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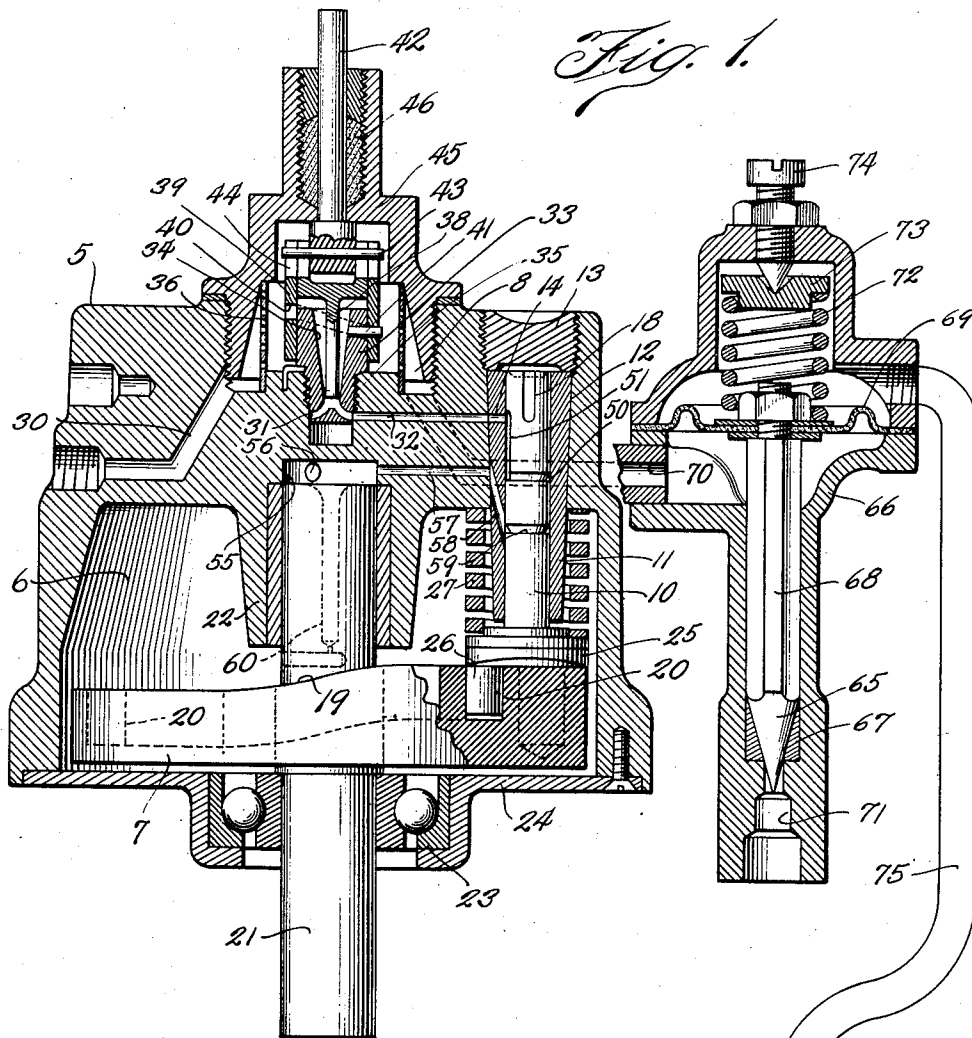
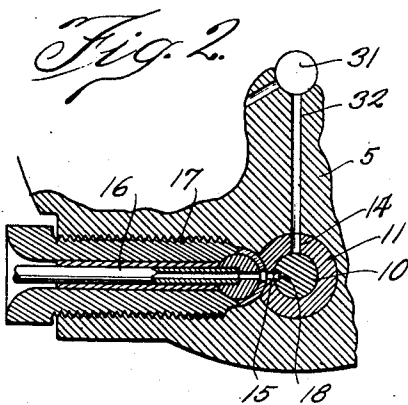
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FUEL PUMP

Filed July 11, 1936

2 Sheets-Sheet 1



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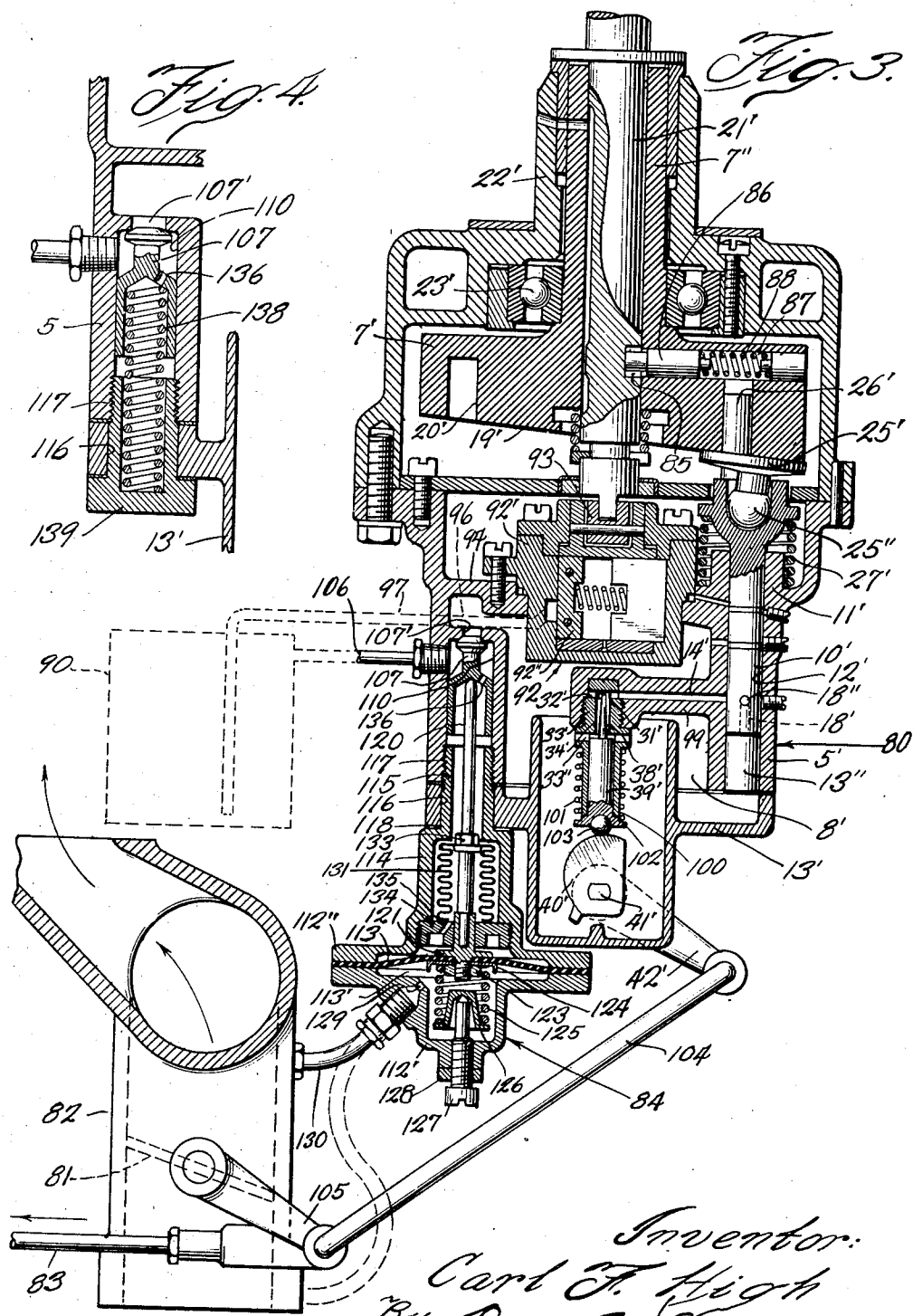
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UNITED STATES PATENT OFFICE

2,146,184

FUEL PUMP

Carl F. High, Flint, Mich.

Application July 11, 1936, Serial No. 90,056

7 Claims. (Cl. 123—139)

The invention relates generally to a fuel injection pump for internal combustion engines, the pump being of the type disclosed in my copending application Serial No. 654,275, filed January 10, 1933, of which this application is a continuation in part.

In the use of fuel injection pumps of this character, the fuel discharge is, of course, varied as to quantity in accordance with the desired engine speed, and a corresponding or correlated variation in the air supply is essential throughout the range of speed variation of the engine. Thus in some installations an interconnected manual actuating means is provided for varying the fuel pump output and the effective air intake opening in a predetermined relation throughout the range of engine speeds so as to produce the most efficient mixture at all speeds. It is found, however, that in some installations such, for example, as the installation on an aircraft engine, the pressure variations due to changes in altitude, or in some instances to the action of a supercharger, result in a disruption in the ultimate fuel-air ratio with a consequent inefficient performance of the engine.

An important object, therefore, of the present invention is to provide a new and improved fuel pump construction wherein the manually controlled means for coordinately varying the fuel volume and the air inlet to vary the engine speed have in combination therewith pressure responsive means operable to maintain the desired fuel-air ratio as variations in air pressure or altitude become effective upon the engine.

A further object is to provide a fuel pump having such a pressure responsive fuel-air control means which operates with equal facility in response to normal altitude variations or in response to the pressure variations which are created in the air intake manifold when a supercharger is employed.

Another object of the invention is to provide a suction-metered, fuel injection pump having a manual control for varying the quantity of fuel discharged acting in conjunction with an automatic control regulating the pressure on the fuel supplied to the pump in accordance with the pressure effective in the intake manifold of the engine with which the pump is associated.

More particularly stated, it is an object of the invention to provide a fuel injection pump having a plurality of pumping elements, a distributing chamber supplied with fuel under pressure, a manually actuated metering valve for controlling the quantity of fuel supplied the pumping

elements, and a valve controlling the discharge of excess fuel from the distributing chamber responsive to the pressure of the fuel in the chamber and to the intake manifold of the engine being supplied with fuel, to vary the pressure on the fuel in the distributing chamber in accordance with the pressure in the intake manifold of the engine.

Another object is to provide a fuel injection pump so constructed that it may be readily assembled to provide for use at a substantially constant altitude or to provide for automatic compensation for altitude or pressure variation.

Other objects and advantages will be readily apparent from the following description, taken in connection with the accompanying drawings, in which:

Fig. 1 is a diametrical sectional view of a fuel pumping mechanism embodying the features of the invention.

Fig. 2 is a fragmentary transverse section through one of the pumping elements showing the inlet and exhaust ports thereof.

Fig. 3 is a central sectional view of an alternative embodiment of the invention.

Fig. 4 is a fragmental sectional view illustrating an alternate manner of assembly of the pump of Fig. 3 adapting the same for use at a constant altitude.

While I have shown in the accompanying drawings and will herein describe in detail the preferred embodiment of the invention, together with two alternative embodiments thereof, it is to be understood that this disclosure is given for the purpose of illustrating the invention and is not intended as a limitation of the invention to the constructions disclosed. In the appended claims, I aim to cover all modifications and alternative constructions falling within the scope of the invention.

In the form chosen for purposes of disclosure in Figs. 1 and 2 hereof, the invention is embodied in a pump comprising a cylindrical casing 5 having a plurality of individual pumping units concentrically arranged about the axis of the casing. In its lower portion the casing is formed with a large recess 6 housing a plate 7 for actuating the pumping units. In its upper portion, the casing is formed with a small recess 8 constituting a distributing chamber from which fuel is supplied to the various pumping units.

In the present instance, each pumping unit comprises a piston 10 longitudinally reciprocable and oscillatable in a cylindrical sleeve 11 received in a vertical bore 12 formed in the housing

5 and closed at its upper end by a plug 13. Spaced downwardly a short distance from the plug, the sleeve 11 is formed with a radial inlet duct 14 and spaced approximately 90° therefrom is an outlet duct 15, as best seen in Fig. 2. The outlet duct 15 communicates with a conduit 16 leading to the engine with which the pump is associated, the conduit being retained in the casing 5 by means of a plug 17 threaded into a bore formed in the casing. The piston 10 in turn is formed with a longitudinal groove 18 extending to the end of the piston, alternately to provide communication between the space above the piston and the inlet duct and between the space above the piston and the outlet duct, as the piston is reciprocated and oscillated.

The pistons of the pumping units are reciprocated and oscillated by means of the plate 7 formed on its upper surface with a cam 19 and with a cam groove 20. The plate 7 is fixed on a vertically disposed shaft 21 rotatably journaled at its inner end in a bearing formed by a depending annular flange 22 of the casing and journaled at its outer end in a ball bearing 23 retained in a plate 24 closing the recess 6. Beneath the flanged lower end of each piston 10 is a shoe 25 rounded slightly at the edges of its lower face and slidable on the cam surface 19 of the plate 7 to reciprocate the piston upon rotation of the plate, and rigid with the flange of the piston and projecting through a suitable radial slot in the shoe 25 into the cam groove 20 is a finger 26 by means of which the piston is oscillated. The cam groove 20 and the cam 19 are so shaped that the longitudinal groove 18 formed in the piston 10 registers with the inlet duct 14 during a down stroke of the piston and is then oscillated through 90° to register with the outlet duct 15 during the up or working stroke of the piston. A compression spring 27 surrounding the sleeve 11 bears at one end against the casing 5 and at the other end against the shoe 25 to retain the shoe in contact with the cam 19 and to effect a return stroke of the piston.

Fuel is supplied to the recess 8 through a duct 30 in the casing communicating with a source of fuel under pressure, not shown. At its bottom, the recess 8 is formed with a bore 31 from which ducts 32 radiate to communicate with the inlet ducts 14 in the sleeves of the various pumping units. Threaded into the bore 31 is a plug 33 formed with an inverted conical passage 34 communicating at its upper end with the recess 8 and at its lower end with radial passages 35 registering with the radiating ducts 32. A screen 36 preferably is interposed between the duct 30 and the passage 34 to prevent foreign matter in the fuel from reaching the pumping units.

The quantity of fuel supplied to the pumping units is controlled by a manually actuated metering pin 38 disposed in the conical passage 34. The metering pin 38 is supported on a sleeve 39 rotatably and slidably mounted on the projecting cylindrical portion of the plug 33. To impart precise longitudinal movement to the pin for varying the quantity of fuel metered thereby, the sleeve 39 is formed with a helical cam groove 40 and the plug 33 is provided with a pin 41 projecting laterally into the groove. Rotational movement is imparted to the sleeve 39 by a manually actuated operating shaft 42 carrying a pin 43 engaging slots 44 formed in the sleeve to permit relative longitudinal movement between the shaft and the sleeve, but to prevent relative rotational movement. A cap 45 threaded into the

recess 8 encases the metering mechanism and completes the fuel distributing chamber. Suitable packing 46 prevents leakage of fuel along the shaft 42.

Means is provided herein for arresting fuel leaking along the piston 10 and for returning the same to the distributing chamber. To that end each piston is formed with a circumferential groove 50 and with a longitudinally extending groove 51 communicating at one end with the circumferential groove 50 and adapted to register with the inlet duct 14 near the completion of the up stroke of the piston. In this manner fuel leaking along the piston is collected in the groove 50 and then discharged to the distributing chamber upon the up stroke of the piston.

Provision is also made for lubricating the pistons and the friction surfaces of the plate for reciprocating and oscillating the pistons. To that end there is formed in the housing above the shaft 21 a chamber 55 supplied with lubricant through a duct 56. Leading from the chamber 55 to each of the sleeves 11 is a duct 57 communicating with an oblique passage 58 formed in the sleeve. To distribute the lubricant, each piston 10 is formed with a second circumferential groove 59 which in the reciprocation of the piston spreads the lubricant over the inner wall of the sleeve. To supply lubricant to the cam 19 and the cam groove 20, the shaft 21 is formed with a restricted passage 60 communicating with the chamber 55 and the recess 6 permitting the flow of a limited amount of lubricant.

As illustrated in Fig. 1 of the drawings, means is provided herein for automatically and additionally controlling the quantity of fuel supplied to the pumping units in proportion to the air pressure effective upon the engine, the particular embodiment of Fig. 1 being such as to be actuated by the pressure within the intake manifold of the engine. This means when used with aircraft engines is in the nature of an altitude control. The control means employed in the form shown functions to vary the quantity of fuel metered by controlling the quantity of excess fuel returned to the fuel reservoir from the distributing chamber, thereby to vary the pressure on the fuel in the distributing chamber. To that end there is interposed in a by-pass conduit leading from the distributing chamber to the fuel reservoir (not shown) a valve 65 herein shown housed in a separate casing 66 providing a valve seat 67. As seen in Fig. 1, the valve stem 68 is attached to a diaphragm 69 secured between and dividing the casing into an upper and lower portion. The lower portion of the casing 66 communicates with the distributing chamber through a duct 70 and discharges to the fuel reservoir through a passage controlled by the valve 65 and terminating in an outlet 71 adapted to receive a conduit, not shown. The diaphragm 69 is thus exposed to the fuel passing through the valve casing and is thereby made responsive to the pressure on the fuel in the distributing chamber, such pressure herein tending to open the valve 65. The valve is urged to closed position by means of a compression spring 72 bearing at one end against the diaphragm and at the other end against a plug 73. The plug in turn bears against a set screw 74 by means of which the tension of the spring may be adjusted.

In addition, the diaphragm 69 is exposed to the air pressures in the intake manifold of the engine with which the pump is associated, and to that end the upper portion of the casing 66 above

the diaphragm communicates through a conduit 75 with the intake manifold, a portion of which is shown at 76. The combined action of the pressure in the intake manifold and the spring 72 thus serves to counteract the pressure of the fuel on the diaphragm and by control of the valve 65 vary the pressure on the fuel in the distributing chamber. When the pressure in the intake manifold of the engine is low, the valve 65 is readily opened against the action of the spring 72 so that the pressure on the fuel in the distributing chamber is low. When the pressure in the intake manifold is high, the valve 65 is closed until pressure on the fuel in the distributing chamber is substantially higher, thereby forcing a larger quantity of fuel into the individual pumping units. It will be apparent that this control functions entirely automatically and independently of the metering valve so as to provide a combined manual and automatic control for the fuel, the automatic control being responsive in this embodiment to intake manifold pressures.

In the form illustrated in Fig. 3 of the drawings, the invention is embodied in a variable output fuel pump 80 of the general type illustrated in Fig. 1, but inverted as to position, the pump being operatively associated with the control valve 81 of a common air intake manifold 82 of an engine. Thus the fuel and air supply to the engine may be varied by a manually actuable accelerator connection 83 to govern the engine speed while maintaining the most efficient proportioning of fuel and air during such variation, and in connection with this manually controlled means there is provided a pressure responsive device 84 operable to maintain the desired proportioning of fuel and air as changes in altitude or air pressure become effective upon the engine.

The pump 80 has a cylindrical casing 5' having a plurality of individual pumping units concentrically arranged about the axis of the casing and actuated by a rotatable cam plate 7' housed in the upper portion of the casing. In its lower portion the casing is formed with a relatively large recess 8' constituting a fuel supply chamber from which fuel is supplied to the various pumping units. In the present instance, each pumping unit comprises a piston 10' longitudinally reciprocable and oscillatable in a cylinder formed by a vertical bore 12' formed in the casing 5' and closed at its lower end by a plug 13' held in place by a bottom plate 13'. Spaced upwardly from its closed lower end, each cylinder 12' has a radial inlet duct 14' and spaced approximately 90° therefrom is an outlet duct (not shown) located in the manner shown in Fig. 2, the outlet duct communicating with a suitable conduit (not shown) leading to the engine with which the pump is associated. The piston 10' in turn is formed with a central bore 18' extending to the lower end of the piston and having a lateral extension or port 18'' through the side of the piston 10', alternately to provide communication between the space beneath the piston and the inlet duct and between the space beneath the piston and the outlet duct as the piston is reciprocated and oscillated.

The pistons of the pumping units are reciprocated and oscillated by means of the plate 7' which is formed on its lower or adjacent face with a cam surface 19' and with a cam groove 20'. The plate 7' is adapted to be driven by a vertically disposed shaft 21' which extends ax-

ially into the upper end of the casing 5'. As shown, the plate 7' has an upstanding annular bearing sleeve 7'' journaled at its upper end in a bearing formed by an upstanding annular flange 22' of the casing and journaled downwardly thereof in a ball bearing 23' mounted in the casing just above the plate 7'. Above the upper end of each piston 10', and engaging the piston through a ball and socket joint 25'', is a shoe 25' slidable along the cam surface 19' of the plate 7' to reciprocate the piston upon rotation of the plate. Rigid with the piston and projecting through a radial slot in the flanged upper end of the shoe into the cam groove 20' is a finger 26' by means of which the piston is oscillated. The cam groove 20' and the cam 19' are so shaped that the port 18'' formed in the piston 10' registers with the inlet duct 14' during an upward or suction stroke of the piston and is then oscillated through 90° to register with the outlet duct during the downward or working stroke of the piston. A compression spring 27' surrounding an upwardly extending sleeve 11' bears at its lower end against the casing 5' and at its upper end against a shoulder on the piston 10' so as to maintain the desired relationship in a ball and socket connection 25'' between the piston and the shoe 25', maintain contact of the shoe 25' with the cam, and effect a return stroke of the piston.

The drive shaft 21' in Fig. 3 extends downwardly through the sleeve 7'' and the plate 7', and in order that the pump may not be damaged when back-fire of the engine causes reversal of the pump cycle, the plate 7' is arranged to be driven by the shaft only in a forward direction. Thus the shaft 21' has a single notch 85 therein arranged to be engaged by a radially movable plunger 86 which is mounted in a bore 87 in the plate and is normally urged inwardly to its active position by a spring 38. A suitable cam surface (not shown) merging with the notch 85 cams the plunger 86 to its retracted position upon reverse rotation of the shaft 21'. This safety latch mechanism is described in greater detail and is claimed in my copending application Serial No. 124,063, filed February 4, 1937.

In the form illustrated in Fig. 3, fuel is drawn from a fuel supply tank 90 and fed to the chamber 8' by a fuel feed pump 92 which is preferably mounted within the fuel pump housing 5' so as to be driven by the shaft 21' thereof. Thus the feed pump 92 has its casing 92' fixed axially of the casing 5' in alignment with the shaft 21' so that its rotor 92'' may be driven from the shaft 21' by a coupling 93. The casing 92' extends downwardly through the top wall 94 of the chamber 8' and has its outlet (not shown) discharging into the chamber 8', while its intake 96 is formed through an enlarged or thickened portion (not shown) of the wall 94 as a continuation of a pipe 97 leading from the fuel tank 90. The pump is of the well known vane type, the particulars of which form no part of this invention.

Beneath the pump 92 and in the supply chamber 8' a spider-like distributing member 99 is formed with a central distributing chamber 31' from which ducts 32' radiate to communicate with the inlet ducts 14' of the several pump cylinders. Threaded upwardly into the member 99 beneath the chamber 31' is a plug 33' formed with a vertical passage 34' communicating at its lower end with the supply chamber 8' and

at its upper end with the distributing chamber 31' so as to supply fuel to the radiating ducts 32'.

The quantity of fuel supplied to the pumping units is controlled by a manually actuated tapered metering pin 38' disposed in the passage 34'. The metering pin 38' is supported on a piston 39' slidable vertically within a sleeve-like downward extension 100 of the plug 33'. Above the piston 39' transverse ports 33'' in the plug 33' provide for communication between the passage 34' and the chamber 8'. To provide for longitudinal movement of the pin for varying the quantity of fuel metered thereby, a spring 101 surrounds the extension 100 and acts against a bottom flange 102 of the piston 39' to maintain bearing 103 on the piston in contact with an actuating control cam 40'. Preferably the cam 40' is carried within the casing 5' on a horizontal shaft 41' so that by rotation of the cam the valve 38' may be opened or closed as desired. On the projecting outer end of the shaft 41' an arm 42' is fixed, the arm 42' being connected by a link 104 to an actuating arm 105 of the air control valve 81. Thus when the arm 105 is actuated by the manually operable accelerator connection 83, the fuel metering pin and the air control valve 81 are opened or closed in unison.

In maintaining the most efficient quantity relationship between the fuel and air throughout the range of adjustment of the fuel and air valve means, the valves of the present embodiment are relatively simple in form and the requisite variation in relative movement of the several parts is obtained through the conformation of the effective cam surface of the cam 40' which is for this reason termed the "fuel-air cam" of the mechanism.

In modifying or correcting the action of the manually governed fuel and air control means thus provided so as to maintain the optimum fuel-air ratio despite changes in altitude or pressure, the pressure responsive device 84 is in the present instance arranged to obtain the desired result through a governing action on the fuel pressure within the supply chamber 8'. This is accomplished by so constructing the feed pump 92 as to feed fuel in excess of the requirements of the fuel pumping units 10'-12', and by providing a by-pass line 106 from the chamber 8' to the fuel tank 90 for the return of excess fuel under the control of a relief valve 107 governed by the pressure responsive device 84.

As shown in Fig. 3, the by-pass line 106 is connected to a valve chamber 110 formed by a vertical bore extending upwardly into the side wall of the casing 5', there being a valve port 107' axially located in the upper end of the bore and communicating with the chamber 8' so as to be adapted to be opened and closed by vertical movement of the valve 107 in its chamber 110. Thus the pressure of the fuel in the supply chamber 8' acts on the exposed upper end of the valve 107 with a tendency to unseat or open the same, this valve opening action being controlled by the pressure responsive device 84 which is located at the lower end of the casing 5' and is associated with the valve 107 in a governing relationship. In the form shown, the pressure responsive device 84 comprises a two-part body or housing having upper and lower sections 112'' and 112' between which is clamped a flexible diaphragm 113. On the upper section 112'' there is formed an upward cylindrical extension 114 terminating in a reduced screw thread upper end or nipple 115 adapted to project through an opening 116 in

the bottom plate 13' to engage threads 117 in the lower end of the bore 110. By this arrangement a shoulder 118 formed by the upper end of the extension 114 may be engaged with the bottom plate 13' to aid clamping the same in position.

To operate the valve 107 a central stem 120 bears at its upper end in a suitable seat on a lower face of the valve member, and at its lower end is attached centrally to the diaphragm 113. Such attachment is effected by a flanged head 121 fixed to the stem 120 and having a threaded nipple extending through a central opening in the diaphragm to receive a clamping and sealing nut 123.

Preferably a relatively large downwardly cupped washer 124 is interposed between the nut 123 and the diaphragm to receive and position the upper end of a spring 125 which at its lower end is positioned and guided by an upwardly extending guide 126. Through the lower housing section 112' a vertically positioned adjusting screw 127, carrying a lock nut 128, extends into engagement with the guide 126 for varying the upward, valve-closing force of the spring 125.

Thus there is formed beneath the diaphragm 113 a barometric chamber 113' which through a port 129 may be subjected to the variable air pressure which is to govern the fuel feeding action of the pump 80. If desired, this port 129 may merely be left open to atmosphere, or connected to the air intake manifold 82 anterior to the control valve 81 as shown in dotted outline in Fig. 3, or it may be connected to the air intake manifold posterior to the control valve 81 by a pipe 130 so as to be sensitive to the air pressure as modified by the action of a supercharger.

To render the diaphragm unusually sensitive to pressure variations in the barometric chamber 113', the present device is so constructed as to protect the upper face of the diaphragm against correspondingly varying forces which would tend to offset and nullify the desired controlling action of the pressure variations in the chamber 113'. To this end there is provided between the stem 120 and the casing section 112'' a sealing means which permits substantially free axial movement of the stem while providing an upwardly facing pressure sensitive area substantially less than the area of the diaphragm 113.

Thus a siphon bellows 131 surrounds the stem 120 above the diaphragm and within the cylindrical extension 114, the closed upper end of the bellows being clamped between a shoulder and a nut 133 on the stem while the flanged lower end of the bellows is clamped between an externally threaded nut 134 and a shoulder formed in threaded lower end of the extension 114. This construction forms an inert space between the bellows and the diaphragm, a bore 135 being provided through the nut 134 so as to provide for free communication between all portions of the space. Free communication of the fuel in valve chamber 110 with the upper face of the bellows 131 is also preferable, as through a bore 136 in the valve 107.

With this construction, the air pressure in the barometric chamber augments the valve closing action of the spring 125, so that the resulting valve closing force varies with the air pressure thus applied, while this valve closing force is opposed by the downward forces transmitted to the valve 107 and the bellows 131 by the fuel pressure in the pump. Since the effective upwardly facing surfaces of the bellows and the valve 107 are substantially less in area than the down-

wardly facing effective surface of the diaphragm 113, any variable action of atmospheric pressure reflected or transmitted from the fuel tank back through the fuel and to the valve and bellows 131 is substantially less than the variable action of the atmospheric pressure on the lower face of the diaphragm, so that the device 84 is unusually sensitive to the pressure variations.

When the pump 80 is to be used at a substantially constant altitude, the pressure responsive device 84 is eliminated and a spring 138, placed in the bore 110 beneath the valve 107 (Fig. 4), is held in place by a cap nut 139 which extends through the opening 116 in bottom plate 13' and is threaded into the lower end of the bore 110. Thus the pump 80 is readily adaptable for use at a constant or a variable altitude.

I claim as my invention:

1. In a fuel injection pump for internal combustion engines, a casing housing a plurality of pumping units, a fuel chamber in said casing supplied with fuel under pressure, a manually actuated metering pin for controlling the quantity of fuel flowing from said chamber to said pumping units, an excess fuel return conduit leading from said chamber, and a valve controlling said conduit responsive to the air pressure to which the engine is subjected to regulate the pressure in said fuel chamber in proportion to such pressure.

2. In a fuel injection pump for an internal combustion engine having an air intake manifold, a casing housing a plurality of pumping units, a fuel chamber in said casing supplied with fuel under pressure, a manually actuated metering pin for controlling the quantity of fuel flowing from said chamber to said pumping units, and means responsive to the air pressure in the air manifold of the engine and operable to regulate the pressure on the fuel in said chamber to vary said fuel pressure in proportion to said manifold pressure.

3. In an internal combustion engine fuel injection pump supplied with fuel under pressure, manual means for controlling the quantity of fuel supplied by said pump to an engine with which it is associated, and means controlled by the pressure in the air intake manifold of the engine regulating the pressure of the fuel supplied to the pump and thereby the quantity of fuel supplied to the engine in proportion to the manifold pressure.

4. In combination with a fuel injection pump for internal combustion engines, means for supplying fuel to said pump under pressure, a valve controlled by air pressure for automatically regulating the fuel pressure in a predetermined proportion to such air pressure, said valve comprising a casing, a diaphragm mounted in said casing, a portion of the casing forming a space on

one side of the diaphragm provided with a passage communicating with the fuel supply means for said pump, an outlet from said portion of the casing, a valve carried by said diaphragm for controlling said outlet, said casing having a space on the other side of said diaphragm communicating with a source of air pressure, and an adjustable spring opposing said diaphragm to normally seat said valve.

5. In combination with a fuel injection pump for internal combustion engines having a common distributing chamber provided with a metering orifice, a casing provided with a diaphragm and having a hollow portion of said casing at one side of the diaphragm provided with an inlet in communication with said distributing chamber, said portion being provided with an outlet, and a valve carried by the diaphragm for controlling said outlet, and a spring opposing the opposite side of said diaphragm to normally seat said valve, that side of the casing housing the spring having communication with the air pressure to which the intake ports of the engine are subjected.

6. In a fuel injection pump for internal combustion engines, a casing housing a plurality of pumping units, a fuel chamber in said casing supplied with fuel under pressure, a manually actuated metering pin for controlling the quantity of fuel flowing from said chamber to said pumping units, an excess fuel return conduit leading from said chamber, and a diaphragm valve controlling said return conduit to regulate the pressure in said fuel chamber, the diaphragm of said valve on one side thereof being subject to the pressure of fuel in said chamber and on the other side thereof to pressure of the air supplied to the engine, said valve being set so that pressure of the fuel in said chamber tends to open said valve against the resistance offered by said air pressure.

7. In combination with the air intake of an internal combustion engine, an air control valve governing said intake, a fuel pump for said engine having a plurality of pumping units and a common distributing chamber from which fuel is drawn to all of said pumping units, a supply chamber from which fuel is fed to said distributing chamber, a shiftable valve for controlling and varying the amount of fuel fed from said supply chamber to said distributing chamber, means for feeding an excess of fuel to said supply chamber under pressure, manually actuable means for actuating said valves in predetermined relation to each other to vary the fuel and air supply to the engine, a return by-pass fuel line from said supply chamber, a valve in said by-pass line, and means responsive to air pressure exteriorly of said pump operable to control said by-pass valve to vary the pressure in said supply chamber in accordance with the air pressure variation.

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