

Dec. 11, 1945.

F. C. MOCK

2,390,658

LIQUID CONTROL MECHANISM

Filed April 15, 1938

2 Sheets-Sheet 1

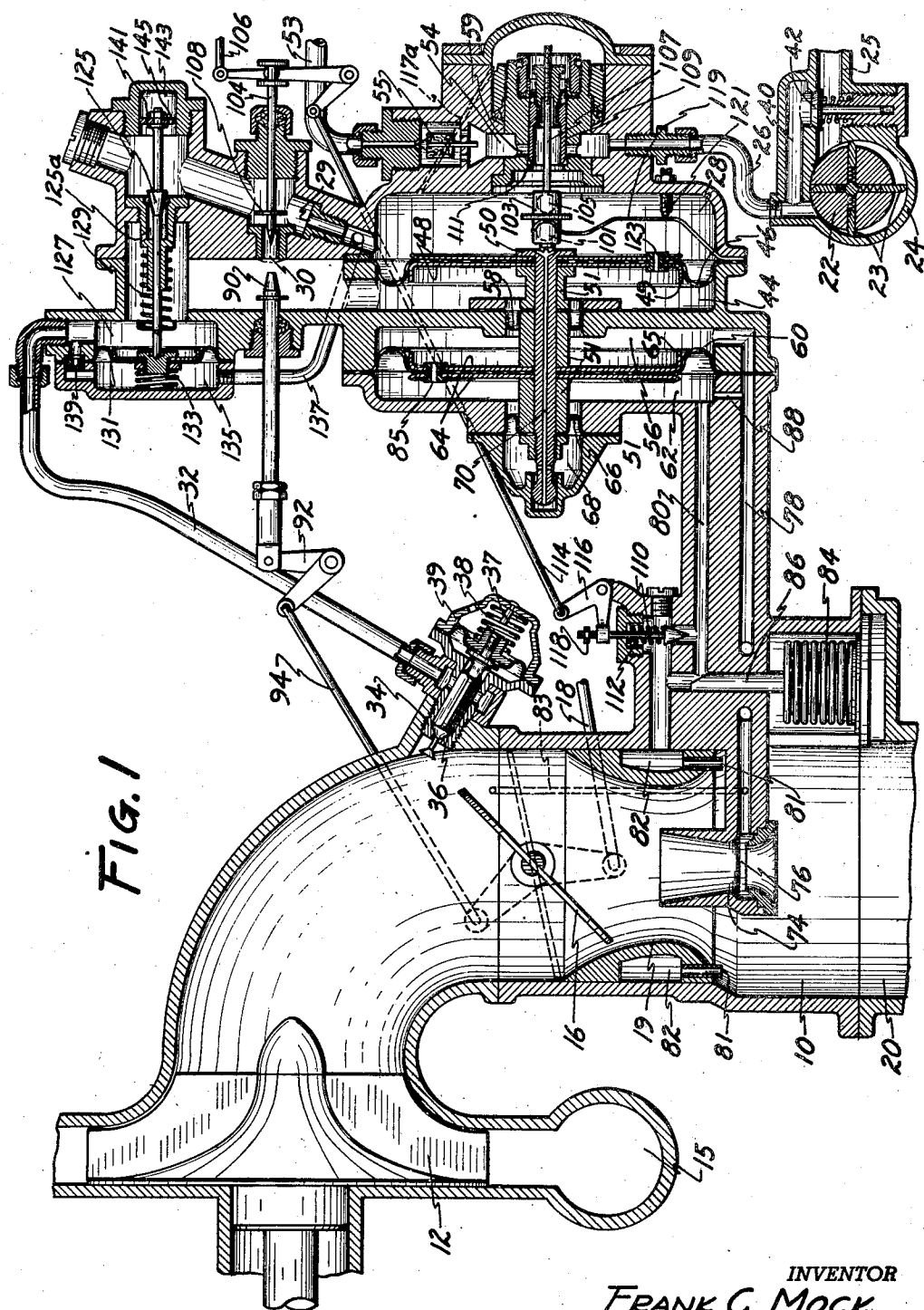


FIG. 1

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2 Sheets-Sheet 2

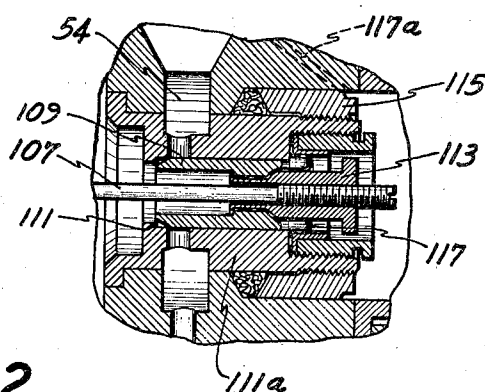


FIG. 2

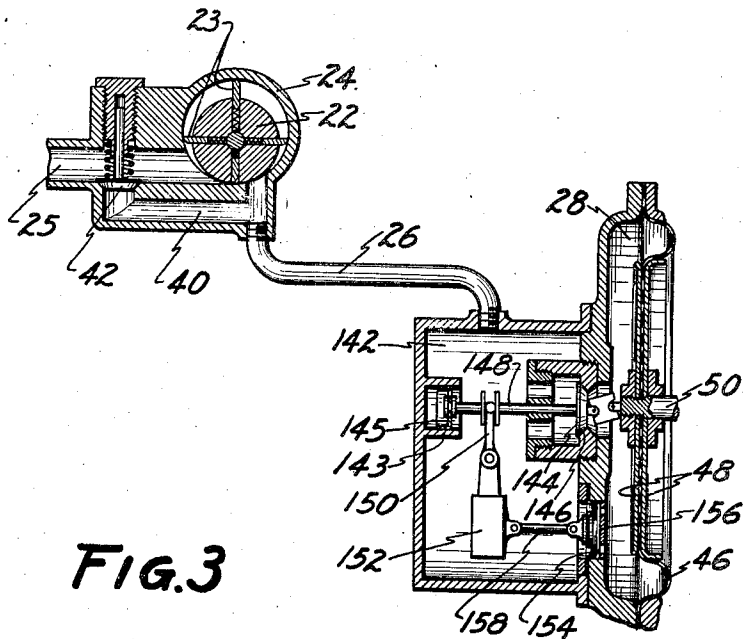


FIG. 3

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LIQUID CONTROL MECHANISM

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Application April 15, 1938, Serial No. 202,206

17 Claims. (Cl. 261-69)

This invention relates to fuel feeding systems for internal combustion engines and more particularly to devices or control mechanism in such systems for increasing the ratio of fuel to air supplied the engine during periods of high power operation. This application is a continuation-in-part of my applications Serial Nos. 118,718 and 171,461, filed January 2, 1937, and October 28, 1937.

One of the principal objects of the invention is to provide an accurately metered fuel supply whereby the fuel and air ratio can be maintained within very close limits and at desired values throughout the range of engine operation.

Another object of the invention relates to the provision of an improved economizer control to vary the richness of the mixture under different operating conditions. The economizer control is particularly desirable in engines equipped with superchargers and serves primarily to increase the richness of the mixture as the engine approaches full power operation.

A further important object of the invention relates to the provision of a fuel flow economizer subjected to the fuel metering differential pressure of the normal fuel supply to the engine for controlling the supply of supplementary fuel to the engine.

Other desirable features and characteristics of the present invention relate to the provision of a fuel flow control mechanism influenced by air pressure at spaced points in the induction passage of the carburetor or manifold and by fuel pressure at spaced points in the system; the use of an improved fuel valve mechanism controlled by said air and fuel pressures; the use of an improved combination of manual and automatic control of the supply of fuel to the engine.

A further object of the invention relates to the modification of the normal and supplemental fuel supplies in accordance with variations in the barometric pressure of air supplied to the engine.

While a principal utility of the invention is in connection with aircraft engines, it is also applicable to engines of other types or to other uses where fuel is to be supplied under more or less analogous conditions.

The characteristics and advantages of the invention are further sufficiently referred to in connection with the following detail description of the accompanying drawings, which represent certain preferred embodiments. After considering these examples, skilled persons will understand that many variations may be made without departing from the principles disclosed; and I con-

template the employment of any structures, arrangements, or modes of operation that are properly within the scope of the appended claims.

Figure 1 is a diagram illustrating the principles of the invention in a schematic way;

Figure 2 is an enlarged partial view in section of the diaphragm-balanced fuel inlet valve of Figure 1;

Figure 3 is a partial view in section illustrating a modified form of balanced inlet valve.

Referring first to Figure 1, a main air intake conduit 10 leads to a rotary blower or supercharger 12 of an internal combustion engine which may be of any desirable type. The conduit 10 is controlled by a throttle 16 which is operated by a rod 18 extending from the pilot's cockpit. The pilot thus controls directly the air charge of the engine while the fuel charge is automatically controlled by the apparatus hereinafter described in detail. Anterior to the throttle is a venturi 19 of any suitable contour. In some cases a second supercharger may be employed to supply air at higher than atmospheric pressure to the entrance 20 of passage 10, and in such cases the supercharger 12 serves both to step up the pressure and as a fuel mixer and distributor. In other cases the entrance 20 is merely flared and opens in the direction of travel of the craft, so that the inertia of the entering air will build up a pressure above atmospheric at the entrance, which is in such cases usually referred to as a scoop.

An instrumentality such as the blower 12 is not essential to the invention, but is here shown as representing approved practice in aircraft engines, and serves to or assists in atomizing and properly distributing fuel introduced into the air line in the manner presently referred to. The blower discharges into a generally annular chamber 15 from which pipes lead to the intake ports of the various cylinders, as usual in this type of engine.

It is to be understood that the entire air passage between the throttle and the engine intake ports represents broadly an intake manifold, and the term is to be so construed in this specification. Any known or suitable fuel pump, capable of delivering fuel under positive pressure, is provided, that shown being of the sliding vane type and comprising a rotor 22 slidably carrying a set of vanes 23 and rotatably mounted in a casing 24.

The casing has a fuel inlet 25, an outlet 26, and a return bypass 40 controlled by a pressure re-

sponsive valve 42, so as to maintain a substantially constant outlet fuel pressure, in the known manner. The pump thus delivers fuel to passage 26 and thence into annular chamber 54, through ports 59, past a tapered poppet or lift type of valve 109 which seats at 111, into pressure chamber 28, through fixed metering orifice 29, an adjustable metering orifice 30, into chamber 127 and through passage 32 to a discharge jet 34 positioned in the conduit 10 posterior to the throttle.

The discharge jet 34 is provided with a valve 36 opening away from the manifold and connected to a flexible diaphragm 39. Fuel pressure entering through the pipe 32 acts on one face of the diaphragm 39 tending to open the valve 36, and is opposed by a spring 38. Since manifold vacuum is effective on valve stem 36 merely to the extent of its application on an area equivalent to that of the valve orifice whereas the fuel pressure is effective to the extent of its application on the relatively large area of the diaphragm 39, the fuel discharge pressure is practically unaffected even by large changes in manifold vacuum. The relatively large diaphragm area also enables the valve to change from a relatively closed position to a wide open one (to give low and high rates of fuel discharge) with but a slight change in discharge pressure. This relatively constant pressure feature aids in obtaining accurate metering under variable operating conditions. A fixed stop 37 is preferably provided to limit opening of valve 36 to prevent damage in case of backfire or the like.

A second pressure chamber 44 is positioned adjacent chamber 28 and is separated therefrom by a flexible diaphragm 46 which is preferably of the type having no elastic reaction to stress, comprising a fabric sheet secured at its outer edges and having its central portion secured between a pair of disks 48. The disks 48 are in turn secured to a rod 50 which terminates at its extreme right end in a ball 101 slidable within a socket 103 which also receives a ball 105 carried by the extreme left end of a valve stem 107 of inlet valve 109. A universal connection is thus provided between the valve and the rod 50 of the diaphragm assembly hereinafter described. The parts are thus free to float to align themselves, thereby decreasing side pressure on the rod or valve which might cause binding.

As is best shown in Figure 2, the valve 109 is loosely slidable in a bore of a valve cage 111A and is adapted to seat at 111 to control the flow of fuel into chamber 28. Valve 109 is carried by a plug 113 threaded on the valve stem 107 and should preferably be adjusted to seat when the diaphragm assembly hereinafter described is in the neutral position. The valve assembly is held in position by means of an outer nut 115 which may be removed to take the assembly apart without disturbing the adjustment of the poppet valve on the valve stem. A diaphragm 117 is secured to the valve 109 and to the cage 111A. A passage 117A communicates the fuel chamber 28 with the space to the right of the diaphragm 117. The diaphragm 117 is equal in effective area to the effective area of the valve seat 111 and is thereby effective to balance the unbalance which would otherwise result from the differential in pressure across the valve 109 and to seal any leakage of fuel from annular chamber 54 past the free fitting valve. The pressure of the fuel in chamber 28 acts to the right on the valve 109 over an area

equal to the effective area of the seat 111 and, by means of passage 117A, to the left on diaphragm 117 over an equal area thus balancing the effect of the pressure in chamber 28. The high pressure fuel in chamber 54, due to the free machine fit of valve 109 in the bore of cage 111A, leaks past the valve 109 and acts to the left on the valve 109 and to the right on diaphragm 117. The unbalanced force normally resulting from the differential pressure across a poppet valve is thus eliminated.

It may be noted that if a slide or sleeve type of valve were used the balancing diaphragm 117 would be unnecessary; however, such a valve requires a very accurately lapped fit in order to regulate the fuel flow at low rates of flow corresponding to idle, and the slightest deposit of gasoline gum or a fine particle of dirt would cause such a sleeve valve to bind and interfere with the operation of the device.

A leaf spring 119 engages the socket 103 to urge the valve assembly toward the open position to provide an enrichment at idling speeds as will be described hereinafter. The force of the spring urging the valve toward open position may be varied by means of an adjusting screw 121. The spring is preferably of such design that it acts on rod 50 and valve 109 only when the said valve is in a nearly closed position. The flange of collar 103 moves away from and is completely free of any effect of the spring at any substantial valve opening. The spring 119 is carried by a gasket which engages the outer edge of the diaphragm 46 and when the shell surrounding the valve mechanism 109 is removed the spring 119 remains in position, whereby it is possible to check the adjustment of the valve and valve assembly.

The chamber 54 is preferably connected to the top of the fuel tank, not shown, by a pipe 53 controlled by a float valve 55 to vent back to the tank any air or vapor entrained by the pump.

Adjacent the chamber 44 is a chamber 56, separated therefrom by a small diaphragm 58, which merely serves the purpose of a leakless stuffing box. A second large diaphragm 60 separates chamber 56 from another chamber 62, and rod 50 is connected to the disks 64 of this diaphragm in the same manner as to those of diaphragm 46. A second "stuffing box" diaphragm 66 is secured to the end of rod 50 and separates the chamber 62 from a chamber 68 positioned adjacent thereto.

The sealing diaphragms 58 and 66 are preferably made of Duprene, synthetic rubber or other suitable material and are formed with annular grooves as clearly shown to give a rolling action against the confining walls. It will be observed that the effective area of the diaphragm is unchanged regardless of the position to which it is moved. Fluctuations of pressures which might interfere with the proper operation of the parts to which the diaphragm is attached are thereby avoided. To facilitate assembly of the parts, the diaphragms may be formed with thickened attaching flanges while the working sections remain thin.

In order to balance out the unavoidable pressure effects of diaphragms 58 and 66, chambers 28 and 68 are interconnected by a pressure equalizing passage 70 formed in the rod 50.

The rod 50 carries enlarged cylindrical hub members 51 adjacent the diaphragms 58 and 66 of substantially the same diameter as the flat central portions of the diaphragms on the low pres-

sure sides thereof. The diaphragms are formed with deep annular grooves as shown, the sides of which lie respectively against the members 51 and outer circular confining walls. Due to this construction and the differential in fluid pressure which exists on the two sides of the diaphragms, the grooves in the diaphragms maintain a substantially constant effective radius as the rod 50 moves, so that the effective areas thereof remain constant regardless of movement of the rod 50. The same construction is preferably followed in connection with the diaphragms 46 and 60 by providing circular flanges 49 and 65 on the plates 48 and 64 respectively. This is an important feature since it enables the diaphragms always to exert the same force in response to equal pressures regardless of the deflection of the diaphragms. It will be observed that the end of the rod 50 is rounded to minimize friction and to permit it to seek a nonbinding position.

A small venturi 74 is positioned in the intake conduit 10 concentrically with the venturi 19 and is formed with an annular opening 76 substantially at its throat which is connected through a passage 78 with chamber 56. A small bypass 83 may if desired interconnect the passage 78 with the induction passage posterior to the throttle 16. A similar passage 80 leads from chamber 62 to an annular chamber 82 formed in the venturi 19 and communicating with the inlet end of the conduit 10 through a series of tubes 81 so as to be subjected to the pressure of the incoming air. The tubes 81 project out a substantial distance so that any rain or the like washing up the walls of the air conduit 10 will flow around them and will not enter the chamber 82.

The basic principles of operation of the invention thus far described are here introduced in order to aid in clarifying the functions of parts of the invention hereinafter described. Chamber 62 is subjected to air scoop pressure, chamber 56 to Venturi suction, modified by the pressure in the induction passage posterior to the throttle at idling speeds, chamber 44 to what is generally referred to as "metered-fuel" pressure and chambers 28 and 68 to "unmetered-fuel" pressure. When the engine is in operation, it draws air through the air conduit 10, and a differential pressure is thus created between the air scoop and the venturi, the amount of which is a function of the rate of air flow. This differential in pressures acting in chambers 56 and 62 creates a net force tending to move rod 50 to the right in a direction to open valves 109. If this force were unopposed the rod 50 and valve 109 would move to the extreme right. As valve 109 opens, however, fuel which is supplied under pressure to valve chamber 54, will flow into the unmetered-fuel chamber 28, through the metering orifices, into the metered-fuel chamber 44, and thence to the discharge jet 34 as previously described. A differential in pressure between chambers 28 and 44 is therefore created which is equivalent to the pressure drop across orifice 29 and passage 30 and is a function of the rate of fuel flow therethrough. Since the pressure in chamber 44 is maintained within relatively narrow limits by the action of jet 34, opening of valve 109 will increase the pressure in chamber 28 (due to decreased throttling loss across said valve) thereby increasing the differential pressure across the metering orifices and increasing the rate of fuel flow. The differential in pressure between chamber 44 and chambers 28 and 68 will exert a force on rod 50 tending to move it to the left or in a direction to

close valve 109, thus opposing the force on rod 50 created by the depression at venturi 74.

A summation of forces acting on the rod 50, neglecting the spring 119 which has no effect except at very small flows corresponding to idling range, will show that the rod 50 will adjust itself to a point of equilibrium such that the differential across the fuel metering orifices is equal to the differential pressure between air scoop and venturi. If now, the pressure of fuel delivered by pump 22 is increased, as by faulty pump action, the pressure in chamber 28 will increase, which will cause valve 109 to move toward closed position thereby restoring the fuel metering differential pressure to its original value. If the engine speed is decreased, by a change in the propeller pitch or from any other cause, the rate of air flow through venturi 74 decreases, decreasing the differential pressure acting on diaphragm 60, causing valve 109 to move toward closed position and thus decreasing the fuel flow to compensate for the decreased rate of air flow which initiated the adjustment. The rate of fuel flow is directly controlled therefore by the rate of air flow, and a constant mixture ratio can be attained.

At low air flows, corresponding to idle operation, the spring 119 acts on rod 50, thus adding an increment of force to the normal venturi action tending to open the valve 109 and thereby requiring an increased pressure differential across diaphragm 46 to balance the forces on rod 50. This results in increased fuel flow and a richer mixture for idle operation.

The bypass 83 interconnecting the passage 78 with the induction passage posterior to the throttle 16 introduces a net force operating on rod 50 to move it in the same direction as it is urged by the spring 119. It will be observed that the opening of the port 83 into the induction passage is uncovered by the throttle valve when it has moved a small distance in the opening direction. The port 83 is therefore effective only during the low speed or idling ranges of the engine. Another desirable feature of the bypass 83 is that it is possible to use a leaner mixture at wide open throttle than is used at part throttle.

The passage 80 is controlled by a capsule or aneroid 84, shown in Figure 1 as a sealed, corrugated bellows which carries a valve member 86 which tends to open passage 80 at high barometric pressures (as at ground or sea level) and to close the same at low pressures (as at high altitudes). A calibrated passage 88 connects the lower portion of chamber 62 to the passage 78. Passage 88 is sufficiently small in comparison with passages 78 and 80 that when valve 86 is open, air flow through passage 88 is not effective in materially altering the pressures existing in chambers 62 and 56. As altitude is gained, valve 86 moves toward closed position under action of the bellows 84, flow of air from chamber 62 into passage 80 is thereby restricted and the air flow from passage 80 through passage 88 becomes more effective in reducing the pressure existing in chamber 62, thus decreasing the differential pressure acting on diaphragm 60 and tending to close valve 109 and lean out the mixture as desired with increase in altitude. Passage 88 also serves as a drain for any moisture collecting in chamber 62.

To guard against the building up of a differential of fluid pressures between chambers 56 and 62 which might prevent the rod 50 from actuating the valve 109 when it is desired to start the engine, a small bleed orifice 85 may be employed

to interconnect the chambers 56 and 62. It will be understood of course that the orifice 85 cooperates with the passage 88 to equalize pressures between the chambers 56 and 62; however, these two passages may be made sufficiently small that they will accomplish their desired functions without interfering with the operation of the device.

The bellows 84 is preferably only partially evacuated so that it will be responsive to changes in temperature as well as pressure, the amount of temperature response being controlled by the degree of evacuation. As the temperature of the air entering the air scoop 20 increases, bellows 84 will elongate slightly, moving valve 86 to a position to restrict the passage 80, reducing the pressure in chamber 62, and thereby reducing the pressure differential across the diaphragm 60. Consequently the fuel flow will be slightly reduced to provide a leaner mixture as the inlet air temperature rises.

It is desirable to design spring 110 and bypass 83 to give an excessively rich idling mixture and then use valve 90, which is throttle connected through bellcrank 92 and link 94 and arranged to move into passage 30 at closed throttle, to restrict the flow of fuel through passage 30 so as to obtain the desired idle richness. The valve 90 can be given any desired configuration to provide the desired rate of fuel flow at closed as well as substantially closed throttle. Valve 90 is drawn clear of passage 30 as the throttle valve 16 is opened so that during normal operation the valve 90 occupies substantially the position shown and does not affect the fuel flow.

The port 30 may further be controlled by a plunger 104 controlled manually from the pilot's seat through a linkage 106 to provide either a rich or lean mixture. When the end of the plunger 104 is projecting into the port 30, as shown, the flow of fuel is restricted and a lean mixture results. To obtain a richer mixture the pilot may operate linkage 106 to withdraw the plunger 104 completely from the port 30 to leave it unrestricted. Preferably the plunger 104 carries a disc 108 adapted to close the port 30 completely so that the pilot can cut off the fuel supply at will in case of emergency or when the engine is to be stopped.

A further manual control is provided by a valve 110 in the passage 80 urged onto its seat by a spring 112 and connected to the linkage 106 by a link 114. The link 114 is pivoted to one end of a bellcrank lever 116, the other end of which is slidable on the stem of the valve 110 and is adapted to engage a nut 118 on the end thereof. This arrangement provides a lost motion connection so that the plunger 104 can be operated as described above without affecting the valve 110. However, if the linkage 106 is pulled back to its extreme limit the valve 110 will be opened to admit air at intake pressure to the chamber 62 thereby opening the valve 109 further and increasing the richness of the mixture regardless of position of valve 86.

The control means thus far described provide a mixture of suitable richness for varying speeds, loads, and throttle openings, and provide a degree of compensation for changes in altitude. However, during periods of operation at high power output it is desirable to enrich the mixture and for this purpose a fuel-metering-head economizer is employed. In this device a calibrated by-pass 125a around metering orifice 30 connects the unmetered fuel in chamber 28 with the metered fuel

in chamber 127 above the chamber 44. A valve 125 controls the by-pass and is urged toward the closed position by a spring 129. The valve may be urged toward the open position by a diaphragm assembly 131. A spring 133 in the diaphragm chamber 135 urges the diaphragm in the direction to open the valve 125 against the spring 129. The spring 133 may be adjusted to seat the valve 125 at any predetermined value. The rate of valve opening is of course a function of the differential forces exerted by the springs 129 and 133 and the differential in the fuel pressures on opposite sides of the diaphragm 131.

The diaphragm 131 is subjected on the right side to the metered fuel pressure in the chamber 127 and on the left side to the pressure of the unmetered fuel in the diaphragm chamber 135, a conduit 137 being employed in the form shown to transmit the unmetered fuel from the chamber 28 to the diaphragm chamber 135. A small vent 139 serves to permit the escape of any air from the chamber 135, which might be trapped in the unmetered fuel.

The end of the economizer valve 125 remote from the diaphragm assembly 131 carries a plunger 141 slidably mounted in a cylinder 143. The plunger is provided with an orifice 145 which permits fuel to flow through the plunger, to damp out sudden oscillations or movements of the valve. An efficient dashpot is thus conveniently provided.

As the power output of the engine increases, by opening the throttle or otherwise, the fuel delivered to the engine increases and consequently the fuel metering differential pressure increases. The fuel metering differential pressure, that is the differential in the pressures in chambers 28 and 44, acting on the economizer diaphragm 131 tends to open the economizer valve 125. When the fuel differential pressure equals or exceeds a predetermined value the force of spring 129 will be overcome and the valve 125 will open, thereby enriching the mixture as is desired.

It is to be noted that with this type of economizer control only one diaphragm is utilized in contrast to other arrangements in which balanced sealing diaphragms are required in addition to the main actuating diaphragm.

It will be observed that a small orifice 123 extends through the diaphragm 46 to permit both diaphragm chambers 28 and 44 to fill with fuel simultaneously. The size of this orifice is proportioned in such a manner as not to have any materially bad effect on the operation of the device. In the event that the fuel control body which includes the fuel metering jets 29, 30, the economizer valve structure 125, fuel chamber 127 and the fuel outlet, are mounted in a plane parallel to and displaced from the axis of the diaphragm and inlet valve control assembly, the fuel can, if desired, be taken from the lower end of chamber 28 and passed upwardly through the fuel control body. In this event the orifice 123 should be positioned to connect chamber 28 with chamber 127 at the upper end thereof, and the chamber 127 should be vented to chamber 44 at the upper end thereof. In order to subject chamber 44 to the pressure existing in chamber 127, a conduit should connect these chambers, preferably at the lower end thereof.

Some operators desire to be able to regulate richness of the mixture during emergency operation when the valve 125 is open, while others prefer that the richness of the mixture at this time shall be automatically regulated independ-

ent of the control of the pilot. Either of these conditions can be obtained as desired by inclusion or exclusion of the orifice 29 or by properly proportioning the size of this orifice. For example, if the area of passage 125a is greater than that of orifice 29, orifice 29 functions as the sole restriction to fuel flow when valve 125 is open as at full power, and operation of plunger 104 has then no effect on the fuel flow. On the other hand, if the restriction formed by the orifice 29 is omitted or the orifice is made larger than the combined areas of passages 125a and 30, fuel flow is metered by these two passages and the pilot, through operation of plunger 104, may control the mixture both during normal and emergency operation.

Figure 3 illustrates a modified construction for controlling the flow of fuel into the chamber 28 and as shown includes a chamber 142 receiving fuel from the pump through the pipe 26. Communication between the chambers 28 and 142 is controlled by a poppet valve 144 seating on a tapered valve seat 146 and connected to the rod 50 to be controlled thereby. The valve 144 has its stem 148 connected to one end of a lever 150 which is pivoted at its center in the chamber 142 and has its opposite end formed as a weight 152. The weight 152 has substantially the same effective mass as the rod 50 and its related parts such as the disks 48 and 64 and serves to counterbalance any inertia effects on the rod 50 which might change the richness of the fuel mixture.

Fuel pressure on the valve 144 is balanced by a diaphragm 154 exposed on one side to the pressure in the chamber 142 and on its other side to the pressure in the chamber 28 through openings in a plate 156. The effective moment on the lever pivot of the diaphragm 154 is the same as that of the valve 144 and the diaphragm is connected to the weight 152 by a link 158 so as to balance out the effect of fuel pressure on the valve 144.

The openings in plate 156 are preferably made small to provide a dashpot effect tending to damp any vibrations or any tendency of the valve 144 to flutter. If this dashpot effect is not sufficient a second dashpot may be provided by a cylindrical extension 143 in the chamber 142 slidably receiving a piston 145 carried by the valve stem 148. The piston may have a relatively loose fit in the cylinder, or a suitable by-pass may be provided and since the cylinder will be filled with fuel a liquid dashpot is formed.

It will also be understood that many changes might be made in form and arrangement of parts and it is not intended that the scope of the invention shall be limited to the forms shown and described nor otherwise than by the terms of the appended claims.

Certain of the subject matter disclosed but not claimed herein is being claimed in my copending applications Serial Nos. 350,518 and 350,519, filed August 3, 1940, and Serial No. 362,572, filed October 24, 1940.

What is claimed is:

1. A charge forming device comprising an induction passage having an air inlet, a venturi in said passage, a fuel conduit leading from a fuel source and discharging into said passage, fuel metering means in said conduit, manually operable means for varying the effective area of said fuel metering means, a valve having a conical seat controlling the fuel conduit, a balancing diaphragm connected to said valve and subjected on opposite sides to the pressure in said conduit anterior and posterior to the valve for bal-

ancing the differential pressure across said valve, a control rod connected to said valve, a pair of diaphragms connected to said control rod, means for subjecting two of the faces of said diaphragms to the pressures at the venturi and air inlet respectively, means for subjecting the remaining two faces of the diaphragms to the fuel pressure in said conduit anterior and posterior to said fuel metering means, a by-pass around said fuel metering means, and means responsive to the fuel pressures in said conduit anterior and posterior to said fuel metering means for controlling said by-pass.

2. A charge forming device comprising an induction passage having an air inlet, a fuel conduit leading from a fuel source and discharging into said passage, fuel metering means in said conduit, manually operable valve means for varying the effective area of said fuel metering means, a main control valve assembly including a poppet type valve in said conduit, a balance diaphragm connected to said valve for balancing the differential pressure across said valve, means connected to said poppet valve and responsive to a differential pressure created by air flow through the passage for urging the valve toward open position, means responsive to the differential in fuel pressure across said fuel metering means connected to said valve for urging the valve toward closed position, and means responsive to the fuel differential across said fuel metering means for varying the area of said fuel metering means.

3. A charge forming device for an internal combustion engine comprising an air passage, a fuel conduit for supplying fuel to the engine, a valve controlling said conduit, fuel metering means in said conduit, means responsive to a differential pressure resulting from air flow through the air passage for controlling said valve, means responsive to fuel pressures anterior and posterior to said fuel metering means for controlling said valve, manually operable valve means for varying the effective area of said metering means, and means responsive to the differential in the fuel pressures anterior and posterior to said fuel metering means for varying the effective area of said metering means, said first named valve being operative independently of said last named means.

4. A charge forming device for an internal combustion engine having an air passage, a fuel conduit receiving fuel from a source and discharging into the air passage, a metering restriction in said conduit, manually operable means for varying the effective area of said restriction, a valve in said conduit, means responsive to the differential in pressure at spaced points in the air passage and to the differential in the fuel pressure on opposite sides of said metering restriction for controlling said valve, a by-pass around said metering restriction, a valve seat fixed in said by-pass, a valve cooperating with said fixed seat to control the flow of fuel through the by-pass and adapted to close the by-pass during periods of low power output, and means responsive to the differential in the fuel pressures on opposite sides of the metering restriction for controlling said by-pass valve, and adapted to open the valve at high rates of fuel flow corresponding to periods of high power output.

5. In a charge forming device a fuel control valve assembly comprising a member having a conical seat, a plunger slidably mounted in said

member and cooperating with said seat, means engaging the plunger and influenced by differential of fluid pressures at spaced points to control the position of the plunger with reference to the seat, a balance diaphragm connected to said plunger and subjected to the differential in the pressures on opposite sides of said seat to balance the plunger, adjusting means between the position control means and the plunger, and a casing surrounding the valve assembly, said valve assembly being mounted in the casing as a unit to permit removal of the casing without altering the adjustment of the plunger with reference to its seat.

6. In a charge forming device having a casing, a fuel control valve assembly comprising a member having a conical seat, a plunger cooperating with said seat, fluid pressure responsive means connected to said plunger for positioning the same with reference to the seat, and a balance diaphragm connected to said plunger and to said member and subjected on opposite sides to the fuel pressures anterior and posterior to said seat, said member, plunger, and balancing diaphragm being thereby insertible into the casing as a unit.

7. The invention defined in claim 1 comprising in addition a counterweight connected to said control rod for balancing the inertia of said control rod assembly.

8. The invention defined in claim 2 comprising in addition a counterweight and a dashpot associated with said valve for respectively balancing inertia effects and damping oscillations of the valve.

9. In a charge forming device for an internal combustion engine having an air passage, means in said air passage for creating an air differential pressure in response to flow therethrough, a fuel conduit for supplying fuel to the engine, area restricting means in said conduit for creating a fuel differential pressure in response to fuel flow therethrough, a fuel valve for variably controlling the fuel flow to the engine, and diaphragm means responsive to said air and fuel differential pressures for controlling the said fuel valve: the combination therewith of a valve for varying the effective area of the area restricting means to thereby vary the ratio between the rate of fuel flow therethrough and the fuel differential pressure, means operable only when the fuel differential exceeds a predetermined relatively high value for operating said valve comprising a diaphragm operably connected to the valve and subjected to the said fuel differential pressure, and manually operable means separate from said valve for varying the effective area of the area restricting means independently of said valve.

10. A charge forming device comprising an induction passage having an air inlet, a venturi in said passage, a fuel conduit leading from a fuel source and discharging into said passage, fuel metering means in said conduit, manually operable means for varying the effective area of said fuel metering means, valve means for controlling the flow of fuel through said conduit, a pair of diaphragms connected to said valve means, means for subjecting two of the faces of said diaphragms to the pressures at the venturi and air inlet respectively, means for subjecting the remaining two faces of the diaphragms to the fuel pressure in said conduit anterior and posterior to said fuel metering means, a by-pass around said fuel metering means, and means re-

sponsive to the fuel pressures in said conduit anterior and posterior to said fuel metering means for controlling said by-pass.

11. In a charge forming device for an internal combustion engine having an air passage, a throttle in the passage, an air differential pressure creating means in the passage anterior to the throttle, a fuel conduit receiving fuel from a source and supplying it to the engine, fuel metering means in said conduit for creating a fuel differential pressure in said conduit upon flow of fuel therethrough, valve means for controlling the flow of fuel through the conduit, a plurality of diaphragms connected to the valve means for operating the same, means for subjecting the diaphragms to the air and fuel differential pressures, a valve for varying the effective area of the fuel metering means, a diaphragm operably connected to the valve, and fuel passages interconnecting the last named diaphragm and the fuel conduit for transmitting the said differential fuel pressure to the last named diaphragm, said diaphragm operated valve being inoperative at low values of fuel differential pressures corresponding to low power output and being arranged to open when the differential fuel pressure exceeds a predetermined value corresponding to a relatively high power output of the engine.

12. In a charge forming device for an internal combustion engine, an air passage for supplying air to the engine, a fuel conduit for supplying fuel to the engine, a metering restriction in the conduit, fuel valve means for controlling the flow of fuel through said conduit, diaphragm means operably connected to said valve means and directly subjected to the fuel pressures in said conduit on opposite sides of the metering restriction for controlling said valve means, a by-pass around said metering restriction and having a fixed valve seat therein, a valve cooperating with said seat for controlling said by-pass, a spring yieldingly holding said by-pass valve in a closed position with a positive force, and pressure responsive means directly subjected to the fuel pressures in said conduit on opposite sides of the metering restriction for opening the by-pass valve against the force of the spring when the differential in said fuel pressures exceeds a predetermined value to thereby increase the richness of the mixture at high power outputs.

13. A fuel supplying device for an internal combustion engine comprising a fuel pump, a conduit receiving fuel under pressure from the pump and delivering it to the engine, manually variable metering means in said conduit for varying the richness of the mixture delivered to the engine during periods of low power output, a fuel by-pass around said manually variable metering means, a valve normally closing said by-pass, and means responsive to the differential of the fuel pressures in said conduit anterior and posterior to said variable metering means for moving said valve toward open position when the differential pressure exceeds a predetermined value to thereby increase the richness of the mixture at high power outputs.

14. The invention defined in claim 13 comprising in addition a dashpot associated with the by-pass valve to damp out oscillations imparted thereto.

15. A carburetor having a fuel supply passage including a metering orifice fixed against orifice area varying movement in response to changes

in engine operation, an air supply passage including means for creating a differential of pressures proportional to air flow, a fuel inlet valve in said fuel supply passage movable to vary the supply of fuel to said metering orifice, valve actuating means including a plurality of diaphragms, one responsive to changes in said differential of pressures in said air passage and another normally balancing said first mentioned diaphragm and acted upon by fuel pressures on opposite sides of said orifice, and means movable proportionally with and responsive to changes in the differential of pressures on opposite sides of said orifice for unbalancing said last mentioned diaphragm and effecting displacement of said valve to increase the fuel flow through said valve to enrich the mixture and restore the balance of said diaphragms in the new position of the valve.

16. A carburetor having a fuel supply passage including a metering orifice fixed against orifice area varying movement in response to changes in engine operation, an air supply passage including means upstream from the throttle for creating a differential of pressures proportional to air flow, a fuel valve in said fuel supply passage movable to vary the supply of fuel to said orifice means and normally balanced by opposing pressures of unmetered fuel being delivered to said orifice means, valve actuating means responsive to changes in said differential of pressures in said air passage and normally balanced by fuel pressures on opposite sides of said orifice for maintaining a substantially con-

stant fuel air ratio, economizer means for effecting an increased fuel flow through said fuel supply passage to enrich the mixture and controlled by changes in the said fuel pressures on opposite sides of the orifice, and pressure responsive means for modifying the action of said differentials of pressures on said actuating means and on said economizer means in accordance with variations in the density of the air at different altitudes.

17. A carburetor having a fuel supply conduit including a main metering orifice fixed against orifice area varying movement in response to changes in engine operation and an economizer orifice in parallel with said main orifice, an air supply passage including means for creating a differential of pressures proportional to air flow, a fuel inlet valve in said fuel supply conduit, valve actuating means including a diaphragm responsive to the differential of pressures in said air passage and also including a diaphragm acted upon by metered and unmetered fuel, and an economizer valve for effecting an additional flow of metered fuel and controlling the operation of said first mentioned valve by controlling the flow through said economizer orifice and having an actuating diaphragm actuated under high engine power output conditions by a differential of pressures varying proportionally with and in response to changes in the differential of fuel pressures actuating said second mentioned diaphragm.

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