Aug. 17, 1948. F. C. MOCK **2,447,261**

CHARGE FORMING DEVICE

Filed Oct. 24, 1940 2 Sheets-Sheet 1

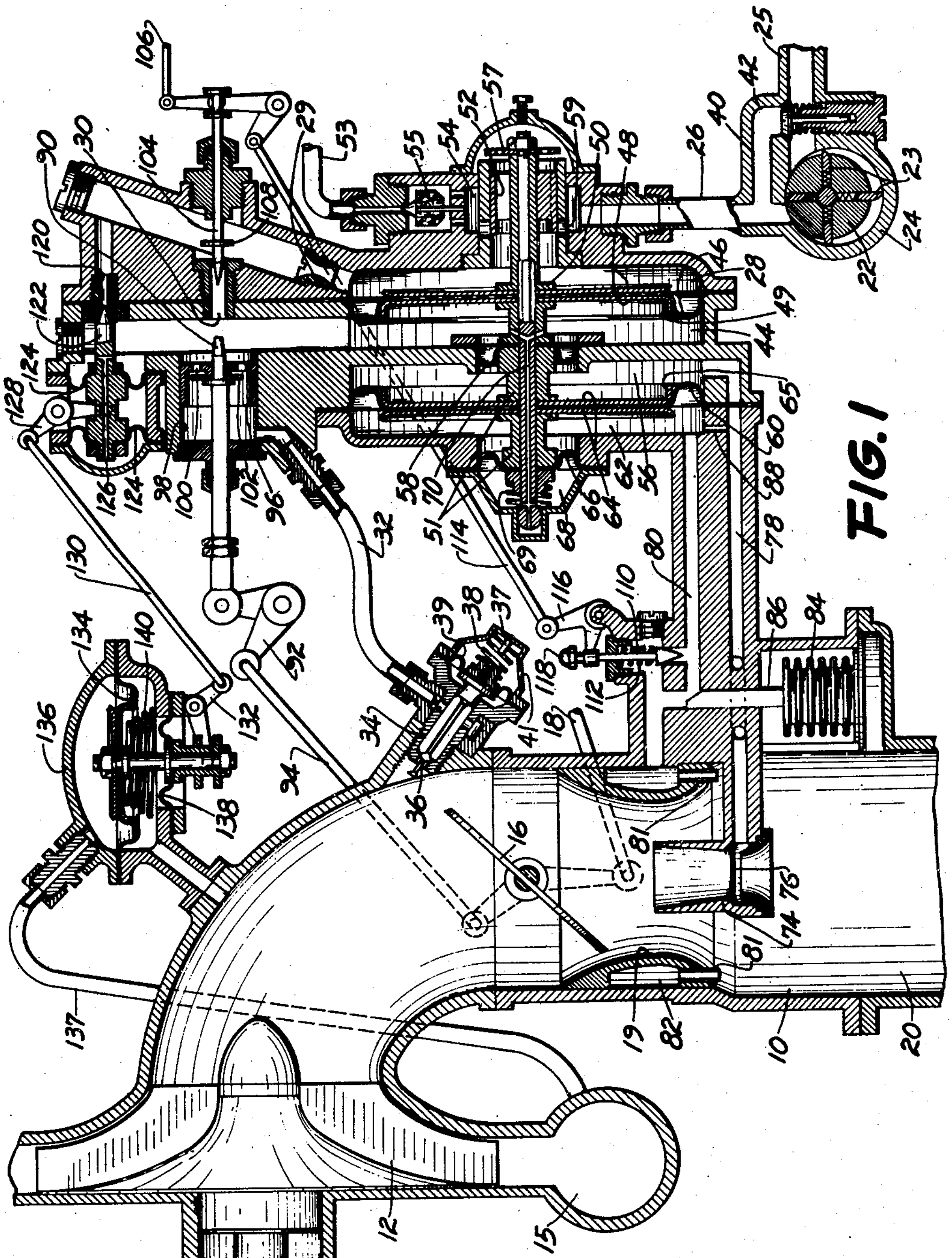

FIG. 1

INVENTOR
FRANK C. MOCK

BY A R McGrady
ATTORNEY

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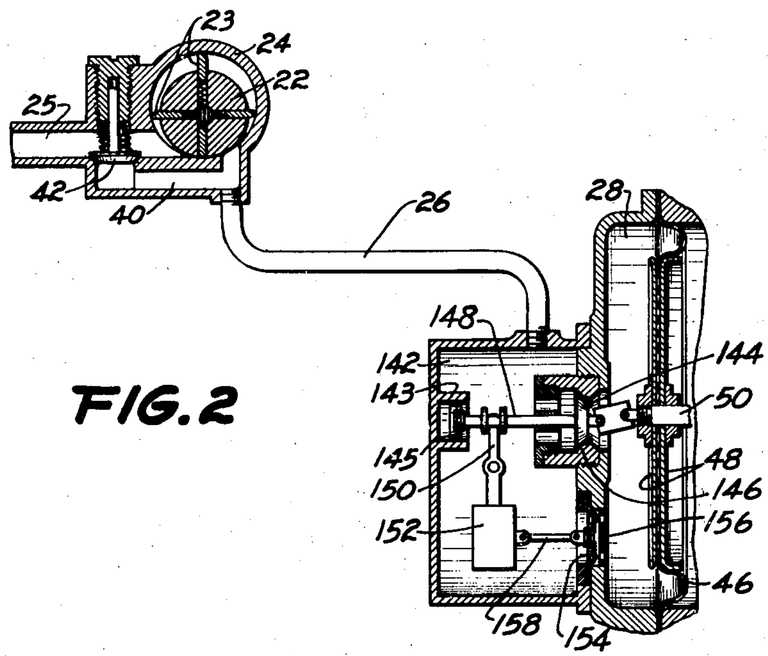

FIG. 2

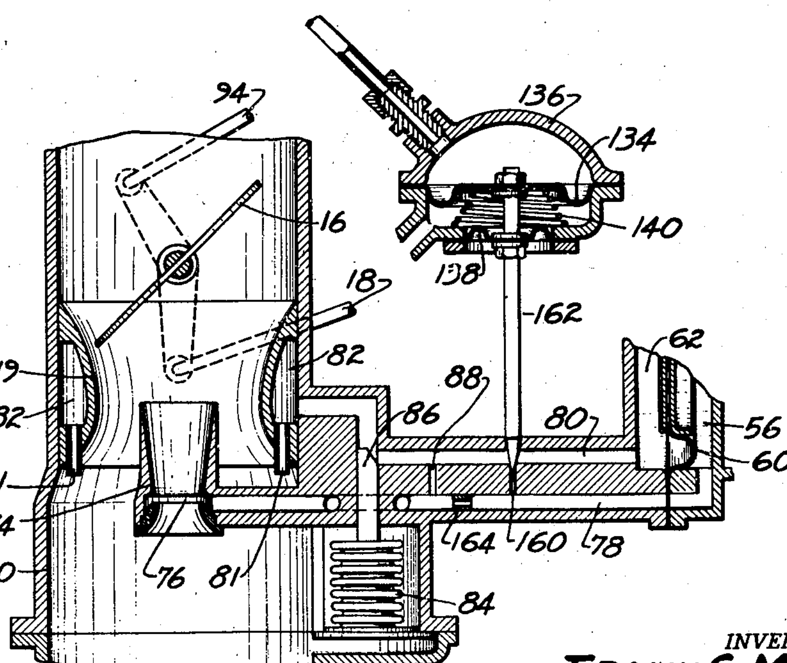

FIG. 3

INVENTOR
FRANK C. MOCK
BY A R McCrady
ATTORNEY

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UNITED STATES PATENT OFFICE

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CHARGE FORMING DEVICE

Frank C. Mock, South Bend, Ind., assignor to Bendix Aviation Corporation, South Bend, Ind., a corporation of Delaware

Application October 24, 1940, Serial No. 362,572

52 Claims. (Cl. 123—119)

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This invention relates to fuel feeding devices or systems for internal combustion engines and more particularly to devices or systems in which liquid fuel is supplied under positive pressure tc a current of air and is mixed therewith to form a combustible mixture.

One of the principal objects of the invention is to supply the liquid fuel under positive pressure, the fuel supply being regulated to maintain a proper fuel-to-air ratio. This arrangement causes the fuel to be atomized under pressure to produce a better mixture and keeps the fuel under atmospheric or superatmospheric pressure at all times thereby eliminating boiling of the fuel and insuring accurate metering.

Another object of the invention is to eliminate the formation of ice in the fuel mixing device, a function which is particularly important in the use of aircraft flying at high altitudes. This is accomplished by injecting the fuel into a warm or hot part of the manifold system or the like posterior to the throttle.

Another object is to provide a fuel feeding device or system which will operate properly in any position so that when it is installed on aircraft the engine will be properly supplied with fuel regardless of the position of flight. This is highly important during maneuvers of different kinds at which time an adequate fuel supply is indispensable.

The invention has for still another object to provide an accurately metered fuel supply whereby the fuel and air ratio can be maintained within very close limits. I have found that, in a conventional carburetor in which fuel is aspirated into an air stream passing through a venturi, the suction effect of the venturi is materially weakened by introduction of the fuel, which volatilizes and thereby to a considerable (and variable) extent satisfies or destroys the suction existing at the throat of the venturi. In the present invention wherein the fuel is positively injected at a point posterior to the venturi, the full suction effect of the venturi may be realized to control the fuel metering, and since this suction is from three to four times as much as that obtained in a conventional carburetor the fuel can be controlled more accurately.

Further objects of the invention relate to modification of the fuel control in accordance with variations in the barometric pressure of air supplied to the engine and to the provision of an 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.

This fuel supply apparatus, while especially ap-

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plicable to fuel supply regulating systems of the character hereinafter particularly described, is not limited to such uses, but is evidently available, with or without modification, in a great variety of cases where fuel is to be supplied under more or less analogous conditions against substantial back pressure; as, for example, that afforded by the spring of an injection valve, or by internal pressure in the vessel or chamber into which the fuel is introduced.

The present application discloses certain improvements in the devices disclosed in United States Patent 2,008,143, granted July 16, 1935, to the present applicant and is a continuation-in-part of my copending abandoned application Serial No. 118,718, filed January 2, 1937. A portion of the subject matter disclosed but not claimed in the present application is being claimed in my copending divisional application Serial Nos. 3,393 and 3,394, both of which were filed January 21, 1948.

While a principal utility of the invention is in connection with aircraft engines, it is also applicable to engines of other types or those used for other purposes, too numerous to mention, but some of which are brifly referred to hereinafter.

The characteristics and advantages of the invention are further sufficiently referred to in connection with the following detailed 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 contemplate 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 a partial section illustrating a modified construction; and

Figure 3 is a partial diagrammatic view illustrating a modified control system.

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, and outlet 26, and a return bypass 40 controlled by a pressure responsive valve 42, so as to maintain a substantially constant outlet fuel pressure, in the known manner. The pump thus delivers fuel to passage 26 thence into the annular fuel chamber 54, through radial ports 59 which are varied in effective area by the movement of sleeve valve member 52, and thence into pressure chamber 28. From chamber 28 the fuel flows through fixed metering orifice 29, an adjustable metering orifice 30, ports 100, and 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 passage 32 acts on the inner face of the diaphragm 39 tending to open the valve 36, and is opposed by a spring 38. A vent 41 to atmosphere is provided in the discharge jet cap to permit free movement of diaphragm 39. 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 nearly 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. The discharge jet cap may, if desired, be vented to a source of variable pressure, such as venturi suction, as is more particularly disclosed in the copending application of Mock and Partington Serial No. 243,067, filed November 30, 1938, now Patent No. 2,310,984, granted February 16, 1943.

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 carries a sleeve valve member 52 which controls the passage of fuel from a peripheral valve chamber 54 to the chamber 28, a suitable perforated disk 57 being provided to limit closing movement of the valve 52. 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 present in the fuel supplied 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. A small spring 69 urges the rod 50 in a direction to open valve 52. In order to balance out the unavoidable pressure effects of diaphragms 58 and 66, chambers 44 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 protions of the diaphragms on the low pressure sides thereof. The diaphragms are formed with annular grooves as shown, the sides of which lie respectively against the members 51 and outer circular confining walls. Due to this construction the grooves in the diaphragms maintain substantially the same 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.

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 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 subject 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 passage 80 is controlled by an altimeter or aneroid 84, shown in Figure 1 as a 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 the chamber 62 to the passage 78 and serves as a drain for any moisture collected in the chamber 62. Passage 88 also serves to draw air from chamber 62 and passage 80 into passage 78 so as to lower the pressure in chamber 62 and reduce the pressure differential acting on diaphragm 60, so as to decrease the richness of the mixture, whenever valve 86 is in a position where it restricts the passage 80, as it will be at all times when the vehicle is at such altitude as to make an altitude correction desirable. The bellows 84 preferably contains some air or other gaseous medium so that it will be responsive to changes in both temperature and pressure, the amount of temperature response being controlled by the amount of gas within the bellows at the time it is sealed.

The passage 30 is preferably controlled by a valve 90 which is connected through a bell crank 92 and link 94 to the throttle valve 16 to be operated thereby. The valve 90 is so arranged as to throttle the flow of fuel through the passage 30 when the throttle valve 16 is closed to or near the idling position and to open the passage 30 fully as the throttle valve 16 is opened beyond idling position. The valve 90 carries a piston 96 slidably fitting in a cylinder 98 and formed with ports 100 for passage of fuel. A valve disk 102 is slidably mounted on the valve in a position to close the ports 100 so that when the throttle valve 16 is opened suddenly the piston 96 and cylinder 98 form a fuel pump to increase temporarily the flow of fuel to provide a rich mixture for acceleration. When the throttle valve 16 is stationary or is moved slowly the pressure of fuel moves the valve disk 102 to the position shown to uncover the ports 100.

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 disk 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 bell crank 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 52 further and increasing the richness of the mixture regardless of the 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, great changes in altitude bring in certain additional factors for which it is desirable to correct the mixture ratio, and this is done by providing an auxiliary fuel supply which is controlled by barometrc pressure, supercharger inlet pressure, and pressure at the supercharger outlet. To this end, a fuel by-pass 120 controlled by a valve 122 is provided around the passage 30. A pair of diaphragms 124 is connected to the valve 122 to provide a leak-proof packing therefor and the valve is drilled at 126 to connect the outside surfaces of the diaphragms 124 to balance the pressure thereon. The valve 122 is connected to one end of a bell crank lever 128 whose other end is connected through a link 130 with one end of a lever 132, the opposite end of which is connected to a diaphragm 134. A casing 136 encloses the diaphragm 134 and is connected on one side to the air conduit 10 anterior to the supercharger 12 and on its other side through a conduit 137 to the manifold posterior to the supercharger. The casing 136 is closed by a diaphragm 138 and a spring 140 is provided to urge the diaphragm up in a direction to close the valve 122. The diaphragm 138 is exposed on one side to atmosphere and on its other side to the pressure in conduit 10 posterior to the throttle to modify the action of the diaphragm 134, the degree of modification being controlled by the relative sizes of the two diaphragms. To illustrate the function of the control just described, consider the case of an airplane rising at a uniform rate of speed from (Condition A) ground level where atmospheric pressure is 30″ of mercury to (Condition B) an altitude where atmospheric pressure is 21″ of mercury, the throttle being so manipulated during the climb that the pressure at the entrance of the supercharger is maintained at 20″ of mercury. At ground level the throttle will be partly closed, and let us say the pressure at the air horn 20 is 30″, at the supercharger inlet is 20″, and at the supercharger outlet is 27″. As altitude is gained, the pilot will gradually open the throttle in order to maintain the same pressure at the supercharger inlet, until Condition B is reached, where a barometric pressure of 21″ obtains at the air horn, and the throttle is practically wide open. If we assume for the present that the engine speed remains constant, the 27″ pressure will still obtain at the outlet of the supercharger. But because of the decreased pressure in the exhaust line at altitude and since the charge density is constant, the horsepower developed under Condition B will be higher. This increase in power output will cause the engine speed to increase, which in turn will cause the pressure at the supercharger outlet to increase. The conditions therefore obtained will be 20″ mercury at the supercharger inlet and, say, 28″ at the supercharger outlet. The increased horsepower output, coupled with the fact that the air is thinner, which decreases its cooling effect, tends to overheat the engine. To correct for this tendency, at Condition B, the increased supercharger rise acting on diaphragm 134 and the decreased atmosphere-to-supercharger inlet differential pressure acting on diaphragm 138 produce a combined effect to open valve 122 to provide an additional flow of fuel which enriches the mixture and thereby tends to cool the engine.

The operation of the apparatus thus far described is as follows.

Operation at sea level

In normal operation with the engine running and driving the pump 22 and supercharger 12, fuel is pumped into the chamber 28 past the valve 52 and through ports 29 and 30 into the chamber 44. Fuel flowing through the port 30 also passes through the openings 100 in piston 96 and through the pipe 32 to be sprayed into the manifold by the jet 34. Since the pressure variations in chamber 44 are maintained within narrow limits the pressure in chamber 28 will always be higher by an amount equal to the drop through orifice 29 and passage 10, excessive pressure in chamber 28 tending to close valve 52 and deficient pressure therein tending to open this valve. Thus the pressure differential acting on the diaphragm 46 is always a governing function of the flow through orifice 30 regardless of the discharge pressure, which may be high or low depending upon the setting of the jet 34.

Air flowing through the venturi 74 creates a depression at 76 which is transmitted through the passage 78 to the chamber 56. At the same time, due to the fact that the bellows 84 is contracted at sea level to open the valve 86, pressure of the incoming air will be communicated to the chamber 62 through the tubes 81, chamber 82 and passage 80. Thus there will be a pressure differential acting on the diaphragm 60 tending to open the valve 52 in a degree which is proportional to the rate of flow of air through the conduit 10 and venturi 74. Due to the relatively small size of the passage 88 it has substantially no effect when the valve 86 is open so the pressure relationship described is not materially affected by it.

With the system in equilibrium, the differential of pressure on the diaphragm 60, which is a function of the rate of air flow through the device, is balanced by the differential of pressure on the diaphragm 46, which is a function of the rate of fuel flow through the device. If now the pressure of fuel delivered by the pump 22 is increased, as by erratic operation of valve 42, the pressure in chamber 28 will increase, which will cause valve 52 to move toward closed position and restore the pressure in the chamber 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 depression at 76 and chamber 56, causing valve 52 to move toward closed position and slightly decreasing the pressures in chamber 44, tube 32 and at nozzle 36. Valve 34 adjusts itself to the decreased pressure by moving toward closed position, with the result that the rate of fuel discharge is decreased to compensate for the decreased rate of air flow which initiated the adjustment. If the operator moves the throttle toward open position, other factors being constant, the engine speed will increase, increasing the depression at venturi throat 76 and increasing the fuel flow accordingly. The device thus operates to provide the desired fuel-air ratio at sea level under widely differing conditions of fuel pressure, engine speed, and throttle opening.

Due to the fact that the bellows 84 is responsive to temperature changes, it will expand slightly at high temperatures moving the valve 86 to a position to restrict the passage 80 to an extent dependent upon the temperature. As the passage 80 is restricted the effect of the passage 88 becomes more important and tends to reduce the pressure in the chamber 62, thereby reducing the pressure differential across the diaphragm 60. Consequently the fuel flow will be slightly reduced to provide a leaner mixture as the air density decreases due to rise in temperature.

Idling

When the throttle valve 16 is moved to substantially closed position for idling, the air flow and consequently the suction in venturi 74 drops. As a consequence the pressure differential across diaphragm 60 drops and valve 52 moves toward its closed position under the influence of the decreased pressure differential across the diaphragm 60. At this time the effect of the spring 69 becomes important to urge the rod 50 to the right, thereby requiring a greater pressure differential across the diaphragm 46 to balance it. This results in increased fuel flow and a richer mixture for idling, but in order to insure better control, ease of adjustment and more accurate metering at the low pressures and low flow velocities involved during idling it has been found desirable to design the spring to give an excessively rich idle and then utilize the valve 90 connected to the throttle to be moved into the passage 30 when the throttle is closed to meter the fuel at this point. The valve 90 can be given any desired configuration to provide the desired rate of fuel flow at closed or substantially closed throttle. Of course, during normal operation the valve 90 occupies substantially the position shown and does not affect the fuel flow.

Operation of the economizer

When maximum possible power is required as in taking off or for emergency operation of other kinds the pilot opens the throttle to deliver mixture to the engine at high pressure. During this time it is desirable to increase the richness of the mixture considerably and for this purpose the diaphragm 134 will be depressed by the increased differential between the supercharger outlet and inlet pressures to open the valve 122. At this time the passage 120 conducts additional fuel around the passage 30 to increase the flow to the discharge jet 34 and increase the richness of the mixture. This emergency operation is ordinarily maintained for only a few minutes at a time to avoid overworking of and damage to the engine and as soon as the throttle is returned to cruising position the pressure on top of diaphragm 134 drops permitting it to rise under the influence of the spring 140 to again close the valve 122.

Operation of the plunger 104

When the engine is in operation and conditions are favorable, as when flying under good weather conditions and light load, the pilot may desire to reduce the richness of the mixture to conserve fuel. For this purpose he may operate the linkage 106 to move the plunger 104 more or less into the passage 30 to restrict the same. The rate of fuel flow is thereby restricted to lean the mixture.

Some operators desire to be able to regulate richness of the mixture during emergency operation when the valve 122 is open while others prefer that the richness of the mixture at this time shall be automatically regulated independently 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 combined area of passage 120 and passage 30 with plunger 104 in the lean position is greater than that of orifice 29, orifice 29 functions as the primary restriction to fuel flow at full power, operation of the plunger 104 then having substantially 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 120 and 30, fuel flow is metered by these two passages and the pilot, through plunger 104, may control the mixture both during normal and emergency operation.

Operation at higher altitudes

As the craft rises the atmospheric pressure drops and the bellows 84 expands, moving valve 86 toward its closed position. This restricts passage 80 and tends to cause equalization of pressure between chambers 56 and 62 due to the passage 88 so that the valve 52 will be moved toward its closed position to lean the mixture. It will be noted that the effective cross-sectional area of passage 80 as limited by valve 86 is varied in accordance with changes either in the temperature or pressure of the air acting on the bellows 84. In case a supercharger is used to supply air to the conduit 10 the bellows 84 is responsive to supercharger pressure and maintains the mixture at the correct value.

Figure 2 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.

Figure 3 illustrates the application of a modified economizer control to the fuel feeding apparatus of Figure 1. In this form the passages 78 and 80 are connected by a calibrated passage 88, as in Figure 1, and by a second passage 160 controlled by a valve 162. The valve 162 is connected directly to the control diaphragm 134 and normally occupies a position in which the passage 160 is open. A calibrated restriction is preferably placed in the passage 78 between the passages 88 and 160. During periods of normal operation air is bled from passage 80 through passage 160 and reduces the suction in chamber 56 to a valve below that at the venturi 76. When the supercharger pressure rises, the increased pressure on top of the diaphragm 134 closes the valve 162 eliminating the bleeding action of port 160 and causing the suction in chamber 56 to increase thereby to open the main fuel valve further and increase the richness of the mixture. Air bled through passage 88 will vary the pressure in chamber 62 at such times as valve 86 restricts the passage 80 in response to changes in altitude, as has been previously described in connection with Figure 1. Thus the altitude control is primarily accomplished by bleeding air through passage 88 to modify the pressure in chamber 62 and the economizer control is primarily accomplished by bleeding air through passage 160 to modify the pressure in chamber 56. It will be apparent that each bleed has some effect upon the pressure in the other chamber, the amount thereof being dependent on the relative sizes of the passages, bleeds, and restriction.

It will be understood that, if desired, the altimeter valve could be used to control the passage 78 instead of the passage 80 or that the altimeter and economizer valves could be reversed. 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.

I claim:

1. A device for supplying fuel mixture to an engine comprising an air passage, a source of fuel under pressure, a connection from said source to the air passage, means responsive to pressures varying as a function of the rate of air flow through said passage to control said connection, and means responsive to variations in the density of air supplied to the engine for modifying said control.

2. A device for supplying fuel to an engine comprising a fuel pump, a connection for conducting fuel from said pump to the engine, a fixed metering orifice in said connection, and regulating means for regulating the pressure of fuel at the anterior side of said orifice, said regulating means including a fuel control element and balanced means for operating said element in accordance with the fuel pressures on opposite sides of said orifice and a force varying in accordance with variations in the rate of air flow to the engine.

3. A device for supplying fuel to an engine comprising an air passage, means to supply fuel under pressure, a connection from said means to the air passage, means responsive to pressures dependent upon the rate of air flow through said passage to control said connection, a valve in said connection, and a diaphragm connected to said valve and subjected on one side to fuel pressure in said connection and on its other side to a substantially constant force thereby to maintain a substantially constant discharge pressure regardless of pressure fluctuations in the air passage.

4. A device for supplying fuel to an engine comprising an air conduit, a pump for supplying fuel to the engine, and means for controlling the fuel supply including a valve, means responsive to pressures varying in accordance with the rate of fuel flow for controlling said valve, means responsive to pressures varying in accordance with the rate of air flow to the engine for controlling said valve, and means responsive to the density of air supplied to the engine for modifying the effect of said controlling means.

5. A device for supplying fuel to an engine comprising an air conduit, a fuel conduit discharging in said air conduit, a pump supplying fuel to said fuel conduit, and means for controlling the fuel conduit including a valve therein, a fixed fuel orifice in the fuel conduit posterior to the valve, a diaphragm responsive to fuel pressures on opposite sides of said orifice and connected to said valve, and means responsive to

pressures dependent in degree upon the rate of air flow to the engine connected to said valve to urge it open as the air flow increases.

6. A device for supplying fuel to an engine comprising an air conduit, a fuel pump, a connection from said pump to the conduit, a valve in said connection, and a pair of diaphragms connected to said valve, one of said diaphragms being subject on opposite sides to pressures existing at spaced points in said connection posterior to said valve and the other being subject to a pressure variable with changes in the rate of air flow through said air conduit.

7. A device for supplying fuel to an engine comprising an air conduit, a fuel pump, a connection from said pump to the conduit, a valve in said connection, and a pair of diaphragms connected to said valve, one of said diaphragms being subject on opposite sides to the pressure at different points in said connection posterior to said valve, a venturi in said conduit, and a connection from said venturi to the other of said diaphragms whereby it exerts on the valve a force which is a function of the rate of air flow.

8. A device for supplying fuel to an engine comprising an air conduit, a venturi therein, a fuel pump, a connection from said pump to the air conduit, a valve and a metering orifice in said connection, a pair of spaced diaphragms connected to said valve, the opposite sides of one of said diaphragms being connected to said connection on opposite sides of said orifice, connections from opposite sides of said other diaphragm to said air conduit and venturi respectively, and means for modifying the pressures applied to said other diaphragm in response to variations in altitude.

9. A device for supplying fuel to an engine comprising an air conduit, a venturi therein, a fuel pump, a connection from said pump to the air conduit, a valve and a metering orifice in said connection, a pair of spaced diaphragms connected to said valve, the opposite sides of one of said diaphragms being connected to said connection on opposite sides of said orifice, and connections from opposite sides of said other diaphragm to said air conduit and venturi respectively, and means responsive to air density controlling one of said last named connections.

10. A device for controlling the supply of fuel to an engine comprising an air conduit, a venturi therein, a fuel pump, a connection from said pump for supplying fuel to the engine, a valve and a metering orifice in said connection, a pair of spaced diaphragms connected to said valve, the opposite sides of one of said diaphragms being connected to said connection on opposite sides of said orifice, and connections from opposite sides of said other diaphragm to said air conduit and venturi respectively, a restricted passage between said last named connections, and means responsive to air density controlling one of said last named connections.

11. A device for supplying fuel to an engine comprising an air conduit, a venturi therein, a fuel pump, a connection from said pump to the air conduit, a valve in said connection, a diaphragm connected to said valve to operate it, connections transmitting pressure from said air conduit and venturi respectively to the opposite sides of said diaphragm, and a pressure responsive variable restriction immediately adjacent the outlet of said connection.

12. A device for controlling the supply of fuel to an engine comprising an air conduit, a venturi therein, a fuel pump, a connection from said pump for supplying fuel to the engine, a valve controlling said connection, a diaphragm connected to said valve to operate it, connections from opposite sides of said diaphragm to said air pressure transmitting conduit and venturi respectively, and means responsive to air density controlling one of said pressure transmitting connections.

13. A device for supplying fuel to an engine comprising an air conduit having a throttle valve therein, a venturi in said conduit anterior to the throttle, a fuel pump connected to said conduit posterior to the throttle to supply fuel thereto, a valve to control the supply of fuel, a flexible element connected to said valve to control it, and connections from said element to said venturi and to the conduit anterior to the throttle whereby it is responsive to the flow of air through said conduit.

14. A device for supplying fuel to an engine comprising an air conduit having a throttle valve therein, a venturi in said conduit anterior to the throttle, a fuel pump connected to said conduit posterior to the throttle to supply fuel thereto, a valve to control the supply of fuel, diaphragm means connected to said valve to control it, and connections from said diaphragm means to said venturi and to the conduit anterior to the throttle whereby it is responsive to the flow of air through said conduit, and valve means responsive to the air density in said conduit to control one of said connections.

15. A device for supplying fuel to an engine comprising a fuel pump, a connection from said pump to the engine to supply fuel thereto, a conduit for supplying air to the engine, regulating means responsive to pressures dependent in degree upon the rate of air flow through said conduit to control the supply of fuel by said connection, and means responsive to variations in the density of the air supplied to the engine to modify the control effected by said regulating means.

16. A device for supplying fuel to an engine comprising a fuel pump, a connection from said pump to the engine to supply fuel thereto, a conduit for supplying air to the engine, regulating means responsive to pressures varying as a function of the rate of air flow through said conduit to control the supply of fuel by said connection, passages for conducting a pressure medium to said regulating means to operate it, and valve means responsive to variations in the density of the air supplied to the engine to control one of said passages.

17. A device for supplying fuel to an engine comprising a fuel pump, a connection from said pump to the engine to supply fuel thereto, a conduit for supplying air to the engine, regulating means responsive to pressures dependent in degree upon the rate of air flow through said conduit to control the supply of fuel by said connection, a valve in said connection, and means responsive to variations in the pressure of the air in said conduit for controlling said valve.

18. A device for supplying fuel to an engine comprising an induction passage, a fuel pump, a connection from said pump to the induction passage to supply fuel thereto under pressure, regulating means responsive to the pressures variable in accordance with changes in the rate of air flow through said induction passage to control the supply of fuel by said connection, a throttle valve to control the induction passage, a cylinder

in said connection, a piston in said cylinder connected to the throttle valve, and a check valve in said piston whereby said piston and cylinder operate as a pump to increase the supply of fuel to the engine when the throttle valve is opened.

19. A device for supplying fuel to an engine comprising a fuel pump, a connection from said pump to the engine to supply fuel thereto, regulating means responsive to pressures varying as a function of the rate of flow of air to the engine to control the supply of fuel by said connection, a throttle valve to control the supply of air to the engine, a cylinder in said connection, a piston in said cylinder connected to the throttle valve, and a check valve in said piston whereby said piston and cylinder operate as a pump to increase the supply of fuel to the engine when the throttle valve is opened, and a valve connected to said piston to control the supply of fuel through said connection.

20. A device for supplying fuel to an engine comprising a fuel pump, a connection from said pump to the engine to supply fuel thereto, regulating means responsive to pressures varying as a function of the rate of flow of air to the engine to control the supply of fuel by said connection, passages for conducting a pressure medium to said regulating means to operate it, a manual valve operable at will to control one of said passages, a second valve controlling a bypass around said manual valve, and means responsive to the density of an air charge entering the engine to control said second valve.

21. A device for supplying fuel to an engine comprising a fuel pump, a connection from said pump to the engine to supply fuel thereto, regulating means responsive to pressures dependent upon the rate of flow of air to the engine to control the supply of fuel by said connection, passages for conducting a pressure medium to said regulating means to operate it, a valve controlling one of said passages, a valve controlling the supply of fuel through said connection, and operating linkage for both of said valves and having a lost motion connection with one of them.

22. In a device for supplying fuel to an engine having a fuel pump, regulating means for controlling the rate of fuel supply to the engine by said pump comprising a diaphragm having an annular groove formed therein, a rod connecting said diaphragm to a control element, an enlarged cylindrical member secured to said rod and lying against one face of the diaphragm in a position to be encircled by said groove, and a support for said diaphragm having a circular portion encircling and lying against the outside of said groove, whereby said diaphragm will be supported by said member and said portion to keep the bottom of said groove on a substantially constant radius of curvature.

23. In a charge forming device for an internal combustion engine, an air passage, a source of fuel under positive pressure, a connection from said source to said air passage, means responsive jointly to pressures varying as a function of rate of air flow through the air passage and to pressures varying as a function of the rate of fuel flow to control said connection, and means responsive to the fuel pressure adjacent the outlet of said connection to control said outlet.

24. In a charge forming device for an internal combustion engine, an air passage having a venturi therein, a source of fuel under positive pressure, a fuel conduit leading from said source for supplying fuel to the engine and provided with a calibrated restriction, means responsive to the pressure at the venturi and to the pressure drop across said restriction for controlling said fuel conduit at a point anterior to said restriction.

25. A device for supplying fuel mixture to an engine comprising an induction passage, a throttle controlling said induction passage, a fuel pump, a connection from said pump to the induction passage posterior to the throttle to supply fuel thereto, regulating means responsive to pressures dependent in degree upon the quantity of air flow through said induction passage to control the supply of fuel by said connection, passages for conducting a pressure medium from the induction passage anterior to the throttle to said regulating means to operate it, and a valve manually operable independently of the position of said throttle to control one of said passages.

26. In a device for supplying fuel mixture to an internal combustion engine, an induction passage, a fuel pump, a connection from the fuel pump to the induction passage, and means responsive to pressures varying as a function of the rate of air flow through the passage for regulating said connection, said pressure responsive means including a valve and a sealed bellows connected thereto, said bellows being responsive both to temperature and to barometric pressure to modify the control effected by said pressure responsive means.

27. A device for supplying fuel to an engine comprising an air conduit having a throttle valve therein, a venturi in the conduit anterior to the throttle, a connection from a source of fuel to the air conduit, a valve in the connection, means responsive to venturi pressure and to pressure in the air conduit anterior to the throttle for controlling said valve, and means responsive to variations in air pressure in the conduit for modifying said control.

28. In a pressure carburetor adapted to receive fuel from a fuel source, an induction passage having an air inlet, a throttle for controlling the passage, a venturi in the passage anterior to the throttle, unmetered and metered fuel chambers, a connection from the metered fuel chamber to the induction passage posterior to the throttle, means to meter the fuel from the unmetered to the metered fuel chambers in accordance with the pressure difference between the air inlet pressure and the venturi pressure, and means responsive to variations in air density for modifying the quantity of fuel so metered.

29. A charge forming device comprising an induction passage, a fuel conduit discharging in said induction passage, means for supplying fuel under pressure to said fuel conduit, valve means controlling the admission of said fuel to the fuel conduit, means responsive to pressures varying as the rate of air flow through said induction passage for controlling said valve means, and means responsive to a source of substantially atmospheric pressure influencing the application of one of said pressures to said pressure responsive means.

30. In a device for supplying fuel to an engine having a fuel pump, a cylindrical chamber, a diaphragm closing an end of said chamber and adapted to control a function of the device in response to variations in pressures on opposite sides thereof, an annular groove formed in the diaphragm and having its outer diameter substantially conforming to the diameter of the chamber, and a cylindrical cup-shaped member having an external diameter substantially conforming to the

inner diameter of the groove and having its base secured to the diaphragm, whereby said diaphragm will be supported by said member to maintain the bottom of the groove on a substantially constant radius of curvature.

31. A device for supplying fuel to an engine comprising a fuel pump, means for conducting fuel from the pump to the engine including a fuel passage, a poppet type valve controlling said passage, a diaphragm subjected on opposite sides to the pressures anterior and posterior to said valve and connected to the valve for balancing out the unbalance across the valve, and control means for said valve including a pair of diaphragms responsive to pressures varying in accordance with variations in the rates of air and fuel flow to the engine.

32. The invention defined in claim 31 comprising in addition a counterweight associated with the valve for balancing the inertia effects thereon.

33. A device for supplying fuel to an engine comprising an air passage, a throttle and a venturi anterior thereto in the passage, a source of fuel, a conduit connecting said source and the passage, area restricting means in said conduit, a valve in said conduit of a type having an unbalanced force created thereon by the differential in pressure thereacross, a diaphragm connected to said valve and subjected to said differential in pressure for balancing said valve, and a plurality of diaphragms connected to said valve and subjected to the pressures at the venturi and in the conduit anterior and posterior to said area restricting means.

34. The invention defined in claim 33 comprising in addition a counterweight associated with said valve for balancing the inertia effects thereon.

35. A device for supplying fuel to an engine comprising an air conduit, a venturi therein, a fuel pump, a connection from said pump to the air conduit, a valve controlling the flow through the connection, a metering orifice in said connection, means responsive to the drop in pressure across said orifice and to the pressure at said venturi for controlling said valve, and a counterweight associated with said valve for balancing inertia effects thereon.

36. A charge forming device for an internal combustion engine having a throttle controlled induction passage, a venturi in said passage anterior to the throttle, a second venturi in the passage extending into the first venturi, a connection from a source of fuel to the engine to supply fuel thereto, regulating means responsive to the pressure at the second venturi to control the quantity of fuel supplied to the engine, and means responsive to variations in the density of the air supplied to the engine for modifying the quantity of fuel supplied to the engine by the regulating means.

37. A device for supplying fuel to an engine comprising an air conduit, primary and secondary venturis in said conduit, a fuel source for supplying fuel to the engine, and means for controlling the fuel supply including a control element, means responsive to pressures varying in accordance with the rate of fuel flow for controlling said element, means responsive to the pressure at the primary venturi for controlling said element, and means responsive to the density of air supplied to the engine for modifying the control effected by said controlling means.

38. In a charge forming device for an internal combustion engine, a throttle controlled air passage, primary and secondary venturis in said passage anterior to the throttle, a source of fuel, a connection from said source for supplying fuel to the engine, a metering element in said connection, a valve for varying the quantity of fuel flowing through said connection, and a pair of diaphragms subjected to the pressure in the connection on opposite sides of the metering element and to the pressure at said primary venturi for controlling said valve.

39. A charge forming device for an internal combustion engine comprising an air passage having a throttle valve therein, a primary venturi and a secondary venturi in said passage anterior to the throttle, a fuel conduit leading from a source to the passage posterior to the throttle to supply fuel thereto, a valve to control the supply of fuel, and a flexible element responsive to pressures at said primary venturi and in the passage anterior to the throttle for controlling said valve.

40. Invention defined in claim 39 comprising in addition means responsive to variations in barometric pressure for influencing the application of one of said pressures to the flexible element.

41. A device for supplying fuel to an engine comprising an air passage, a fuel pump, and regulating means for controlling the fuel supplied to the engine by said pump comprising a pair of diaphragms having annular grooves formed therein, means connecting said diaphragms to a control element including structure supporting the central portions of said diaphragms and closely encircled by said grooves whereby the effective areas of the diaphragms will be substantially unaffected by displacement of the control element, and means for subjecting the faces of said diaphragms to pressures dependent in degree upon the rates of air flow and fuel flow to the engine.

42. A charge forming device for an internal combustion engine comprising a throttle controlled air passage, primary and secondary venturis in said passage anterior to the throttle, a fuel conduit leading from a source to said passage, a metering element in said conduit, a valve for controlling the flow through said conduit, a pair of air chambers separated by a diaphragm having an annular groove formed therein, a pair of fuel chambers separated by a diaphragm having an annular groove formed therein, structure supporting the central portions of said diaphragms and encircled by said grooves, means connecting said diaphragms to the valve, means connecting the air chambers to the primary venturi and air passage, and means connecting the fuel chambers to the conduit anterior and posterior to the metering element.

43. A device for supplying fuel to an engine comprising a fuel pump, regulating means for controlling the rate of fuel supplied to the engine by said pump comprising a control element, at least one relatively large actuating diaphragm connected to said element, means for subjecting said diaphragm to a pressure variable in response to variations in the air flow to the engine for controlling said element, at least one relatively small sealing diaphragm connected to said element, said sealing diaphragm having an annular groove formed therein, and structure supporting the central portion of said sealing diaphragm and encircled by the groove whereby the effective area of the sealing diaphragm will remain substantially constant upon displacement of said control element.

44. In a device for supplying fuel to an engine having a fuel pump, regulating means for controlling the rate of fuel supply to the engine by said pump in accordance with pressures varying in accordance with variations in the air flow to the engine, a small sealing diaphragm forming a portion of said means and having an annular groove preformed therein, means connecting said diaphragm to a control element and including a cylindrical member lying against one face of the diaphragm in a position to be encircled by said groove, and a support for said diaphragm having a circular portion encircling and lying against the outside of said groove, whereby said diaphragm will be supported by said member and said portion to maintain the effective area of the diaphragm substantially constant upon displacement of the control element.

45. A charge forming device comprising an induction passage, a fuel conduit receiving fuel from a source and discharging in the passage, a metering element in said conduit, valve means controlling the flow through said conduit, means responsive to pressures varying with variation in the rate of air flow through said passage and to pressures in the conduit anterior and posterior to said element for controlling said valve means, means for modifying the application of at least one of said pressures to said pressure responsive means, means for modifying the effective area of said metering element, manual means for actuating one of said modifying means, and automatic means for actuating the other of said modifying means.

46. The invention defined in claim 45 wherein the said automatic means comprises a sealed capsule responsive to variations in pressure in the induction passage.

47. A method of proportioning the fuel and air supplied to an internal combustion engine having an air passage for supplying air thereto and a fuel passage for supplying fuel thereto, comprising supplying fuel to the fuel passage under pressure, utilizing pressures dependent in degree upon the rate of air flow through the air passage for controlling the fuel flow through the fuel passage, and utilizing variations in the density of the air supplied to the engine for modifying the control effected by said pressures.

48. A method of supplying fuel to an internal combustion engine having a manually throttled passage for supplying air to the engine and a conduit for supplying fuel to the engine, which comprises supplying fuel to the conduit under superatmospheric pressure, metering the fuel while maintaining it under superatmospheric pressure, utilizing pressures in the passage anterior to the point of throttling which vary in accordance with the rate of air flow therethrough and pressures varying with the rate of fuel flow through the conduit for controlling the fuel flow through the conduit, and utilizing variations in pressures accompanying variations in altitude for modifying the said control.

49. A method of supplying fuel mixture to an internal combustion engine having an air passage and a fuel passage discharging thereinto which comprises supplying fuel to the fuel passage under pressure, throttling the air passage at a point anterior to the point of introduction of fuel, utilizing pressures varying in accordance with the rate of flow in the air passage anterior to the point of throttling for controlling the fuel flow through the fuel passage, utilizing pressures varying in accordance with the rate of fuel flow through the fuel passage for modifying the said control, and utilizing variations in the pressure of the air in the air passage resulting from changes in altitude for further modifying the said control.

50. A device for supplying fuel to an engine comprising an air supply passage, a throttle for controlling the supply of air, a fuel pump, a connection for supplying fuel from the pump to the engine, a valve for varying the fuel supplied through the connection, means for urging said valve in a direction to decrease the fuel supply with a force which increases with increase in fuel flow to the engine, means for urging said valve in a direction to increase the fuel supply with a force which increases with increase in air flow to the engine, whereby substantially constant fuel to air proportioning is maintained, and means for modifying one of said forces under certain conditions of engine operation for varying the proportions of fuel and air supplied to the engine.

51. A device for supplying fuel to an engine comprising an air conduit, a venturi therein, a fuel pump, a connection from said pump to the air conduit, a valve in said connection, a metering restriction in the connection, diaphragms connected to said valve to operate it, means for transmitting air pressure from the venturi to one of said diaphragms, said pressure acting in a direction to close the valve, means for transmitting fuel pressure from the connection anterior to the metering restriction to one of said diaphragms, said fuel pressure tending to close the valve, and a valve in the connection posterior to the metering restriction and responsive to the pressure of the fuel in the connection posterior to the metering element.

52. In a fuel control system for an internal combustion engine having an air supply duct, a throttle in the duct, air metering means in the air duct for creating a differential of pressures at spaced points in the duct, a fuel conduit for supplying fuel to the engine, fuel-metering means in the conduit for creating a differential of pressures at spaced points in the fuel conduit, a pair of air chambers, a pair of fuel chambers, movable walls in each of said chambers, means controlled by said walls for controlling the flow of fuel to the engine, air passages connecting the air chambers respectively with the said spaced points in the air duct, an air passage interconnecting the air chambers, means responsive to variations in pressure for controlling the relative flow capacities of said air passages, and means communicating the fuel chambers with the fuel conduit at said spaced points.

FRANK C. MOCK.

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The following references are of record in the file of this patent:

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Certificate of Correction

Patent No. 2,447,261. August 17, 1948.

FRANK C. MOCK

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 4, line 32, for "protions" read *portions*; column 9, line 66, for "valve" read *value*; column 12, line 6, after the word "air" strike out "pressure transmitting" and insert the same in line 4, same column, after the word and comma "it,"; column 18, line 40, for "element" read *restriction*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of December, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.