type. A diaphragm 118 has its outer edge clamped between two parts of the body 86 by screws 120, its central portion being clamped between two discs 122. A cup-shaped guide member 124 is vertically slidable in a bore 126 of the pump body 86. The two discs 122, the cup-shaped guide member 124, and a washer 128 are drawn together on the stem 130 of the valve head 102 by a nut 132. The lower stem 134 of the valve head is guided in a bore 136.

Within the cup-shaped guide member 124 is a smaller cup 138. Cup 138 is inverted and has an outwardly extending flange 140 surrounding the open end. A relatively strong coil spring 142 has its lower end resting on the flange 140 and its upper end on the flange 144 of a nut 146. A relatively weak coil spring 147 has its upper end reacting against the closed end of the inverted cup 138 and its lower end against the washer 128. A hollow screw 148 is threaded to fit the nut 146. Screw 148 has a head 150 by which it may be rotated to advance or withdraw the nut 146 and thereby adjust the spring 142. The strength of the larger spring 142 determines the pressure at which liquid fuel will be returned from the discharge side to the suction side of the pump. The strength of the smaller spring 147 determines the pressure at which air or vapor will be returned from the discharge side to the suction side of the pump. A lock nut 152 clamps a flange 154 against a gasket 156 to seal against pressure leakage. The space within the bore 126 is usually connected to the carburetor intake whereby it is subjected to supercharger pressure. This connection is not shown since it forms no part of this invention.

A small adjusting screw 158, having a head 160 within the inverted cup 138, extends upwardly through the closed end of the cup and loosely through the hollow screw 148 and is provided with a screwdriver slot at its upper end. Screw 158 is adjusted by a nut 161 and secured in the desired position by a lock nut 162. Gaskets 164 seal against leakage past the screw 158.

The head 160 of the screw 158 acts as a stop to arrest expansion of the heavy spring 142 beyond a certain amount, the expansion being arrested just before it has completely closed the valve 100. The distance which the valve head 102 is still off its seat 104 when the expansion of the heavy spring 142 is arrested by the head 160 depends, of course, on the adjustment of the nuts 161 and 162.

When the pump shown in Fig. 2 has been installed in the system shown in Fig. 1, the spring 142 is first adjusted by means of the hollow screw 148 until the valve passes fuel from the discharge side back to the suction side when the discharge pressure exceeds fifteen pounds. The small screw 158 is next adjusted until the head 160 lifts the inverted cup 138 until its flange 140 is raised from the washer 128 a distance of several one thousandths of an inch. The valve head 102 may now rise this several one thousandths of an inch by merely overcoming the small spring 147 but in order to rise farther it must overcome the larger spring 142.

The operation of the system shown in Fig. 1

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when equipped with a pump as shown in Fig. 2 will be substantially as follows:

Let it be assumed that the engine is at rest, the tanks are full and the fuel cock is turned so as to connect the auxiliary tank 40 through the pipes 38 and 18 to the suction side of the engine pump 12. If the system has been inactive long enough to allow the carburetor pressure to fall below twelve pounds, the automatic switch 64 will be closed as shown. The carburetor may now be provided with fuel at ten pounds pressure by closing the manual switch 80 and thus operating the electric auxiliary pump 50, which will deliver fuel to the carburetor through the pipe 54 and check valve 56. When the carburetor pressure reaches ten pounds, which may be observed by the gauge 62, further operation of the electric pump will be of no avail since the relief valve in the electric pump will merely return the fuel pumped from the discharge side back to the suction side.

When the engine is now started, the engine pump 12 will supply fuel to the carburetor at fifteen pounds pressure which will open the automatic switch 64 and thus discontinue operation of the electric pump 50.

When the auxiliary tank 40 becomes empty, air will be drawn by the engine pump 12 through pipes 38 and 18 and discharged into the pipe 16. As soon as even a small volume of air is discharged into the pipe 16 the pressure will momentarily drop materially, since air is a compressible fluid, and this will cause the automatic switch 64 to close and the electric pump 50 to start and again deliver fuel to the carburetor 14 through the pipe 54 and check valve 56.

If the selector cock 24 is now immediately turned so as to connect the main tank 36 to the engine pump 12 through the pipes 34 and 18, the engine pump will pick up its prime and cause the small amount of air which has been delivered into the pipe 16 to be eliminated through the air eliminator pipe 84.

On the other hand, if the pump 12 was conventionally constructed without my improved relief valve 100 and there was any considerable delay in turning the relief cock 24 to the full tank 36, a fifteen pound air pressure would be built up by the pump 12, in the pipe 16, the carburetor 14, and pipe 60, whereby the automatic valve 64 would stop the electrically driven pump and the engine would stop.

However, by providing an engine pump which is constructed as shown and described in Fig. 2 a different result is had, for, when the auxiliary tank 40 becomes empty, the pump 12 will draw and discharge a small volume of air into pipe 16, the pressure in pipes 16 and 60 will momentarily drop, the automatic switch 64 will close, the electric pump will start and pump a ten pound pressure to the carburetor 14 through the pipe 54 and check valve 56, while in the engine pump 12, as soon as the air pressure in the discharge side 106 exceeds two or three pounds, the weak spring 147 will yield and the valve head 102 will lift off its seat 104 until the washer 128 strikes the flange 140. The amount of lift is a matter of several one thousandths of an inch, as determined by adjustment of the small adjusting screw 158, and this slight opening of the valve 100 will return substantially all of the air being pumped by the engine pump 12 from the discharge side back to the suction side.

Engine operation may thus continue off the

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electric pump 50 until the pilot gets around to switching from the empty tank to a full one, whereupon the pump 12 will pick up its prime, deliver fuel to the carburetor at fifteen pounds pressure, and the automatic switch will open and stop the electric pump. Thereafter, in order that the relief valve 100 will pass the surplus liquid fuel from the discharge side back to the suction side, it will be necessary that it rise much higher than was required when pumping air only and this higher rise will be accomplished against the resistance of the stronger spring 142, which as before stated, was set to maintain a fifteen pound discharge pressure when liquid fuel is being pumped.

It will, of course, be understood that the pressures at which the several elements were adjusted was arbitrarily selected for illustrative purposes only, the essential condition being only that the engine pump maintain a higher pressure than the electric auxiliary pump and that the automatic switch will not be opened by the pressure which the electric pump is capable of delivering, but will be opened by the pressure which the engine pump is capable of delivering.

Moreover, the small amount of rise of the valve head 102 against the resistance of the weak spring 147, before it must effect further rise against the stronger spring 142, was given by way of illustration as several one thousandths of an inch, it may be more or less than this amount as the particular situation requires, it being preferable, however, that when the pump is pumping air only, that the lift be at least enough to prevent the build up of air pressure at the discharge side of the engine pump which is equal to the pressure capacity of the electric pump.

Having shown and described an embodiment of my invention, I claim:

1. In a pump, a passageway for returning fluid from the discharge side back to the suction side, a valve in said passageway, a light spring arranged for moving said valve to the closed position but yieldable to a low pressure at the discharge side of the pump for letting said valve open slightly, a heavy spring expandible for urging said valve toward the closed position, and a stop for arresting expansion of said heavy spring at a point just before said valve is completely closed by said heavy spring.

2. In a fluid pump, a passageway for returning surplus fluid from the discharge side back to the suction side, a poppet valve in said passageway biased to prevent flow through said passageway from the suction side to the discharge side, a relatively heavy spring expansible to move said poppet valve toward its seat, an adjustable stop for arresting expansion of said heavy spring when said valve is almost but not quite on its seat, and a light spring for moving said valve the remainder of its way onto its seat.

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