

June 20, 1944.

J. P. JOHNSON

2,351,817

FUEL PUMP

Filed Oct. 10, 1940

2 Sheets-Sheet 1

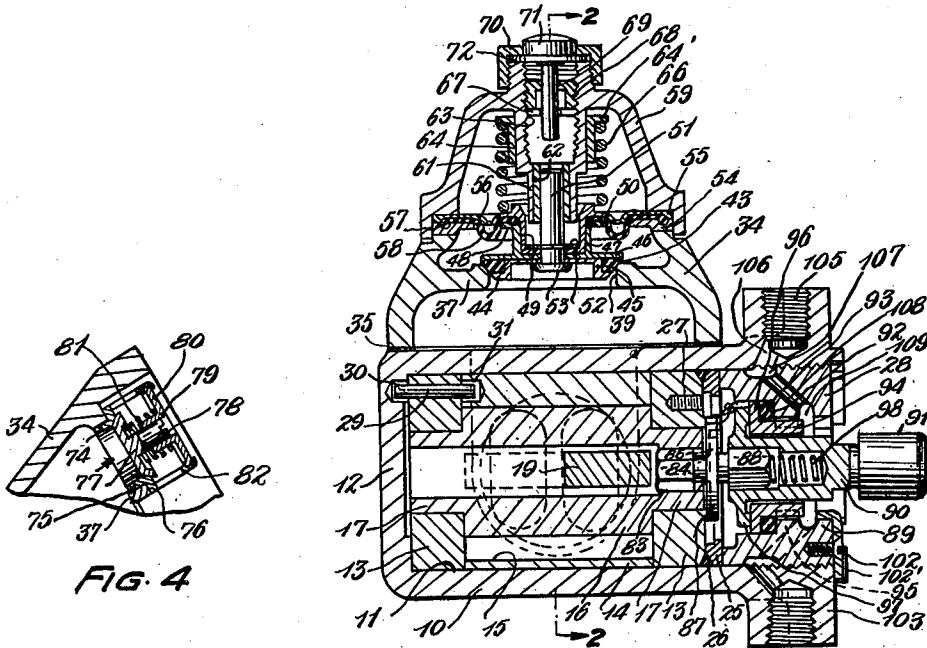


FIG. 1

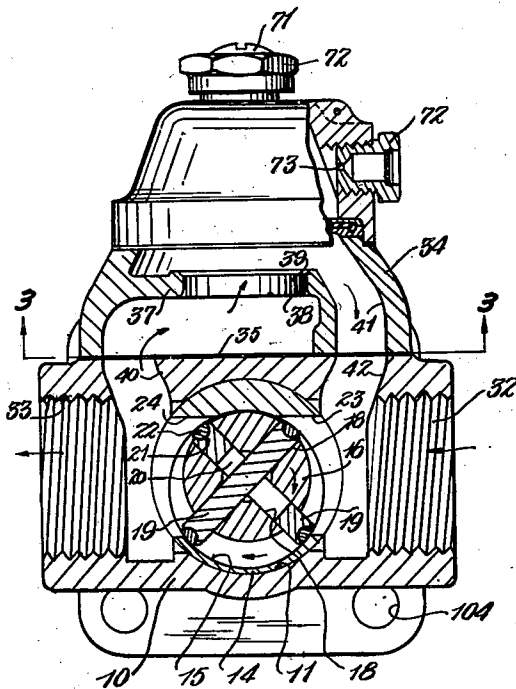
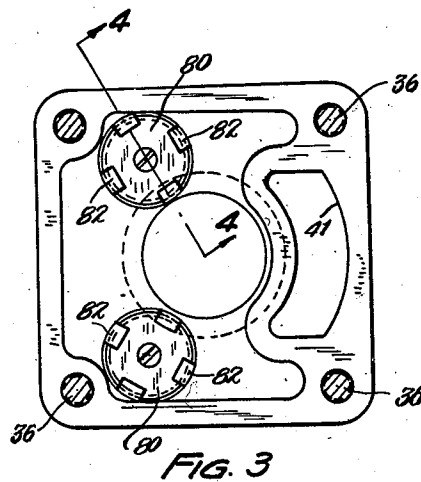


FIG. 2



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2 Sheets-Sheet 2

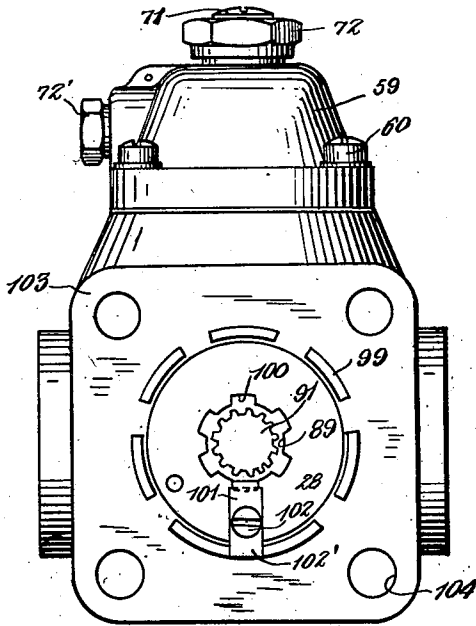


FIG. 5

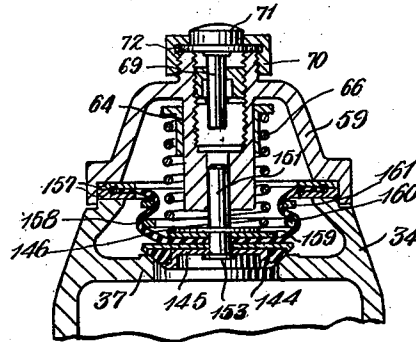


FIG. 6

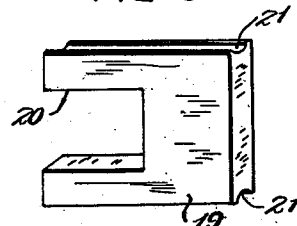


FIG. 7

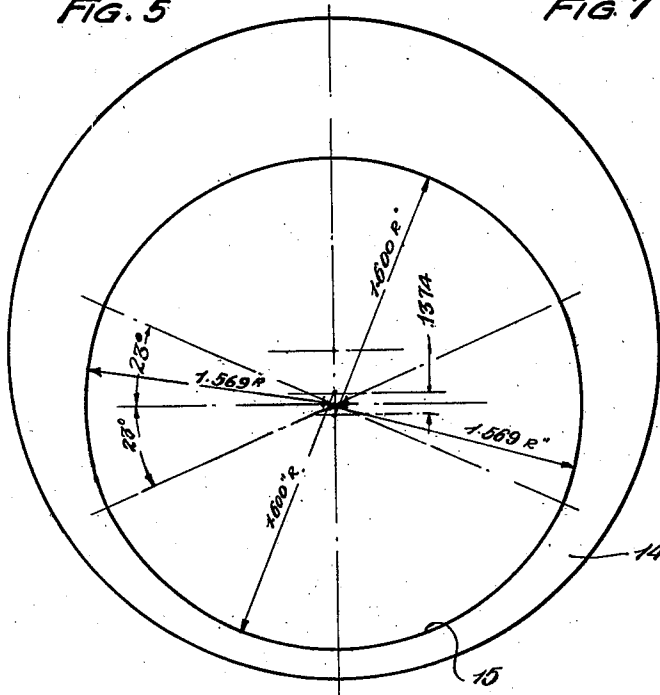


FIG. 8

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2,351,817

FUEL PUMP

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Application October 10, 1940, Serial No. 360,629

8 Claims. (Cl. 103—42)

This invention relates to fuel pumps of the rotatable multi-vane or blade type and more particularly to improvements in a power driven fuel pump, embodying a relief valve for return of excess fuel and a by-pass valve, especially adaptable for use on aircraft although in no manner so restricted.

It is a primary object of the present invention to provide a pump bore having diametrically opposite working faces conforming to the same radius and connecting faces conforming to a common radius nearly approximating the radius of the working faces thereby having the least amount of cam action in the bore, is the nearest to a perfectly round bore, and at the same time is geometrically correct during the working cycle thus affording greater displacement with lesser pulsating characteristics.

Another object of the present invention is to provide shoes or rockers at the opposite ends of the vanes, slidably engageable with the wall of the bore, the engaging surfaces of the shoes conforming to the radius of the working faces of the bore thus affording better working conditions, reducing wear, and providing an effective seal.

Another object of the present invention is to provide a novel double rotatable seal to prevent escape of fuel from the pump chamber and leakage of oil past the drive shaft.

Another object of the present invention is to provide an improved fuel relief valve of the diaphragm type unaffected by pressure at the inlet side of the pump present under certain conditions whereby the valve will effectively function to return excess fuel in the manner intended.

Another object of the present invention is to provide an improved by-pass valve affording means through which fuel may be supplied from an external source in the event the pump becomes inoperative for any reason whatsoever.

Another object of the present invention is to provide a fuel pump which is simple in construction, efficient in operation and inexpensive to manufacture.

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 vertical sectional view of a fuel pump embodying the present invention.

Figure 2 is a transverse vertical sectional view taken along line 2—2 in Figure 1 and showing

further details of the pump structure embodying the invention.

Figure 3 is a transverse sectional view taken along the line 3—3 in Figure 2 and showing details of the by-pass valve means.

Figure 4 is a fragmentary sectional view taken along line 4—4 in Figure 3 and showing further details of the by-pass valve.

Figure 5 is an end elevational view looking at the drive end and showing the plug securing means.

Figure 6 is a fragmentary sectional view of a modified form of relief valve embodying the present invention.

Figure 7 is a perspective view of one of the vanes or blades of the rotor.

Figure 8 is an end view of the pump chamber sleeve showing the shape of the bore and the relative positions of the radius centers on an enlarged scale.

In the drawings I have illustrated a power driven fuel pump embodying the present invention but the latter is in no manner to be so restricted, other adaptations being obvious to those skilled in the particular art. The pump comprises a housing proper 10, preferably made of aluminum or other light weight material, which is provided with a centrally disposed bore 11 extending inwardly from one end thereof and terminating adjacent an integral end wall 12. A pair of bearing members 13, of bronze or other suitable material, is disposed within the bore 11 in longitudinal spaced relation relatively, one of said bearing members being adapted for abutment with the inner face of the end wall 12 to definitely position the same. A sleeve 14, of steel or other similar material, is disposed within the bore 11, extending between the bearing members and is provided with an eccentrically disposed bore 15 which extends longitudinally throughout its length.

Bores provided in pumps at the present time are of various forms, the most common being the lemicon curve, but in practically all of these types of bores the machining is difficult and the operation of the pumps is accompanied by pulsations a decided disadvantage for efficient pump operation. One of the important features of the present pump therefore, is to provide an improved bore the details of which are more clearly shown in the enlarged view of Figure 8 and to which reference should be had. While the relative curvatures shown have been embodied in pumps of this type and successfully operated, they are given for the purpose of more readily under-

standing the objective of the invention and are therefore in no way limited. It is very desirable to provide a pump chamber bore which nearly as possible approaches a perfect circle, readily lends itself to manufacturing facilities, is understandable by the average mechanic and designer, and is geometrically correct during the working cycle of the rotor blades. All of these features have been attained in the present bore by the use of two radii, one effecting the surfaces constituting the working faces and the other effecting the surfaces constituting the connecting faces, the centers being located on a transverse plane passing through the axis of the rotor as shown in Figure 8. The radius of the working faces is 1.600" and their respective centers are spaced apart approximately .1394" both on the transverse plane. This curvature is at diametrically opposite sides of the bore and extends for approximately 67 degrees on both sides of the transverse plane where it intersects the bore.

The connecting faces also have identical radii but slightly shorter than those of the working faces and in the present instance 1.569" has been adopted. In other words, the nearest radius for continuously connecting the working faces is desirable and therefore produces a bore which is nearly a perfect circle affording the best operating conditions. The radius for forming the connecting faces is struck from a common center positioned on the same transverse plane and midway between the centers of the radii forming the working faces. The connecting faces extend over a portion of 46 degrees on diametrically opposite sides and as these do not enter into the work cycle of the rotor their curvature is not so important other than for the purpose already stated.

The shape of this bore is well adapted for use with one or more through blades and in the present instance, referring again to Figures 1 and 2, a rotor 16, of steel or other suitable material, is rotatably disposed eccentrically within the bore so as to have close running engagement with the upper inner portion of the bore, its center of rotation being coaxial with the axis of the outer peripheral surface of the sleeve. The rotor 16 has extensions 17 projecting outwardly on diametrically opposite sides which are rotatably mounted in aligned openings provided in the adjacent bearing members 13. The rotor is provided with a pair of slots 18 extending transversely entirely through the body of the rotor and disposed in angular relation relatively, the slots being coextensive with the longitudinal length of the body of the rotor. A pair of through blades 19 of identical size and formation, made of bronze or other suitable material, is each provided with a recess 20 at one end to afford relative movement of one blade within the other and grooves 21 extending longitudinally on diametrically opposite sides of the blade as more clearly shown in Figure 7. A pair of these blades is mounted in the slots 18 so as to afford relatively sliding movement of the blades radially within the slots to adapt the outer ends of the blades for running engagement with the bore at diametrically opposite points. A shoe 22, of steel or other suitable material, is disposed in each of the recesses 21 at the opposite ends of the blades and each is suitably mounted for relative rocking movement therein, the outer face of each shoe being formed over its entire face on the same curvature as that of the working faces of the bore so that during rotation of the rotor the contacting faces of the

bore and shoes are always in sliding contact throughout the work cycle. The shoes further function as a packing or sealing means between the ends of the blades and the bore in which they rotate. It should be pointed out that by this construction a geometrically correct working cycle is provided during the working period, inasmuch as a uniform space or clearance is maintained between the solid blades and the bore through the working cycle of the pump which is the distance between adjacent inlet and outlet port edges. A pair of ports 23 and 24 is provided on diametrically opposite sides of the sleeve 14 of identical shape and extends transversely through the wall thereof to afford communication with the inside of the bore 15. To securely maintain the pump parts in assembled relation within the housing, a securing ring 25, of bronze or other suitable material, fits within the outer end of the bore 11 and abuts the outer end of the bearing 13. A rubber ring 26 is peripherally disposed in a groove formed between the securing ring and bearing member to provide a fluid seal and a plurality of screws 27 extend through openings in the ring 25 and are threadably secured in the adjacent bearing member so as to exert an outward pressure upon the rubber ring.

The outer end of the bore 11 in the housing is interiorly screwthreaded to receive an externally threaded plug 28 of aluminum or other suitable material having an inner end adapted to abut the outer adjacent marginal portion of the ring 25 for securing the rotor and its respective elements in properly assembled relation. Means should be provided to prevent relative rotation between the inner bearing member 13 and the sleeve 14 and in the present instance a pin 29 is employed which extends through a transverse opening in the upper marginal portion of the bearing member and has its opposite ends disposed in aligned openings 30 and 31 provided in the end wall 12 and the adjacent end of the sleeve respectively. The housing 10 is further provided with a tapped inlet opening 32 and a tapped outlet opening 33 disposed on diametrically opposite sides of the pump chamber and each communicates respectively at its inner end with the adjacent port 23 and 24 provided in the sleeve. It will be obvious that the construction so far provides for operation of the pump in either direction of rotation and the pump is so adapted in a manner which will be later described.

The pump is provided with a relief valve for by-passing fuel in excess of that capable of being handled by the carburetor. In the present construction, the by-pass valve is mounted in a bell-shaped housing 34 of aluminum or other light weight material removably mounted upon the upper rear portion of the housing 10. A gasket 35 is disposed between the contacting faces of the respective housings to afford a fluid tight seal and a plurality of bolts 36 securely maintains the bell-shaped housing in proper position. The housing 34 is provided with a transverse partition 37 having a centrally disposed opening 38 formed with a valve seat 39 at its upper inner edge. The housing proper 10 is provided with an opening 40 affording communication between the outlet side of the pump and the under side of the partition 37, while the partition 37 is provided with an opening 41 which communicates at the upper end with the upper side of the partition and at its lower end with an opening 42 provided in the upper adjacent por-

tion of the housing 10 to afford communication with the inlet side of the pump.

Any suitable relief valve member may be employed for controlling the flow of excess fuel by the valve seat 39 but the one illustrated embodies features which are particularly important in aircraft. The valve member is a composite structure comprising an annular rubber valve head 43 having a beveled lower edge engageable with the valve seat 39. The rubber valve head is mounted on a laterally extending flange 44 formed at the lower end of an inverted cup-shaped metal member 45 while a disc-like metal member 46 fits over the upper face of the rubber valve member and has a depending marginal edge portion extending over the outer adjacent peripheral edge of the rubber valve head to secure it in place. The disc-like member 46 has an upwardly disposed tubular portion 47 the outer end of which terminates in a laterally extending marginal flange 48. A closed end tubular metal member 49 fits within the tubular portion 47 and has its lower end in abutment with the adjacent face of the disc while its outer end terminates in a laterally extending marginal flange 50 disposed in spaced relation above the lateral flange 48, the flange 50 being substantially coextensive with the valve seat 39 and having its extreme outer end turned downwardly. To secure the composite valve member in assembled relation for unitary movement a pin 51 has its upper end extending beyond the flange 50 and a disc 52 adjacent its lower portion engages the closed end of the tubular member 49. The lower end of the pin projects through axially aligned openings in the bottom of the tubular member, the disc, and the cup-shaped lower member, and has its lower end upset at 53 to provide a rigid connection for unitary movement with the valve head. To afford movement of the valve and at the same time to effectively seal the chamber above the valve seat, an inner annular metal disc 54 is removably mounted upon the adjacent portion of the bell-shaped housing and has its inner marginal edge extending inwardly a suitable distance but spaced from the adjacent flange 48. An outer annular disc 55 is disposed in cooperative relation above the inner disc and has its inner marginal edge bent downwardly at 56 in closely spaced relation with respect to the adjacent turned down end of the flange 50. A rubber annular disc 57 has its outer marginal portion secured between the adjacent faces of the lower disc 54 and the upper disc 55 and its inner marginal portion secured between the lower flange 48 and upper flange 50 of the valve member before assembly, the intermediate connecting portion being looped downwardly at 58 thus affording a flexible joint. Due to the fact that vacuum is usually present at the inlet side of the pump, the looped portion 58 of the flexible diaphragm is positioned on the under side and the loop is relatively small due to the fact that the valve member has very little movement limited in a manner to be later described. There are times, however, when pressure does exist at the inlet side of the pump, for instance, when the wobble pump is resorted to for by-passing fuel around the pump when the pump is inoperative for any reason. Also pressure may exist, under flying conditions, where tilting or diving the plane might present a head of gas at the inlet side. When this takes place the metal flanges supporting the rubber diaphragm being disposed fairly close to each other will prevent the rubber loop from passing therebetween and 75

thus becoming inverted on the other side. The inversion of the loop is further prevented by the downwardly extending marginal portions on the flanges on one of the stationary discs and on the valve member and even though, after long service, the rubber becomes soft and flabby the loop will remain in its proper position.

It is to be further pointed out that when adjusting for pressure-area the area of the diaphragm must be approximately the same as that of the valve in order to make it nearly balanced. The importance of a nearly balanced valve will be obvious inasmuch as it affords the use of a much lighter and lesser tensioned spring for pre-loading the valve member thus reducing the weight of the pump and its overall size, and further will be unaffected by the pressure of the by-passed fuel.

Any suitable means may be employed for pre-loading the valve member but a simple and effective structure is shown in the drawings. The bell-shaped housing 34 is made with a removable upper cap portion 59 its lower face being engageable with the upper annular disc 58 for securely maintaining the adjacent discs and rubber diaphragm in assembled relation and a plurality of bolts 60 secures the cap to the lower portion of the bell-shaped housing as a unitary structure. The cap has an integral axially disposed extension 61 projecting on diametrically opposite sides of its outer end, the inner end being of reduced diameter and piloted in the upper adjacent end of the tubular member 49 on the valve member. The inner end of the extension 61 has an inwardly extending axially disposed bore 62 to slidably receive the outer end of the pin 51, the inner end of the bore functioning as a stop to limit the opening movement of the valve member. The extension 61 has an interiorly screwthreaded bore 63 extending axially inwardly from its outer end and terminates short of the inner end of the bore 62. A spring retainer 64 is slidably mounted at the upper end of the lower portion of the extension 61 and has a laterally extending flange 64' adapted to receive the upper end of a coiled spring 66 while the lower end is seated on the flange 50 of the valve member. The retainer member has a transversely disposed tongue 67 slidably mounted in slots provided on diametrically opposite sides of the adjacent extension which prevents relative rotation. An exteriorly screwthreaded plug 68 is threadably mounted in the bore 63 and its lower end abuts the tongue, axial movement of which varies the tension of the spring and the pre-loading of the valve member. An adjustable member comprising a depending pin 69, of square cross section or other non-circular shape, slidably fits in a similarly shaped opening provided in the plug 68 for affording axial movement of the latter and has a circumferential flange 70 at its upper end rotatably engageable with the outer adjacent face of the extension. A head 71 is formed at the outer side of the flange and has an entrant slot to accommodate a screw-driver or other tool, affording adjustment. A securing nut 72 is threadably mounted on the end of the extension and adaptable for engagement with flange for securing it after proper adjustment of the spring. The cap portion 59 has an interiorly screwthreaded opening above the diaphragm adapted to receive a screwthreaded plug 72 having a small opening 73 therethrough affording communication with the atmosphere to render the valve

member unaffected by changes in pressure at the inlet side of the pump.

A modification of the yieldable mounting for the valve member is shown in Figure 6. The valve head is constructed substantially the same as the preferred arrangement except that the upper disc 46 is flat on its outer side and a flexible bellows 158 is substituted for the diaphragm. A pair of annular discs 157 are removably mounted on the bell-shaped housing 34 and have their inner marginal portions disposed in spaced relation relatively. The bellows is made of rubber material and closed at its lower end but open at its upper end, the upper marginal portion being secured between the adjacent spaced discs 157. The lower end of the bellows abuts the upper face of the disc 146 and a washer 159 of suitable diameter is disposed on the inner side of the bellows to retain the adjacent portion of the bellows therebetween. An upwardly disposed pin 151 has a disc 158 at its lower portion resting upon the washer 159 and its lower end projecting through aligned opening in the washer, bellows, disc, and cup-shaped member, the end being upset at 153 to secure the members in rigidly assembled relation for unitary movement. The relative positions of the corrugations is maintained by an internally disposed metal ring 160 at the peak and an externally disposed metal ring 161 at the valley or bottom thus preventing collapse of the bellows from either a negative or positive pressure.

A by-pass for fuel, capable of operation independently of the fuel pump, has to be provided and in the present instance it is incorporated in the pump structure. The transverse partition 37, in the bell-shaped housing 34, is provided with transverse openings 74 spaced apart relatively as more clearly shown in Figures 3 and 4. Each of these openings is provided with a sleeve 75 fitted tightly in the opening and a laterally extending circumferential flange 76 abutting the under side of the partition. The inner lower edge is beveled to provide a valve seat and a valve head 77 is adapted for engagement with the seat to control the flow of the fuel thereby. The valve head has an outwardly extending stem 78 slidably mounted in a depending tubular extension 79 formed upon a disc 80. A coil spring 81 encircles the stem and tubular extension, having one end seated upon the upper face of the valve head and other end seated against the adjacent face of the disc to effect normal separation therebetween. The flange 76 has downwardly extending fingers 82, disposed in spaced relation relatively about the axis of the valve seat and the lower ends are bent over into securing engagement with the underside of the disc 80 to maintain proper relation and exert a spring pressure upon the valve head to normally maintain it in closed position. While two by-pass valves are shown, any desired number may be employed depending upon the displacement requirements. It will be noted that the valve heads 77 are so arranged that they remain closed when subjected to the pressure of the return fuel but will be unseated when fuel is introduced, under pressure, into the inlet side of the pump as by a wobble pump affording by-passing of the fuel to the outlet side of the pump.

As previously pointed out the pump is adapted for operation in both directions and the housing 34 is mounted as shown in the drawings, when the rotor rotates in a clockwise direction as indicated by the arrow in Figure 2. If rotation of

the rotor in the opposite direction is desired, the housing 34 is removed and its position reversed 180° without the necessity of changing any of the relief and by-pass valves.

Rotation is imparted to the pump rotor in a novel manner as more clearly shown in Figure 1. The outer extension 17 has a non-circular opening 83 extending axially inwardly thereof, in the present case hexagonal, to receive a similarly shaped projection 84 axially disposed on one side of a metal seal disc 85. The inner marginal portion of the disc is machined smooth to provide a seal face 86 rotatably engageable with a seal face 87 formed upon the adjacent outer side of the outer bearing member 13. A projection 88 extends axially outwardly on the opposite side of the disc 85 and is of non-circular shape, square in the present case. The plug 23 has a central bore 89 in which a driven shaft 90 is rotatably disposed, the outer end of the shaft being provided with a toothed pinion 91. The bore 89 is of enlarged diameter at its inner end to provide an annular shoulder 92 on which a rubber ring 93 rests. A bronze sleeve 94 loosely encircles the adjacent portion of the shaft 90 and has longitudinal extensions 95, on diametrically opposite sides, slidably mounted in aligned recesses in the adjacent portion of the plug, thus preventing relative rotation. The sleeve is further provided with a laterally extending circumferential flange 97 the outer face of which is engageable with the rubber ring to form a fluid seal. The inner end of the shaft 90 has a laterally extending circumferential flange 97, the outer face of which is machined for rotary engagement with the inner adjacent face of the sleeve flange 95. The end of the shaft 90 is counterbored axially inwardly to conform with the shape of the outer projection 88 in which it is drivingly mounted and a coil spring 98 is disposed within the bore and has one end seated upon the adjacent end of the projection 88 and its opposite end seated at the bottom of the bore to exert a separating force sufficient to effectively maintain the fuel seal disc 87 and oil seal flange 97 in operative sealing relation.

At the open end of the housing are a plurality of radially extending arcuate projections 99 in relative spaced relation about the axis of the bore 89 and the plug 23 has a plurality of recesses 100 adjacent the outer end of the bore, in spaced relation relatively and preferably of a different number than the number of projections 99. A locking plate 102 has its outer end disposed between a selected pair of adjacent projections 99 and its inner end bent inwardly and disposed in the adjacent recess 100, a screw 102 removably securing the plate against displacement after proper adjustment. The inner end of the housing 10 is provided with a lateral flange 103 having transverse opening 104 at its corners by which the pump is adapted for mounting upon the engine pad or other support. Tapped openings 105 are provided at the outer face of the flange and passageways 106 communicate with a peripheral oil groove 107 formed upon the outer wall of the plug 23. A passageway 108 is provided in the plug and communicates at its outer end with the groove 107 while its inner end communicates with an oil groove 109 formed upon the inner peripheral wall of the bore 89 outwardly of the sleeve. This affords for suitably drawing off excess oil passing from the engine pad irrespective of the position in which the pump may be mounted.

In the operation of the pump, the driven pin-

ion is drivingly connected with the engine, usually directly, and the pump rotor is therefore, rotated at substantially the same speed. The fuel inlet opening is connected with the fuel tanks through a selector valve and the outlet opening is connected with the carburetor. With the use of the new type of high pressure carburetors, it is necessary to provide a small reserve tank for supplying the fuel thereto under air pressure and it is essential that air be pumped by the rotor to maintain the desired air pressure during that period when the selector valve is being moved from an emptied tank to a full tank. This is effectively afforded by the sealing characteristics of the cooperating shoes and bore described. Also during the operation of the rotor, there is lesser pulsations, due to the particular contour of the bore, especially as compared with pump chambers having lemicon curves or other generated surfaces. The quantity of fuel pumped by the pump is, of course, far greater than the quantity capable of being handled by the carburetor and the excess is returned to the inlet side of the pump through the relief valve. It is well known that the fuel delivered to the carburetor should be under constant pressure and the relief valve is therefore, adjustable for whatever pressure is desired.

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. A fuel pump comprising: a housing having a fuel inlet opening and a fuel outlet opening therein; pumping means in said housing for drawing fuel into said inlet opening and discharging the same under pressure from said outlet opening; and fuel relief means affording return of excess fuel from said outlet opening to said inlet opening through a communicating passageway in said housing including, a valve member movably mounted in said housing and having a valve head operatively associated with said return passageway for controlling the flow of fuel therethrough, said valve member being further provided with a pair of laterally extending circumferential flanges disposed relatively in axial spaced relation; a pair of annular members mounted on said housing and having their inner marginal portions in axial spaced relation relatively, the inner peripheral edge of the outer annular member being in closely spaced relation with respect to the outer peripheral edge of the outer flange; a flexible annular shaped diaphragm of impervious material having its inner marginal portion secured between the adjacent spaced flanges and its outer marginal portion secured between the adjacent spaced annular members, the intermediate portion having an inwardly extending loop of relative larger size than the spacing between the adjacent edges of the outer annular member and outer flange to prevent reversal thereof, the looped portion effectively sealing the outer side of the return passageway and affording improvement of said valve member; the effective pressure area of said valve head being substantially equal to the effective area of said flanges for substantially balancing said valve member regardless of pressure conditions existing at the inlet opening to which both are subjected; resilient means

mounted in said housing and operatively associated with said valve member for pre-loading the same whereby said valve head is normally maintained in closed position; and means for varying the pre-loading effected by said resilient means.

2. A fuel pump comprising: a housing having a fuel inlet opening and a fuel outlet opening therein; pumping means in said housing for drawing fuel into said inlet opening and discharging the same under pressure from said outlet opening; and fuel relief means affording return of excess fuel from said outlet opening to said inlet opening through a communicating passageway in said housing including, a valve member movably mounted in said housing and having a valve head operatively associated with said return passageway for controlling the flow of fuel therethrough, said valve member being further provided with a pair of laterally extending circumferential flanges disposed relatively in axial spaced relation; a pair of annular members mounted on said housing and having their inner marginal portions in axial spaced relation relatively, the inner peripheral edge of the outer annular member being in closed spaced relation with respect to the outer peripheral edge of the outer flange; a flexible annular shaped diaphragm of impervious material having its inner marginal portion secured between the adjacent spaced flanges and its outer marginal portion secured between the adjacent spaced annular members, the intermediate portion having an inwardly extending loop of relatively larger size than the spacing between the adjacent edges of the outer annular member and outer flange to prevent reversal thereof, the looped portion effectively sealing the outer side of the return passageway and affording movement of said valve member; the effective pressure area of said valve head being substantially equal to the effective area of said flanges for substantially balancing said valve member regardless of pressure conditions existing at the inlet opening to which both are subjected; said valve member being further provided with an outwardly projecting pin slidably mounted in a bore provided in the adjacent portion of said housing, the bottom of the bore being normally spaced from the adjacent end of said pin but providing a stop thus limiting the opening movement of said valve head; a coiled spring disposed within said housing and having its inner end seated on the adjacent flange of said valve member for normally maintaining said valve head in closed position; a sleeve slidably but non-rotatably mounted at the outer portion of the housing and disposed coaxially within the outer portion of said spring, said sleeve having a laterally extending flange against which the outer end of said spring is seated; and means operatively associated with said sleeve for effecting axial movement thereof to vary the spring tension.

3. A fuel pump comprising: a housing having a fuel inlet opening and a fuel outlet opening therein; pumping means in said housing for drawing fuel into said inlet opening and discharging the same under pressure from said outlet opening; and fuel relief means affording return of excess fuel from said outlet opening to said inlet opening through a communicating passageway in said housing including, a valve member movably mounted in said housing and having a valve head operatively associated with

said return passageway for controlling the flow of fuel therethrough; a flexible disc-like annular shaped diaphragm of impervious material having its outer marginal portion sealingly connected to said housing and its inner marginal portion sealingly connected to said valve member, its intermediate portion being looped to afford unrestricted movement of said valve member and to effectively seal the outer side of said return passageway; means operatively associated with said diaphragm for preventing reversal of said looped portion and effecting a pressure area balancing of the valve member unaffected by the pressure conditions existing at the inlet opening; resilient means mounted in said housing and operatively associated with said valve member for pre-loading the same whereby said valve head is normally maintained in closed position; and means for varying the pre-loading effected by said resilient means.

4. A fuel pump comprising: a housing having a fuel inlet opening and a fuel outlet opening therein; pumping means in said housing for drawing fuel into said inlet opening and discharging the same under pressure from said outlet opening; and fuel relief means affording return of excess fuel from said outlet opening to said inlet opening through a communicating passageway in said housing including, a valve member movably mounted in said housing and having a valve head operatively associated with said return passageway for controlling the flow of fuel therethrough; a flexible disc-like annular shaped diaphragm of impervious material having its outer marginal portion sealingly connected to said housing and its inner marginal portion sealingly connected to said valve member, its intermediate portion being inwardly looped to afford unrestricted movement of said valve member and to effectively seal the outer side of said return passageway; means operatively associated with said diaphragm for preventing reversal of said looped portion and effecting a pressure area balancing of the valve member unaffected by the pressure conditions existing at the inlet opening; a coiled spring disposed in said housing and having its inner end seated on said valve member; a sleeve slidably but non-rotatably mounted in said housing and disposed in the outer end of said spring, said sleeve having a laterally extending flange affording a seat for the outer end of said spring; and means operatively associated with said sleeve for effecting movement of the latter whereby said spring may be desirably tensioned for normally maintaining said valve head in closed position.

5. A fuel pump comprising: a housing having a fuel inlet opening and a fuel outlet opening therein; pumping means in said housing for drawing fuel into said inlet opening and discharging the same under pressure from said outlet opening; and fuel relief means affording return of excess fuel from said outlet opening to said inlet opening through a communicating passageway in said housing including, a valve member movably mounted in said housing and having a valve head operatively associated with said return passageway for controlling the flow of fuel therethrough; a flexible disc-like annular shaped diaphragm of impervious material having its outer marginal portion sealingly connected to said housing and its inner marginal portion sealingly connected to said valve member, its intermediate portion being inwardly

looped to afford unrestricted movement of said valve member and to effectively seal the outer side of said return passageway; means operatively associated with said diaphragm for preventing reversal of said looped portion and effecting a pressure area balancing of the valve member unaffected by the pressure conditions existing at the inlet opening; cooperating means on said housing and valve member for limiting the opening movement of said valve head; resilient means mounted in said housing and operatively associated with said valve member for pre-loading the same whereby said valve head is normally maintained in closed position; and means for varying the pre-loading effected by said resilient means.

6. A fuel pump comprising: a housing having a fuel inlet opening and a fuel outlet opening therein; pumping means in said housing for drawing fuel into said inlet opening and discharging the same under pressure from said outlet opening; and fuel relief means affording return of excess fuel from said outlet opening to said inlet opening through a communicating passageway in said housing including, a valve member movably mounted in said housing and having a valve head operatively associated with said return passageway for controlling the flow of fuel therethrough; a flexible disc-like annular shaped diaphragm of impervious material having its outer marginal portion sealingly connected to said housing and its inner marginal portion sealingly connected to said valve member, its intermediate portion being inwardly looped to afford unrestricted movement of said valve member and to effectively seal the outer side of said return passageway; means operatively associated with said diaphragms for preventing reversal of said looped portion and effecting a pressure area balancing of the valve member unaffected by the pressure conditions existing at the inlet opening; said housing having an integral projection the inner end of which is spaced from but adapted for engagement with said valve member for limiting the opening movement of said valve head; a coiled spring disposed in said housing and having its inner end seated on said valve member; a sleeve slidably but non-rotatably mounted on said projection and disposed in the outer end of said spring, said sleeve having a laterally extending flange affording a seat for the outer end of said spring; and means operatively associated with said sleeve for effecting movement of the latter whereby said spring may be desirably tensioned for normally maintaining said valve head in closed position.

7. A fuel pump comprising: a housing having a fuel inlet opening and a fuel outlet opening therein; pumping means in said housing for drawing fuel into said inlet opening and discharging the same under pressure from said outlet opening; and fuel relief means affording return of excess fuel from said outlet opening to said inlet opening through a communicating passageway in said housing including, a valve member movably mounted in said housing and having a valve head operatively associated with said return passageway for controlling the flow of fuel therethrough, said valve member being further provided with a pair of laterally extending circumferential flanges disposed relatively in axial spaced relation; a pair of annular members mounted on said housing and having their

inner marginal portions in axial spaced relation relatively, the inner peripheral edge of the outer annular member being in closely spaced relation with respect to the outer peripheral edge of the outer flange; a flexible annular shaped diaphragm of rubber material having its inner marginal portion secured between the adjacent spaced flanges and its outer marginal portion secured between the adjacent spaced annular members, the intermediate portion having an inwardly extending loop of relatively larger size than the spacing between the adjacent edges of the outer annular member and outer flange to prevent reversal thereof, the looped portion effectively sealing the outer side of the return passageway and affording movement of said valve member; the effective pressure area of said valve head being substantially equal to the effective area of said flanges for substantially balancing said valve member regardless of pressure conditions existing at the inlet opening to which both are subjected; resilient means mounted in said housing and operatively associated with said valve member for pre-loading the same whereby said valve head is normally maintained in closed position; and means for varying the pre-loading effected by said resilient means.

8. A fuel pump comprising: a housing having a fuel inlet opening and a fuel outlet opening therein; pumping means in said housing for drawing fuel into said inlet opening and discharging the same under pressure from said outlet opening; and fuel relief means affording return of excess fuel from said outlet opening to said inlet opening through a communicating passageway in said housing including, a valve member movably mounted in said housing and having a valve head operatively associated with said return passageway for controlling the flow of fuel therethrough, said valve member being further provided with a pair of laterally extending circumferential flanges disposed rela-

tively in axial spaced relation; a pair of annular members mounted on said housing and having their inner marginal portions in axial spaced relation relatively, the inner peripheral edge of the annular member being in closely spaced relation with respect to the outer peripheral edge of the outer flange; a flexible annular shaped diaphragm of rubber material having its inner marginal portion secured between the adjacent spaced flanges and its outer marginal portion secured between the adjacent spaced annular members, the intermediate portion having an inwardly extending loop of relatively larger size than the spacing between the adjacent edges of the outer annular member and outer flange to prevent reversal thereof, the looped portion effectively sealing the outer side of the return passageway and affording movement of said valve member; the effective pressure area of said valve head being substantially equal to the effective area of said flanges for substantially balancing said valve member regardless of pressure conditions existing at the inlet opening to which both are subjected; said valve member being further provided with an outwardly projecting pin slidably mounted in a bore provided in the adjacent portion of said housing, the bottom of the bore being normally spaced from the adjacent end of said pin but providing a stop thus limiting the opening movement of said valve head; a coiled spring disposed within said housing and having its inner end seated on the adjacent flange of said valve member for normally maintaining said valve head in closed position; a sleeve slidably but non-rotatably mounted at the outer portion of the housing and disposed coaxially within the outer portion of said spring, said sleeve having a laterally extending flange against which the outer end of said spring is seated; and means operatively associated with said sleeve for effecting axial movement thereof to vary the spring tension.

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