July 11, 1944. J. M. ROTH ET AL. 2,353,269

HYDRAULIC FUEL SYSTEM

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Fig. 1

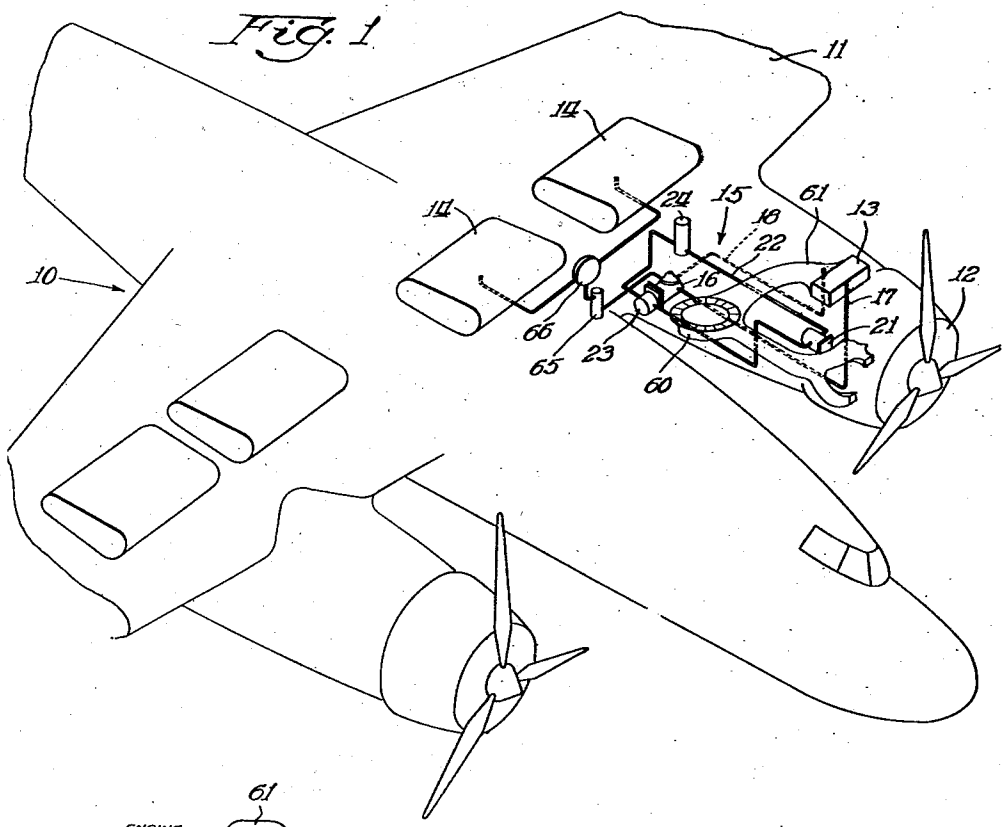
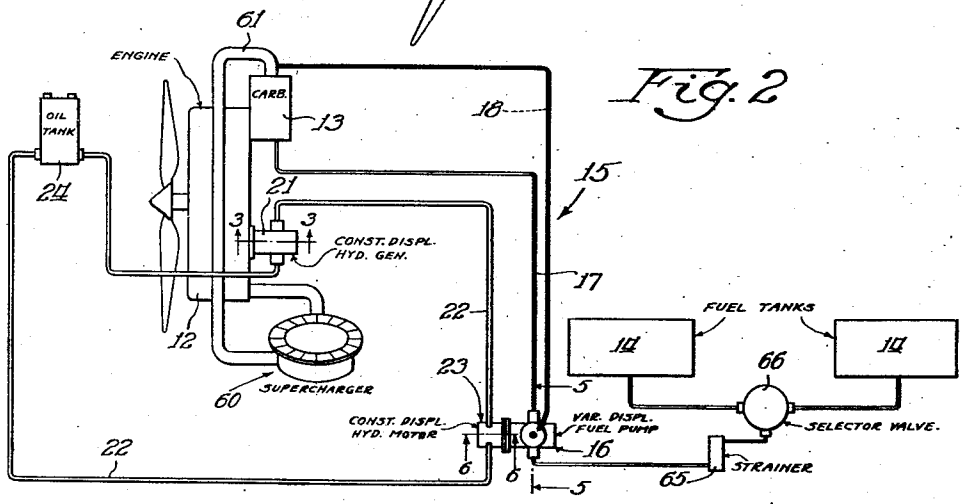


Fig. 2



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Fig. 3

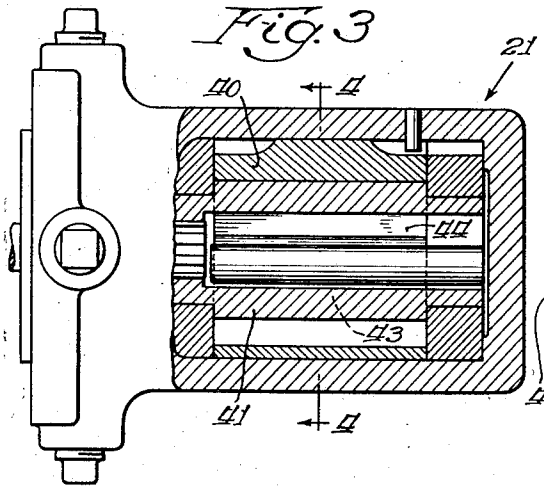


Fig. 4

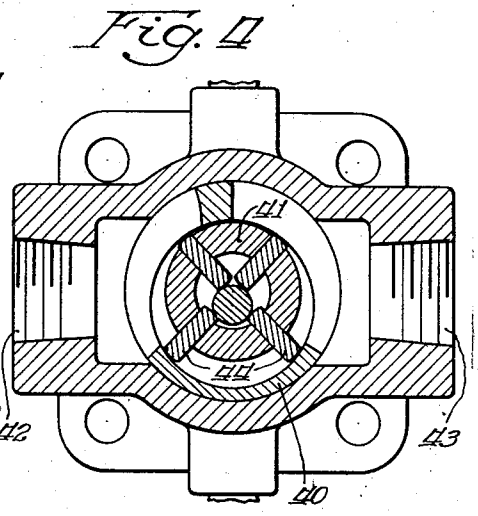
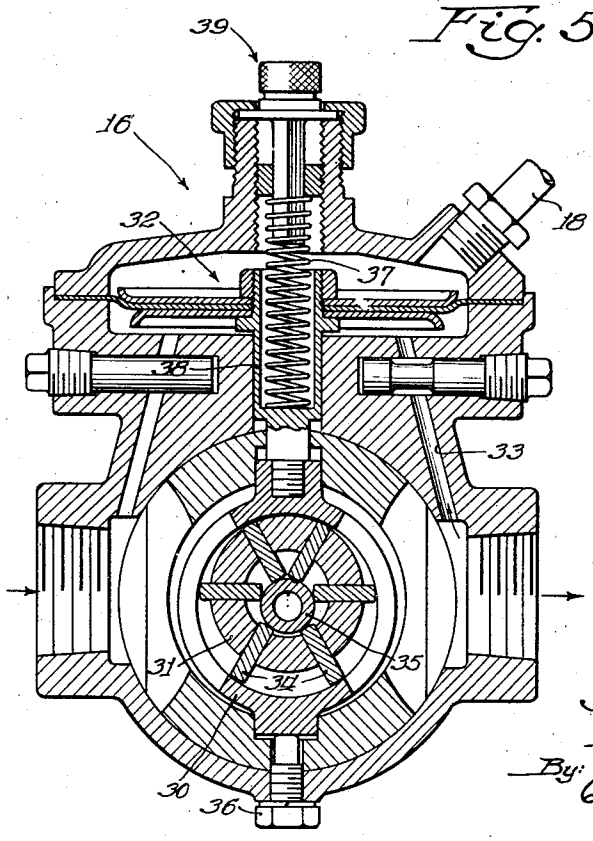


Fig. 5



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Fig. 6

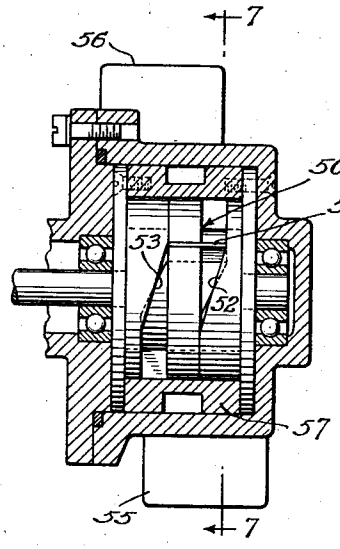


Fig. 7

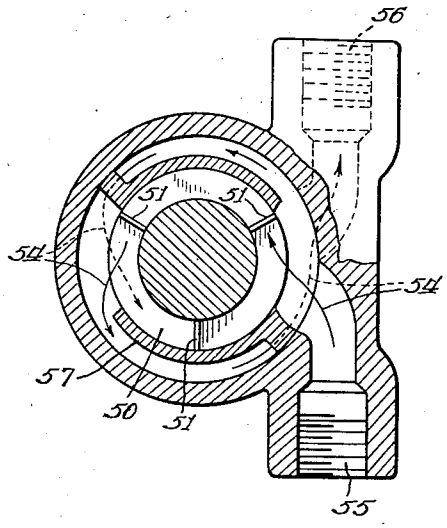
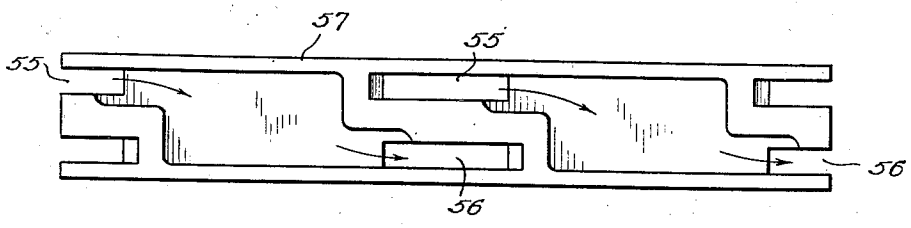


Fig. 8



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Patented July 11, 1944 2,353,269

UNITED STATES PATENT OFFICE

2,353,269

HYDRAULIC FUEL SYSTEM

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Application September 21, 1940, Serial No. 357,826

2 Claims. (Cl. 158—36.4)

This invention relates to fuel supply systems and particularly to aircraft fuel feeding systems for high altitude flying.

It has been found that certain limitations in fuel systems heretofore available have resulted in the occurrence of a condition known to the art as "vapor lock." It has also been determined that this "vapor lock" condition is due largely to the occurrence of reduced pressure in the fuel feeding system, which pressure becomes sufficiently low to cause the fuel to be pulled apart and air bubbles incorporated therein. A number of factors have been credited with producing these low pressure conditions, including: flying at extremely high altitudes; locating the highly volatile fuel tanks at an elevation on the aircraft below that of the means for introducing fuel into the engine; locating these instrumentalities remote with reference to each other; and maneuvering the craft as for example, banking, diving and the like.

Previously available systems have failed to fully take into account all of the factors having an influence upon the proper feeding of a volatile fuel from the supply tank to the means for introducing the fuel into the engine and more particularly have these previous systems failed to provide the necessary arrangement of means for counteracting the effects referred to above.

It is an object of the present invention to provide an improved volatile fuel pumping system for transferring fuel from the supply tank to the aircraft engine under circumstances wherein the tank must necessarily be located remote from the engine and in some instances at an elevation considerably therebelow, our improved system being particularly characterized by the provision of means for preventing the occurrence of pressure in the fuel system of a low value such that the fuel will be pulled apart and air bubbles incorporated therein.

It is a more particular object to provide such an arrangement of means which is capable of compensating for or overcoming the several pressure reducing effects peculiar to aircraft and including flying at extremely high altitudes; normal differences in the elevation of the engine and the fuel tanks; and maneuvering such as banking, turning, diving, and the like.

A more detailed object is to provide a volatile fuel pumping system for producing the above results wherein only that amount of fuel is moved from the tank along the fuel line to the fuel introducing means that is required by the aircraft engine at any particular time there being no appreciable by-passing of volatile fuel from the outlet of the fuel pump back to the inlet thereof such for example as is common in current systems, and which results in whipping up the volatile fuel and the incorporation of air bubbles therein.

Another specific object of this invention is the novel adaptation to the solution of the above problem of the variable eccentricity type of adjustable displacement fuel pump disclosed in Johnson Patent 2,192,266.

The above and other objects, advantages and uses of our invention will become more apparent from a reading of the following specification taken in connection with the appended drawings which form a part of this specification and wherein:

Fig. 1 is a broken-away schematic view in perspective illustrating a preferred arrangement of our fuel system on an airplane;

Fig. 2 is a schematic view in elevation indicating the relative disposition of the elements of our fuel feeding system;

Fig. 3 is a broken away axial view of a hydraulic generator or pump particularly adaptable for use in our fuel system, this view being indicated generally by line 3—3 of Fig. 2;

Fig. 4 is a transverse cross-section taken substantially on the lines 4—4 of Fig. 3;

Fig. 5 is a transverse cross-section view taken substantially on line 5—5 of Fig. 2 showing a variable displacement fuel pump particularly adapted for use in our fuel system;

Fig. 6 is an axial cross-section view indicated generally by the lines 6—6 of Fig. 2 illustrating the interior construction of a preferred form of hydraulic motor for driving the variable displacement fuel pump;

Fig. 7 is a broken away section view taken substantially on the lines 7—7 of Fig. 6;

Fig. 8 is a developed view showing the form of the housing structure embracing the motor rotor and the path of flow of driving fluid through the motor.

Referring to Fig. 1, there is illustrated schematically in perspective an aircraft indicated generally at 10 embodying a preferred modification of the fuel feeding system forming the subject matter of the present invention. Airplane 10 includes the usual outwardly extending wing structures 11 and the forwardly protruding propeller driving motors 12 of one conventional form to which this invention is applicable. The engines or motors 12 are provided with the usual form of carbureter or other fuel introducing

means indicated generally at 13, fuel being supplied thereto from a selected one of a plurality of volatile fuel supply tanks 14 carried in the wing structure 11, this fuel delivery being accomplished by means of our novel fuel pumping arrangement indicated generally at 15, the pumping arrangement for one engine only being illustrated in order to simplify the disclosure.

Referring particularly to Fig. 2, it will be seen that our volatile fuel transfer or pumping system 15 comprises essentially a variable displacement fuel pump 16 located relatively close to or below the fuel in the tanks 14 and arranged to push or force the volatile fuel up through line 17 to the carbureter 13 as differentiated from pulling or sucking up the same to increase the elevation thereof. It is important to note that pump 16 is provided with means for varying the displacement thereof in accordance with changes in the pressure that occurs within the fuel introducing means or carbureter 13. By providing an efficient and variable displacement fuel pump such as that indicated at 16 to be hereinafter described in greater detail and by arranging to vary this displacement in accordance with the most accurate index of fuel demand, namely the pressure condition within carbureter 13 we have made it possible to thus overcome or compensate for all of the many variables present under aircraft flying conditions that normally cause fatal reductions in the fuel pressures accompanied by "vapor lock."

Essential to the successful operation of the present system is the hydraulic fluid drive, comprising the constant displacement hydraulic generator or pump 21 driven directly from the aircraft engine 12 and coupled by means of closed line or circuit 22 with constant displacement hydraulic motor 23 attached to the variable displacement fuel pump 16 for driving the same. Also included in closed line or circuit 22 is an oil tank or accumulator 24. While it is contemplated that oil will normally be used in circuit 22, other fluid power transmitting mediums such as glycerine may be employed to equal advantage. So far as the present invention is concerned it is merely important that a liquid medium be employed which has a much lower volatility than that of the liquid fuel being supplied to the aircraft engine, since it is necessary to maintain at a minimum the amount of whipping and consequent vapor inclusion, this being particularly significant at high altitudes.

With reference to the details of the variable displacement fuel pump, we have found that a pump constructed in general conformity with the disclosure of Johnson Patent 2,192,660 functions in a particularly novel and advantageous manner when employed as disclosed in Figs. 1, 2 and 5. Referring to Fig. 5 it will be seen that the displacement of pump 16 is varied by vertically adjusting sleeve 30 relative to the fixed axis rotor 31, this adjustment being accomplished by exposing the upper side of diaphragm assembly 32 to the pressure conditions existing in the carbureter 13, the connection being made through line 18, and by exposing the under side of diaphragm assembly 32 to the discharge pressure of pump 16 through passage 33. In further detail multiple pumping vanes or blades 34 reciprocate with reference to the fixed axis rotor 31 as the same revolves causing fuel to be drawn into and discharged from the pump, these vanes having their inner edges in running engagement with a floating tubular member 35 limiting the inward movement thereof. Adjustable threaded stop 36 determines the maximum eccentric relation between the rotor 31 and sleeve 30 and hence the maximum displacement of the pump. Elongated coil spring 37 engages the closed end of tubular connector 38 and urges the sleeve 30 in the direction of greatest eccentricity with a pressure which is determined by an adjustment assembly indicated generally at 39. It will therefore be made to appear that three things influence directly the relative eccentricity of the sleeve and rotor and consequently the displacement of the pump, namely; the pressure within the fuel introducing means or carbureter 13 acting through line 18 on top of diaphragm assembly 32; the discharge fuel pressure acting on the under side of diaphragm assembly 32 through passage 33; and the pressure of spring 37 acting in the same direction as the pressure on top of the diaphragm.

The particularly successful results obtained from the use in combination of this pump constructed in the manner disclosed is especially attributed to two things: first, the relatively large area disc-like diaphragm assembly being both sensitive to minute changes in the pressures to which it is subjected and being sufficiently strong to quickly adjust the relative eccentricity between the sleeve and rotor notwithstanding the remote location of this pump assembly with reference to the carbureter and; secondly, the positive and effective pumping action of this vane construction through a wide range of displacements without any appreciable accompanying re-circulation or whipping of the fuel sufficient to cause the inclusion therein of vapor or air bubbles.

While other commercially available forms of constant displacement hydraulic generators or pumps may be employed at 21 we prefer the vane type constant displacement generator of the general type disclosed in Johnson's Patent 2,026,739 and comprising essentially a similar arrangement to that of Fig. 5 except that the sleeve 40 is not adjustable to vary the eccentricity thereof with reference to fixed axis rotor 41. The constructions are otherwise essentially the same, including inlet 42, outlet 43 and reciprocable vanes 44.

Likewise, hydraulic motor 23 may take any one of several commercially available forms. However, we have found the construction shown in Figs. 6, 7 and 8 to be particularly adaptable for use in this connection, the same being of the type covered by Johnson Patent 2,202,911. This hydraulic motor comprises essentially a rotor 50 having axially reciprocating vanes or blades 51 adapted to be actuated by a pair of cams 52 and 53 located adjacent opposite edges thereof for causing these vanes to respond to the fluid pressure stream delivered by hydraulic generator 21 through closed circuit 22, the fluid following the path through the motor indicated generally by the arrows 54, entering inlet port 55 and passing out of outlet port 56. Intermediate housing sleeve 57 embraces rotor 50 and is formed with complementary ports and connecting channels for directing the flow as indicated by the arrows 54.

It will be observed from the above that by employing a constant displacement hydraulic generator 21 and a constant displacement hydraulic motor 23, we have made it possible to avoid the use of complicated control units for the oil or other fluid medium in closed circuit 22, it being necessary to use only a simple accumulator tank 24 having an inlet and an outlet with no complicated control mechanism in the tank.

A conventional supercharger assembly indi-

cated generally at 60 is employed for the purpose of raising the pressure of the air introduced into the carburetor 13 with which it communicates through line 61.

In addition to the above, there will of course be employed the necessary conventional equipment forming no particular part of the present invention, and a detailed description thereof is deemed unnecessary. This may include among other things a strainer 65 receiving fuel from selected ones of tanks 14 through distributor valve 66 and delivering the same to the inlet side of variable displacement pump 16.

While we have described our invention in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not by way of limitation, and that the scope of our invention is to be defined solely by the appended claims.

We claim:

1. In a high altitude volatile fuel supply system for aircraft motors, including carburetor means adapted to be mounted adjacent an aircraft motor for introducing fuel therein, means providing a supply of volatile fuel located at an elevation normally below that of said introducing means, the combination therewith of means for moving said volatile fuel from said lower elevation to said carburetor means located thereabove while maintaining the pressure of said fuel being moved at a value above that point below which vapor lock would normally occur, said means comprising a rotary fuel pump located at a level not substantially different than that of said supply and in communication with said supply, said means being effective to push said fuel from said lower level up to said introducing means, a liquid pressure responsive constant displacement rotary motor for driving said fuel pump, a constant displacement rotory liquid pressure generator adapted to be driven directly from said aircraft motor, means defining a closed liquid circuit connecting said pressure generator and said liquid pressure responsive motor, said circuit including a relatively non-volatile liquid, said fuel pump having a fixed axis rotor supporting a plurality of reciprocable blades embraced by an eccentrically adjustable sleeve for varying the displacement of said fuel pump, and means for adjusting said sleeve relative to said motor comprising a diaphragm assembly connected thereto, means for exposing a first side of said diaphragm assembly to the discharge pressure of said pump and means for exposing the opposite side of said diaphragm assembly to the pressure within said introducing means whereby to deliver fuel to said introducing means at a substantially constant pressure.

2. In a high altitude volatile fuel supply system for aircraft engines, including a carburetor adapted to be located adjacent an aircraft engine for introducing fuel therein, a volatile fuel supply tank arranged to be located remote from and below the elevation of said carburetor, a fuel pump arranged to be carried by said aircraft and located at a level not substantially different from that of the fuel in said tank for receiving fuel from said tank and forcing the same under a predetermined minimum pressure to said carburetor, a fuel delivery line leading from said pump to said carburetor, a constant displacement liquid pressure responsive motor for driving said fuel pump indirectly from said aircraft engine, a constant displacement liquid pressure generator driven directly from said aircraft engine, means defining a closed liquid circuit including said generator and said motor for circulating therethrough a substantially constant volume of non-volatile liquid at a rate depending upon the speed of rotation of said generator, all of said liquid being circulated through said liquid pressure responsive motor, said fuel pump being provided with means for varying the displacement thereof, and means responsive jointly to the discharge pressure of said pump and to the pressure in said fuel introducing means effective to operate said displacement varying means whereby to produce a constant fuel delivery pressure at said fuel introducing means notwithstanding the effects attendant to flight, including change of altitude and maneuvering.

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