

Nov. 18, 1941.

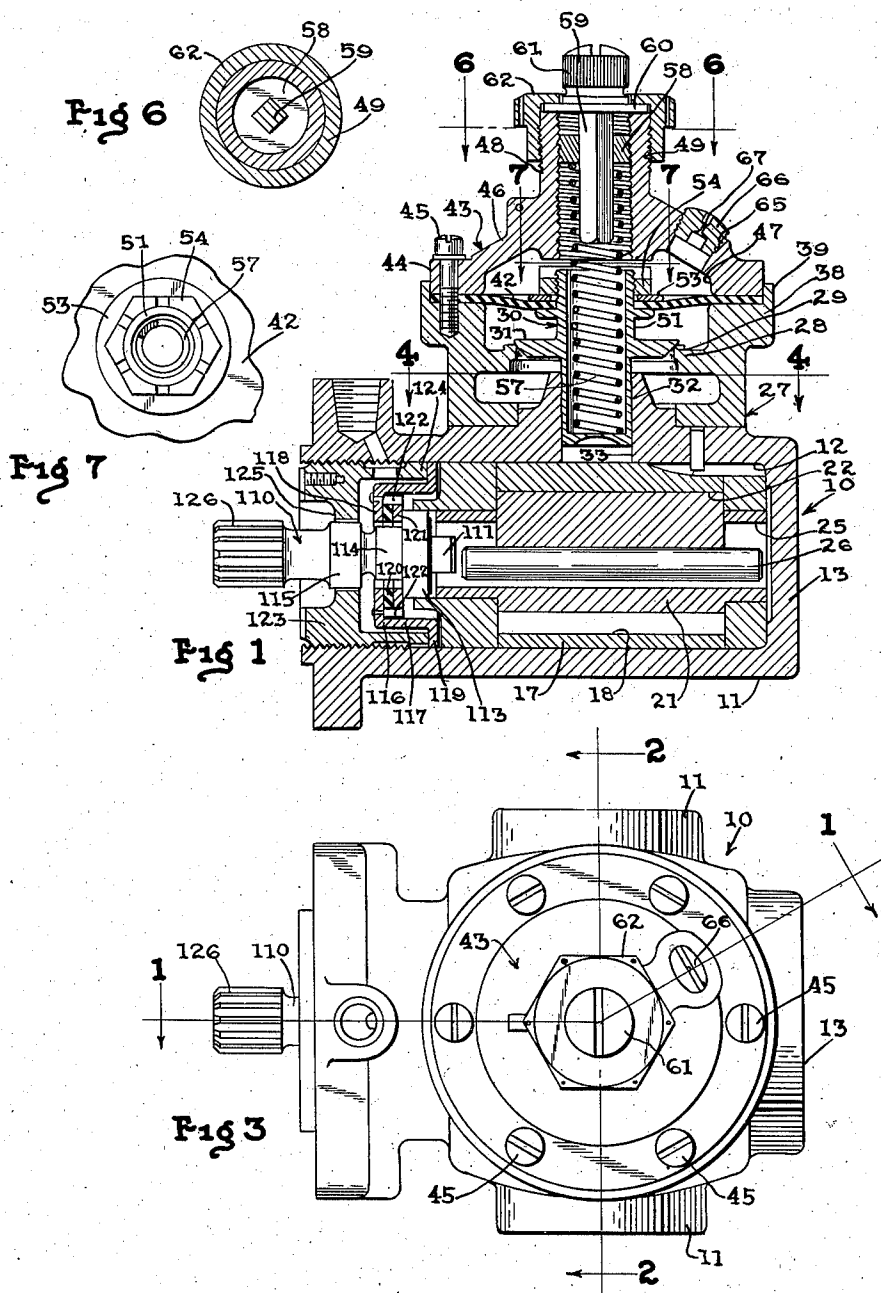
J. P. JOHNSON

2,263,091

FUEL PUMP

Filed March 18, 1938

2 Sheets-Sheet 1



Nov. 18, 1941.

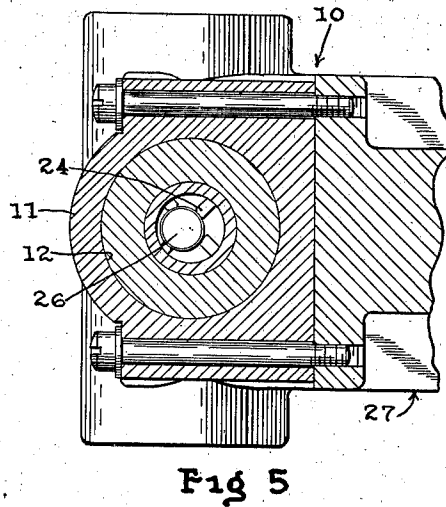
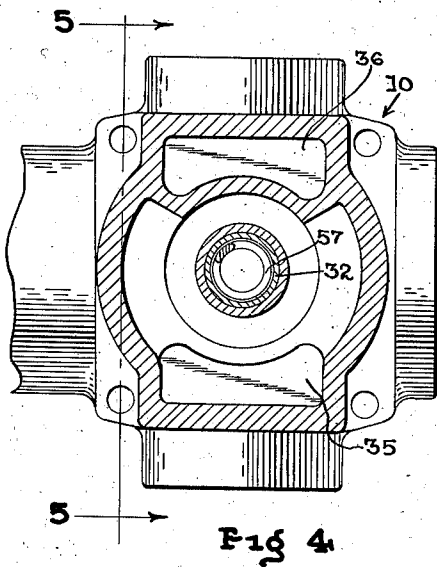
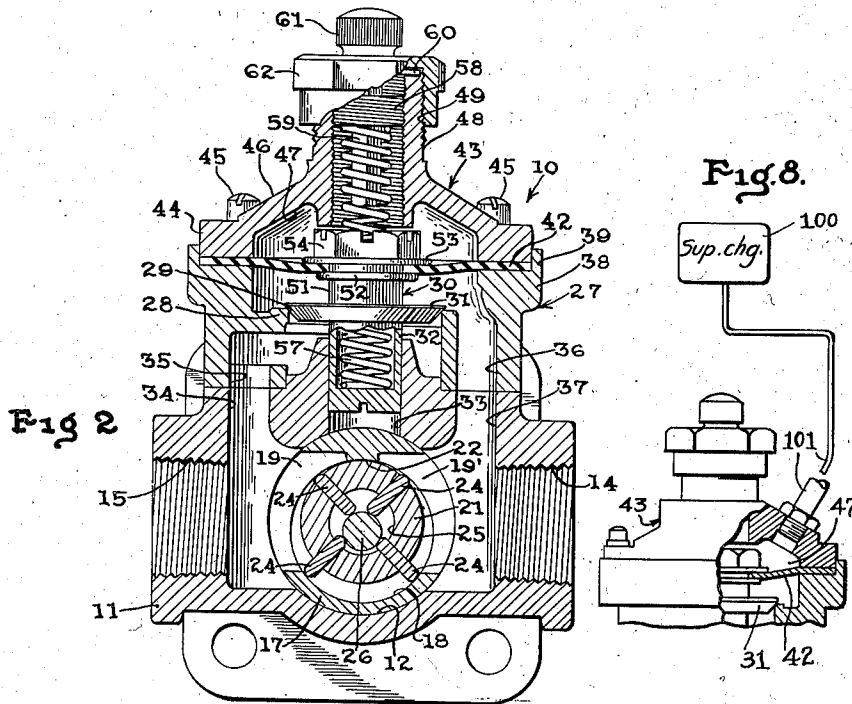
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2 Sheets-Sheet 2



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2,263,091

FUEL PUMP

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ration of Ohio

Application March 18, 1938, Serial No. 196,693

6 Claims. (Cl. 103—42)

This invention relates to fuel pumps for use on aircraft, and particularly to improvements over the form of pump disclosed in my copending application, Serial No. 170,844, filed October 25, 1937.

In the pump disclosed in my copending application the relief and by-pass valve assembly is relatively complicated requiring several steps in the fabrication and assembly thereof resulting in loss of time and added weight. Both of these latter factors are of great importance in this type of fuel pump for use on aircraft and it is, therefore, one of the objects of the present invention to provide a valve assembly which is simple in construction and assembly, of minimum weight with maximum efficiency, and which assembly has a greater range of fuel discharge pressures.

Another object of the present invention is to provide an improved assembly whereby the movement of the valve member is restricted so as to minimize the hammer action between the valve head and its seat.

Another object of the invention is to provide external adjustment for preloading the valve member.

A still further object of the invention is to provide a new and simple means of connecting the detachable reversible relief valve housing to the pump housing proper.

With the objects above indicated and other objects hereinafter explained in view, my invention consists in the construction and combination of elements hereinafter described and claimed.

Referring to the drawings,

Figure 1 is a longitudinal sectional view taken on line 1—1 in Figure 3 and showing the improved pump structure embodying the present invention.

Figure 2 is a transverse vertical sectional view taken on line 2—2 in Figure 3.

Figure 3 is a top plan view of the pump shown in Figure 1.

Figure 4 is a transverse sectional view taken on line 4—4 in Figure 1.

Figure 5 is a transverse sectional view taken on line 5—5 in Figure 4 and showing the means for connecting the reversible housing to the pump housing proper.

Figures 6 and 7 are transverse sectional views taken on line 6—6 and 7—7 respectively in Figure 1 and show details of the valve assembly.

Figure 8 is a schematic broken-away section view showing the upper side of the diaphragm connected with a supercharger.

In the drawings, I have illustrated a rotary fuel

pump provided with a fuel by-pass and relief valve embodying the present invention and designed especially for use on aircraft where lightness, compactness, and efficiency are of utmost importance.

The fuel pump is indicated generally by the numeral 10 and consists of a housing 11, preferably of aluminum or some similar light-weight material, having an axial opening 12 therein extending inwardly from one end of the housing and which is closed at the other end by an integral end wall 13. The housing 11 is provided with an interiorly screwthreaded opening 14 on one side thereof, which communicates with the axial bore 12, while the opposite side of the housing is provided with a similar screw-threaded opening 15 which likewise communicates with the bore 12, as more clearly shown in Figure 2. These openings 14 and 15 are adapted to be connected, one with the fuel supply and the other with the carburetor which supplies the fuel to the motor, and the respective openings will be connected in the manner herein stated, depending on the direction of rotation of the fuel pump.

A liner 17, preferably of hardened steel, is positioned within the axial bore 12 and is provided with an axial bore 18 which is eccentric to the axial bore 12. The liner 17, as more clearly shown in Figure 2, has oppositely disposed, transversely extending openings 19' and 19 communicating respectively with the screwthreaded openings 14 and 15 so as to provide communication with the interior of the bore 18, the latter constituting a circular chamber.

A rotor 21, preferably of hardened steel, is eccentrically positioned within the bore 18 and has a running engagement with the inner peripheral wall of the chamber at 22, which separates the opening 19' from the opening 19. The rotor 21 is provided with tubular extensions which extend axially thereof, and are suitably mounted for rotation in spaced bearings disposed within the housing. The body portion of the rotor 21 is provided with angularly disposed slots positioned longitudinally, and within which are slidably mounted a plurality of blades 24, the blades being coextensive with the body portion of the rotor. The outer ends of the blades 24 are adapted for engagement with the inner peripheral wall of the chamber, while the inner end of the blades extend inwardly within an axial bore 25 provided in the rotor. A roller member 26 is freely positioned within the bore 25 and is adapted for engagement with the inner ends of the

blades 24 to maintain the latter in spaced relation.

A simplified seal is provided which will be herein described but the construction is claimed in my copending application, Serial No. 196,694, filed March 18, 1938. A drive shaft 110 is disposed axially of the rotor 21 and has at its inner end a transversely extending projection 111 which is disposed in aligned recesses 112 provided in the adjacent tubular extension. The projection 111 is mounted for slight axial movement within the recesses 112 but connected thereto in a manner to insure rotation of the rotor 21. Outwardly of the projection 111 is an enlarged circular portion 113 which is disposed within the flanged extension of the bearing opening in the adjacent bearing and has a close running fit therewith. The inner face of the circular portion 113 is spaced slightly from the adjacent end of the rotor extension but is movable axially into engagement therewith for a purpose to be later described. The shaft 110 has a reduced portion 114 outwardly of the circular portion 113 and of relatively smaller diameter and a second enlarged circular portion 115 substantially midway of its ends.

A seal supporting member 116, preferably of steel material, has an annular wall 117 which encircles the flanged extension of the adjacent bearing and an inwardly extending peripheral flange 118 arranged in spaced relation with respect to the adjacent end of the bearing flange. The opposite end of the supporting member 116 has an outwardly extending peripheral flange 119 which rests upon the adjacent portion of the bearing and is of a diameter such as to permit it to be slidably mounted within the bore 12 of the housing. Positioned upon the inner face of the peripheral flange 118 is a flexible disc 120, of duprene and fabric material or other suitable material, and positioned upon the inner face of the disc is a metal disc 121 which has its inner face spaced a suitable distance from the adjacent end of the bearing flange. The metal and flexible discs and flange 118 are secured in any suitable manner for their intended function but in the present instance, a plurality of pins 122 have their outer ends secured to the flange 118 and their inner ends projecting freely through aligned openings in the flexible and metal discs. The metal disc 121 and the enlarged portion 113 of the drive shaft are so arranged that their adjacent marginal portions are in running engagement and their contacting surfaces being machined, produce a seal against the escape of fluid by reason of the pressure existing in the pump during its operation. The flexible and metal disc arrangement provides another advantage in that it insures a proper seal even though the drive shaft 110 is in slight misalignment. This is made possible by the flexible disc 120 yielding slightly without causing any misalignment between the contacting portions of the metal disc 121 and the enlarged portion 113.

The construction is such that when the pump is vacuum tested by the interior of the pump being placed under vacuum, the enlarged portion 113 of the drive shaft is moved inwardly axially into contact with the adjacent end of the bearing flange and because of the close running fit between the peripheral surface of the enlarged portion 113 and the inner surface of the bearing opening an efficient seal is provided so that the loss of vacuum is inconsequential.

The plug 123 which closes the outer end of the

bore 12 has an annular flange 124 which is adapted to engage the flange 119 on the supporting member and by screwing the plug inwardly the flange 119 is secured in rigid position. The plug 123 has an end wall 125 provided with an axial opening to receive the enlarged portion 115 of the drive shaft. The outer end of the drive shaft 110 is in the form of a gear 126 adapted for driving connection with the motor of the aircraft or other means.

The operating parts of the pump are, of course, so arranged that the pump may be operated in either direction without the necessity of rearrangement thereof, which is quite advantageous in view of the fact that different types of motors operate in different directions. It is not necessary, therefore, to change the position of the pump, irrespective of the direction of rotation of the motor used.

When the pump is used on an airplane, the rotor is operated at various speeds, depending upon the R. P. M. of the motor, as the rotor is usually connected to the motor to operate at the same or slightly greater R. P. M. The volume of fuel pumped by the pump therefore varies with the changes in the R. P. M., and, for example, at 1750 R. P. M. approximately 360 gallons of fuel per hour are pumped by the pump. Such a volume of fuel is, of course, out of proportion to the volume of fuel adapted to be handled by the carburetor, and means must therefore, be provided to return the excess fuel to the inlet side of the pump. Furthermore, for efficient operation of the motor, the fuel should be delivered at a constant pressure irrespective of the volume required, and the pressure most effective has been found to be approximately 3½ pounds, although this may vary somewhat, depending upon different conditions. Means is, therefore, provided in the pump to maintain the volume of fuel discharged at a constant pressure irrespective of flying conditions.

A second hollow housing 27, of aluminum or other similar material, is detachably connected to the housing proper 11 and has two positions of mounting thereon so as to adapt the pump for operation in either direction without the necessity of dismantling the operating elements. This housing is provided with a transversely extending partition 28 having an axial opening providing a valve seat 29 on its outer side. A relief valve member 30 has a valve head 31 engageable with the valve seat 29 and a depending tubular stem portion 32 having its lower end slidably mounted in an opening 33 provided in the adjacent portion of the housing 11, the bottom of the stem terminating short of the bottom of the opening to provide a dash pot for minimizing vibrations imparted to the valve member. The under side of the valve head 31 is in communication with the outlet opening 15 through aligned openings 34 and 35 provided in the respective housings while the outer side of the valve head 31 is in communication with the inlet opening through aligned openings 36 and 37 similarly located.

The upper end of the tubular housing 27 has an outwardly extending circumferential flange 38 which is provided with a marginal extension 39 to provide a recessed outer surface and a relatively flat flexible disc 42, of impervious material such as duprene and fabric or other suitable material, is positioned within the recessed outer surface and extends across the open end of the housing. A cover 43 preferably of alumi-

num, has a circumferential flange 44 fitting snugly within the recessed portion and is detachably connected to the flange 38 by means of a plurality of bolts 45 which engage aligned openings provided in the respective flanges and the marginal edge of the disc 42 so as to provide a sealed joint. The cover 43 also has a conical tapered portion 46 providing a chamber 47 above the central portion of the disc 42 and a tubular extension 48 extending axially outwardly therefrom which is provided with an externally screw-threaded end 49.

The valve member 30 is connected to the disc 42 by means of a tubular extension 51 which is an integral part thereof and the outer end of the extension 51 is exteriorly screwthreaded. The extension 51 is formed with a circumferential flange 52 disposed upon the inner side of the disc 42 and the disc is provided with an axial opening through which the extension projects. A washer 53, of metal or other rigid material, has an axial opening through which the extension 51 projects and is disposed upon the outer side of the disc 42 in engagement therewith. A nut 54 is mounted upon the screwthreaded end of the extension 51 and when screwed into place, securely maintains the central portion of the disc 42 between the washer 53 and the flange 52 for unitary movement. It should be noted that the relative diameters or areas of the flange 52 and washer 53 are different and may be varied or arranged in reverse relation to that shown in the drawings for a purpose to be later described.

A coiled spring 57 has its major portion disposed within the tubular extensions 32 and 51 of the valve member 30 and its lower end engaging the bottom of the extension 32, while its upper portion fits freely within the tubular extension 48 of the cover. The tubular extension 48 is interiorly screwthreaded throughout its entire length and receives an adjusting plug 58 which has its inner end in engagement with the outer end of the spring 57 by means of which the tension of the latter may be varied so as to predeterminately preload the valve member and to normally maintain the latter in engagement with its valve seat. By mounting the spring in the manner shown, an extra long spring may be used with the result that a greater variation in the spring tension is possible and consequently a greater variation of pressure of the discharged fluid.

For adjusting the plug 58, a square rod 59 is slidably mounted in a square opening provided in the plug and has its inner portion extending centrally of the spring for a distance sufficient to permit tension adjustment of the spring throughout its entire range. At the outer end of the rod 59 is a relatively flat circumferential flange 60 of a diameter slightly less than the outer diameter of the extension 48 adapted to engage the outer end of the latter. Beyond the flange 60 the rod 59 is provided with a knurled thrust member 61 by means of which the rod may be rotated in the direction desired which causes the plug 58 to be moved axially whereby the tension of the spring 57 is varied. To secure the plug 58 in the desired adjusted position, a nut 62 is provided which is threaded mounted upon the screwthreaded end 49 of the extension 48. The nut 62 is provided with an axial opening through which the thrust member 61 projects and when screwed properly in place the end wall engages the outer face of the flange 60 and thus prevents relative movement, the flange 60 additionally

functioning as a gasket. The inner end of the extension, acts as an abutment for and is preterminately spaced from the outer end of the tubular extension 51 of the valve member so as to limit the movement of the latter and thus minimize the hammer action of the valve head and its valve seat.

The conical portion 46 is provided with a pipe tap 65 which is normally closed by a plug 66 having an axial opening 67 therethrough which connects the chamber 47 and consequently the outside of the disc 42 with the atmosphere. When the motor is super-charged the plug 66 is removed and the super-charger is connected by a suitable conduit with the tapped opening 65 thus establishing communication with the chamber 47. This arrangement is indicated somewhat more clearly in Figure 8, wherein the chamber 47 communicates with the supercharger 100 through conduit 101.

In the operation of the pump with the rotor rotating in a clockwise direction as viewed in Figure 2, fuel is drawn in through the inlet opening 14, passes around the rotor and is discharged from the outlet opening 15 where it passes to the carburetor in desired volume and at the most efficient pressure, the latter two factors being controlled by the preloading of the relief valve. Inasmuch as the capacity of the pump is much greater than the volume of fuel required by the carburetor, the excess fuel passes upwardly through the communicating openings 34 and 35 into engagement with the under side of the valve head 31 and the pressure exerted raises the valve head from its valve seat so as to permit the excess fuel to pass therethrough and return, through the communicating openings 36 and 37, to the inlet opening 14, its return being aided by the suction present at the inlet opening. It will be noted that the washer 53 is of a larger diameter than the circumferential flange formed on the valve member. The flange 52 must be of such size that its effective area combined with the effective area of said diaphragm is substantially equal to the effective area of said valve head to provide a statically balanced relation whereby the pump suction force created at the inlet side of the pump will have no appreciable effect upon the normal operation of the pre-loaded valve member. By reason of the opposite side of the disc 42 being in communication with the atmosphere, or the super-charger as the case may be, the valve member is at all times properly balanced and therefore unaffected by changes in pressure occurring at the inlet opening particularly due to changes in flying conditions. While the actual unit area of the flexible diaphragm and associated means attached thereto may be greater than the actual area of the adjacent upper surface of the valve, the important factor to be taken into account, as pointed out above, is that the effective suction areas of each of the respective opposed surfaces must be substantially equal. In other words, the suction pull-up on the valve must always balance the suction pull-down on the sealing means. While it is not my intention to be committed to any particular explanation of this fact, it would appear that this is the result of the valve being a rigid member while the seal is made up at least in part of a flexible diaphragm.

When the pump becomes inoperative for any reason, fuel may be by-passed by means of the wobble pump installed on a plane in a suitable handy location. The operation of this wobble

pump draws fuel from the tank and forces it into the inlet opening 14 of the pump shown in Figure 2. The fuel passes upwardly through the communicating openings 37 and 36 and into the chamber between the top side of the valve head and the under side of the disc 42. To overcome the otherwise balanced condition of the valve member, the washer 53 is made larger than the flange 52 so that its effective area combined with the effective area of said diaphragm is greater than the effective area of said valve head whereby pressure exerted by the inflow of fluid into the chamber between the top side of the valve head and the under side of said diaphragm causes the valve head to be lifted from its seat and after the valve is once off, the valve area is of no consequence and fuel is passed through the pump into the carburetor at no great pressure difference between the inlet and outlet openings of the pump.

A different and expedient means is provided for detachably connecting the relief and by-pass housing to the pump housing proper whereby the pump may be operated in either direction without the necessity of removing or dismantling the operating elements. This construction is more clearly shown in Figures 4 and 5, wherein a plurality of bolts 65 extend through portions of the housing proper on opposite sides of the drive shaft and their threaded ends engage a plurality of aligned screwthreaded openings provided in the flanged portion 66' of the detachable housing 27. Four of these bolts are shown and preferably connected to diametrically opposite corners to insure proper positioning.

It will be noted that in the present instance, I have illustrated and described the use of an impervious flexible substantially flat disc or diaphragm which well satisfies the conditions required but it should be understood that other types may be adopted which have the required characteristics.

While I have described the preferred embodiment of the invention it is to be understood that I am not to be limited thereto inasmuch as changes and modifications may be resorted to without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In an aircraft fuel pump of the type including a housing having an inlet and outlet, a disc-like relief valve adapted to cooperate with a valve seat formed in said housing for controlling the flow of excess fuel from the pump outlet to the inlet thereof, said valve having a stem portion extending from the upper face thereof, the underside of said valve being in communication with said outlet and the upper side thereof being in communication with said inlet, and means within said housing sealably connecting said stem to said housing for balancing the pull of inlet suction acting on the upper side of said valve tending to open the same, said arrangement being particularly characterized by the provision of sensitive means for rendering said relief valve operable to cause said pump to deliver a wide range of output pressures, said means comprising a hollow bore formed in said stem portion, a second stem portion extending from the underside of said valve being closed at the outer end thereof, said valve being centrally orificed complementary to said stem portions, a long helical sensitive spring positioned with one end thereof in contact with the inner closed end of said stem, and adjustable means engaging the other end of

said spring for adjusting the compression thereof for determining the output pressure of said pump.

2. In an aircraft fuel pump of the type including a housing having an inlet and an outlet, a disc-like relief valve for controlling the flow of excess fuel from the pump outlet to the inlet thereof, the underside of said valve being in communication with said outlet and the underside thereof being in communication with said inlet and sealing means in said housing including a flexible disc-like diaphragm spaced from the upperside of said valve and having an effective suction area substantially equal to the effective suction area of the adjacent exposed portion of said valve whereby to balance the same against inlet suction, said arrangement being particularly characterized by the provision of means for rendering said relief valve operable to cause said pump to deliver a wide range of output pressures depending upon the adjustment thereof, said means comprising a hollow stem member having a first portion extending axially from the upperside of said valve, means sealably attaching said diaphragm to said stem in spaced relation to the upperside of said valve, means sealably connecting said diaphragm to said housing at the periphery thereof, and a second hollow stem portion extending axially from the lower side of said valve, said last named stem portion being closed at the outer end thereof, said valve being complementarily orificed relative to the hollow interior of said stem portions, a long helical sensitive spring positioned with one end thereof in contact with the inner closed end of said second named stem portion, and extending up through said valve orifice and said first named tubular stem portion, and adjustable means carried by said housing engaging the outer end of said spring for varying the compression thereof for determining the output pressure at which said valve will operate.

3. In an aircraft fuel pump of the type including a housing having an inlet and an outlet, a disc-like relief valve in said housing for controlling the flow of excess fuel from the pump outlet to the inlet thereof, the underside of said valve being in communication with said outlet and the upperside thereof being in communication with said inlet and means for dividing said housing adjacent the upper face of said valve into a first compartment and a second compartment, said first compartment being in communication with said pump inlet pressure and means adapted to connect said second compartment with a second source of pressure, said dividing means comprising a flexible disc-like diaphragm, said arrangement being particularly characterized by the provision of means for rendering said relief valve operable to cause said pump to deliver a wide range of output pressures depending upon the adjustment thereof, said means comprising a hollow tubular stem having a first portion extending axially from the upper face of said valve and a second portion extending axially from the underside of said valve, said second portion being closed at the outer end thereof, said valve being complementarily centrally orificed, a long helical sensitive spring positioned with one end thereof in contact with the inner closed end of said stem passing up through the orificed portion of said valve and through said first named hollow stem portion, and adjustable means carried by said housing engaging the other end of said spring for varying

the compression thereof for determining the output pressure at which said valve will operate, means sealably attaching said diaphragm to said stem in spaced relation to the upperside of said valve and means sealably attaching said diaphragm about the periphery thereof to the adjacent housing.

4. In an aircraft fuel pump of the type including a pump housing having an inlet and an outlet and provided with relief means including a disc-like valve for controlling the flow of fuel from the pump outlet to the inlet thereof, the underside of said valve being in communication with said outlet and the upperside thereof being in communication with said inlet and means including a flexible disc-like diaphragm positioned in said housing in spaced relation to the upper face of said valve for balancing the pull of inlet suction acting on the upper side of said valve tending to open the same, said arrangement being particularly characterized by the provision of sensitive means for rendering said relief valve operable to cause said pump to deliver a wide range of output pressures, said means comprising a hollow tubular stem having a first portion extending axially from the upperside of said valve, and a second portion extending axially from the underside of said valve, the outer end of said second named portion being closed, said valve being axially orificed complementarily to said stem portions, a long helical sensitive spring positioned with one end thereof in contact with the inner closed end of said second named stem portion and passing up through said complementary orifice in said valve and through said first named stem portion and adjustable means carried by said housing engaging the other end of said spring for adjusting the compression thereof for determining the output pressure of said pump, said first named stem portion being further characterized by the provision of a rigid annular peripheral flange formed thereon in axial spaced relation to the upper face of said valve, said diaphragm being centrally orificed for reception about said first named stem portion and seating upon said annular flange, a rigid washer member received about said stem in engagement with the upperside of said diaphragm, a threaded locking member received about the upper end of said stem for locking said washer member against said diaphragm with a predetermined pressure and means for sealably connecting the outer periphery of said diaphragm to said housing.

5. In an aircraft fuel pump and relief valve assembly including a housing having fuel inlet and outlet openings, means in said housing for

pumping fuel from said inlet to said outlet, relief means for conducting excess fuel from said outlet to said inlet comprising a passage formed around said pumping means, a disc-like valve for controlling the flow through said passage, the underside of said valve being in communication with said outlet, said arrangement being particularly characterized by the fact that said valve is provided with a hollow tubular stem extending axially from each side thereof, the cross-sectional area of said stem being substantially less than the cross-sectional area of said valve whereby to expose a substantial portion of the underside of said valve to outlet pressure and a substantial portion of the upperside of said valve to inlet suction, a long sensitive helical spring contacting the inner closed end of said hollow stem and extending up beyond the upper end of said stem and adjustable means carried by said housing for varying the compression of said spring, sealing means in said housing for counteracting the opening effect of inlet suction on the upperside of said valve, said means including a flexible diaphragm, a rigid peripheral flange on the upper portion of said stem in spaced relation to the upperside of said valve, said diaphragm being axially orificed for reception about the upper end of said stem and seating on said flange, a rigid washer-like member received about said stem in engagement with said diaphragm, a lock nut threadedly received about said stem in engagement with said washer-like member with a predetermined degree of tightness, said diaphragm being attached about the periphery thereof to the surrounding housing, the size of said flange, the size of said washer-like member and the area of said diaphragm exposed to suction being so proportioned that the suction pull on the seal tending to close the valve is counteracted by the suction pull on the upperside of the valve, tending to open the same for widely varying inlet suction.

6. The structure defined in claim 4 wherein the area of said washer member is greater than the juxtaposed area of said annular flange whereby when said pump inlet is supplied with fuel under pressure from an auxiliary source, the effective area of said diaphragm tending to lift said relief valve is greater than the effective area of the upperside of said relief valve tending to hold the same shut, whereupon when the pressure exceeds the compression at which said helical spring adjustment means is set, said relief valve is caused to open and to by-pass fuel thereby.

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