

E. A. HAASE
FUEL SUPPLY SYSTEM

3 Sheets-Sheet 1

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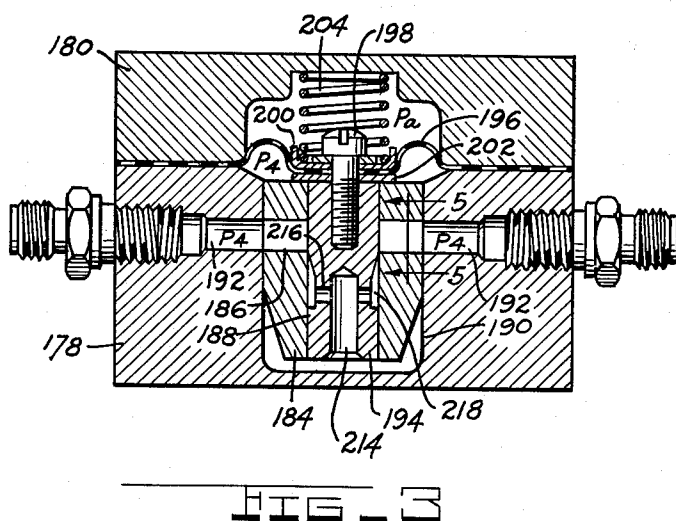
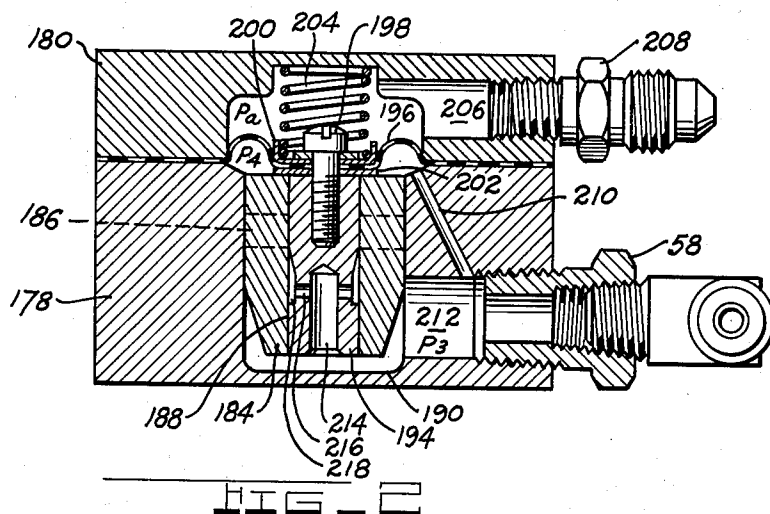
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E. A. HAASE

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3 Sheets-Sheet 2



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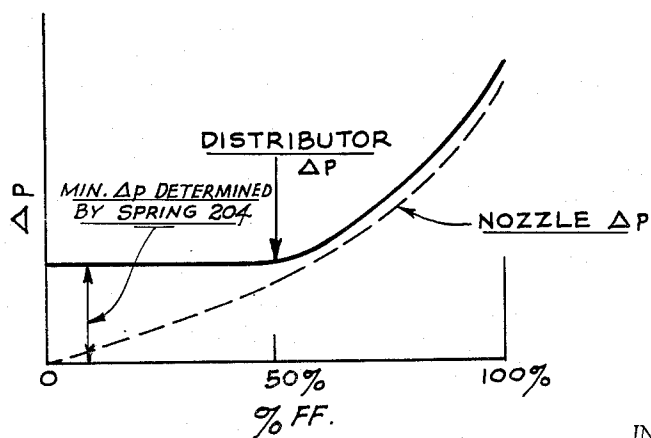
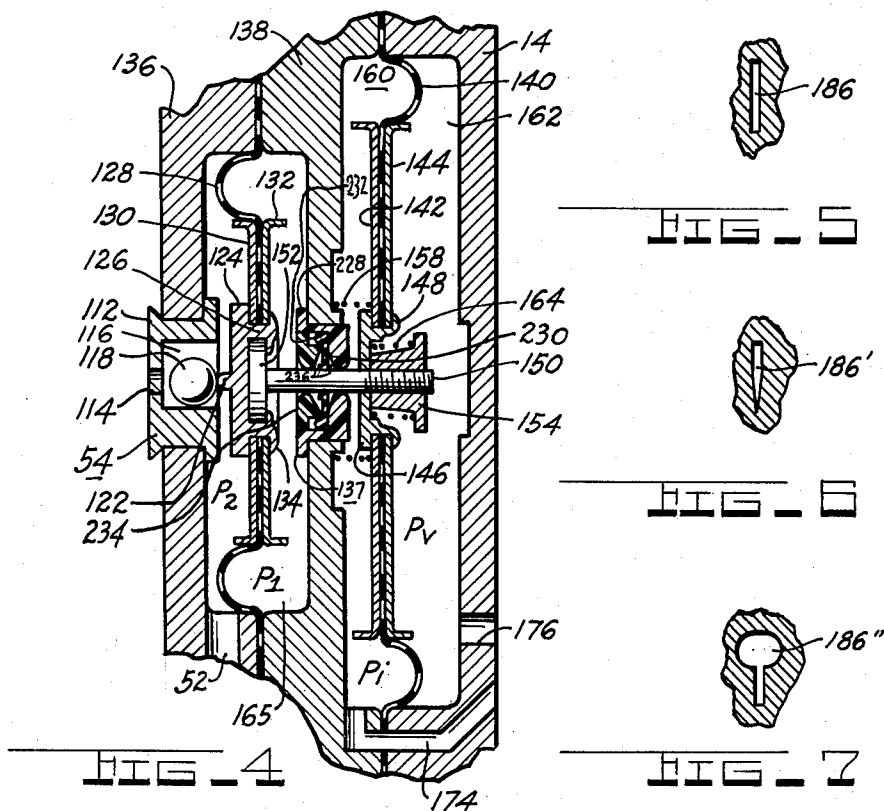
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E. A. HAASE
FUEL SUPPLY SYSTEM

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3 Sheets-Sheet 3



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3,114,359

FUEL SUPPLY SYSTEM

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This invention relates, in general, to fluid flow control apparatus and, in particular, to fuel control apparatus for controlling fuel flow to a plurality of fuel injection nozzles of a combustion engine in proportion to the flow or mass of a second fluid.

It is an object of the present invention to provide a simple and reliable fuel control for a combustion engine.

It is another object of the present invention to provide fuel control apparatus for supplying fuel in equal quantities to each fuel injection nozzle of a combustion engine having a plurality of fuel injection nozzles.

It is an important object of the present invention to provide simple and reliable fuel control apparatus including a fuel distributor for dividing fuel flow equally between a plurality of fuel nozzles.

Other objects and advantages of the present invention will become apparent to one skilled in the art from the following description taken in conjunction with the attached drawings wherein:

FIGURE 1 represents a schematic view of a fuel system embodying the present invention;

FIGURE 2 is a sectional view taken on line 2—2 of FIGURE 1;

FIGURE 3 is a sectional view taken on line 3—3 of FIGURE 1;

FIGURE 4 is an enlarged sectional view shown broken away from the remaining portion of the fuel control of the fuel section 16 of FIGURE 1;

FIGURE 5 is a sectional view taken on line 5—5 of FIGURE 3;

FIGURES 6 and 7 represent modified forms of the slot or passage shown in FIGURE 5; and

FIGURE 8 represents fuel flow curves having a percent fuel flow vs. pressure drop relationship.

Referring to the drawings, numerals 10 and 12 designate in general a fuel metering unit and fuel distributor respectively. The fuel metering unit 10 is provided with a casing 14 which houses an air section and a fuel section designated generally by numerals 16 and 18, respectively.

The air section 16 includes an air induction passage 20 in which a venturi 22 is disposed and through which air is supplied to the air induction manifold of a combustion engine, not shown. A throttle valve 24 fixedly secured to a shaft 26 rotatably supported by casing 14 is adapted to control the flow area of passage 20 and thus the mass air flow through passage 20. The throttle valve 24 is rotatably actuated by a control lever 28 fixedly secured to one end of shaft 26.

The fuel section 18 includes an inlet port 30 which receives fuel under pressure from a suitable source such as a conventional fuel pump, not shown. The fuel pump may be of any known type suitable for pumping fuel at a discharge pressure preferably in a range of 15 to 25 p.s.i. Fuel flows from inlet port 30 through a filter 31 through an opening 32 to a chamber 34 partially defined

2

by an enlarged diameter portion of a bore 36 and then past a mixture control and fuel cutoff plate 38 which controls the effective flow area of a passage 40 formed in a valve member 42. From passage 40, fuel flows through a passage 44 in a valve member 46 containing a metering restriction 48 which defines the maximum effective flow area of passages 40 and 44 and past an idle mixture control plate 50 which controls the effective flow area of passage 44 to a passage 52 containing a valve assembly 54. Passage 52 discharges to an outlet port 56 which communicates via passage 57 with an inlet port or coupling 58 in casing 60 of the fuel distributor 12 which distributor, in turn, divides the fuel flow into equal increments, each increment being discharged through an outlet port or coupling 62 to a passage 64 leading to a fuel injection nozzle 66. There are shown six of such outlet ports or couplings 62 each of which communicates with a separate passage 64 and fuel injection nozzle 66. It will be understood that the number of outlet ports and associated passages and nozzles is not limited to six since the present invention will operate equally well with engines having two or more cylinders and a corresponding number of fuel injection nozzles for supplying fuel thereto as will become apparent in connection with the following description.

The bore 36 is closed at one end by a closure plug 68 fixedly secured to casing 14 by any suitable means, not shown, and at the opposite end by a closure plug 70 which is slidably contained in bore 36 and restrained against movement outwardly from bore 36 by a plurality of lug members 72, only one of which is shown, suitably secured to casing 14 by a screw 74.

The mixture control plate 38 is secured by a pin 76 to one end of a shaft 78 which extends through and is rotatably carried by closure plug 70 and which is rotatably actuated by a lever 80 suitably secured to the opposite end thereof. Valve members 42 and 46 are restrained against rotational movement but are permitted limited axial movement by index pins 82 and 84 which extend into slots 86 and 88, respectively. The valve member 46 bears against idle mixture control plate 50 which is formed on the end of a shaft 90 rotatably carried by closure plug 68. The shaft 90 is rotatably actuated by a lever 92 suitably secured to the one end thereof and is provided with a flanged portion 94 which abuts closure plug 68 thereby fixing the axial position of the shaft 90. The shaft 78 carries a snap ring 96 against which a spring retainer 98 bears. A spring 100 interposed between the spring retainer 98 and closure plug 68 serves to bias the closure plug 68 into engagement with lug members 72 and to bias the shaft 78, valve members 42 and 46 toward idle mixture control plate 50 thereby maintaining the affected members in their proper operating relationship as shown in FIGURE 1. An O-ring seal 101 compressed between inclined surfaces 102 formed on valve members 42 and 46 serves as a fluid seal. The closure plugs 68, 70 and shafts 78, 90 are provided with suitable recesses which contain annular sealing rings 104 and 106, respectively, which prevent leakage of fuel outwardly from bore 36.

The shaft 90 is rotatably actuated by lever 92 which is pivotally connected to one end of an adjustable link 108; the opposite end of the link 108 being pivotally secured to control lever 28. The relative positions of the throttle valve 24 and idle mixture control plate 50,

for a given position of control lever 28, may be adjusted by turning an adjusting screw 110 which increases or decreases the length of link 103 as desired.

The valve assembly 54 includes a bushing 112 having a passage 114 and a recess 116. A ball valve 118 contained by recess 116 controls the area of passage 114 to thereby control fuel flow through passage 114 and is engaged by a raised center portion 122 of a disc-shaped member 124 having an annular projection 126 which extends through the center portion of a diaphragm 128. The radially innermost portion of the diaphragm 128 is clamped between annular plates 130 and 132 which are fixedly secured to annular projection 126 by a crimped edge 134 formed on annular projection 126. The radially outermost portion of diaphragm 128 is clamped between a cap 136 and a spacing member 138 both of which are fixedly secured to casing 14 by a suitable fastening means, not shown. A second diaphragm 140 of larger effective area than the effective area of diaphragm 128 is clamped at its radially outermost portion between spacing member 138 and casing 14 and at its radially innermost portion between annular plates 142 and 144. A disc-shaped member 146 is provided with an annular projection 148 which extends through the center portion of diaphragm 140 and plates 142 and 144 and which is crimped over to lock plates 142 and 144 in position thereon. A pin 150 having an enlarged end portion 152 securely confined in annular projection 126 extends through a fluid seal device generally indicated by numeral 137, a disc-shaped member 145 and a spring retainer 154 threadedly engaged with the free end of pin 150. A spring 158 interposed between spacing member 138 and annular plate 142 serves to pre-load diaphragm 140 for a purpose to be described hereinafter. Diaphragm 140 responds to air impact pressure P_i and venturi throat air pressure P_v in chambers 160 and 162, respectively. The differential area between diaphragm 128 and 140 requires a relatively high pressure differential $P_i - P_2$ across diaphragm 128 to balance a somewhat lower air pressure differential $P_i - P_v$ across diaphragm 140. A spring 164 interposed between disc-shaped member 146 and spring retainer 154 serves to bias the spring retainer 154 away from diaphragm 140 thereby maintaining a pre-load on pin 150 for a purpose to be described hereinafter.

The diaphragm 128 responds to the pressure differential $P_1 - P_2$ generated by metered fuel pressure P_2 in passage 52 upstream from valve assembly 54 and unmetered fuel pressure P_1 in chamber 165 which communicates with chamber 34 via a passage 166, port 168 and passage 170 in valve member 42 and opening 172 in mixture control plate 38.

Chambers 160 and 162 communicate with impact air pressure P_i and venturi throat pressure P_v via passages 174 and 176, respectively.

The fuel distributor 12 includes casing 60 which comprises a body portion 178 and a cap 180 removably secured thereto by any suitable fastening means such as screws 182. An annular valve member 184 provided with a plurality of circumferentially spaced radially extending slots or passages 186 and a bore 188 is fixedly secured in a bore 190 in body portion 178 by any suitable means such as a press fit. The body portion 178 has six circumferentially spaced radially extending passages 192, each of which passages communicate a corresponding slot or passage 186 with a corresponding outlet port or coupling 62. It will be noted that eight slots or passages 186 and only six passages 192 are shown in FIGURE 1. However, it will be understood that annular valve member 184, as shown, is adapted for use with up to eight outlet ports 62 depending upon the number of fuel injection nozzles required in the system. In the present case, only six fuel injection nozzles are utilized which requires that the body portion 178 be provided with only six passages 192. Of course, additional passages 192 can be provided to utilize one or both of the slots 186

which dead-end as shown in FIGURE 1. A valve member 194 slidably carried in bore 188 is fixedly secured to the center portion of diaphragm 196 by a bolt 198 which extends through a support plate 200, diaphragm 196, and a support plate 202 into threaded engagement with valve member 194. The radially outermost portion of the diaphragm 196 is clamped between body portion 178 and cap 180. A spring 204 interposed between plate 200 and cap 180 serves to bias the valve member 194 to a closed position where plate 202 engages annular valve member 184. The diaphragm 196 responds to the differential between atmospheric air pressure P_a which is communicated to the upper side of diaphragm 196 via a passage 206 and vent port or coupling 208 and metered fuel pressure P_2 which is communicated to the under side of diaphragm 196 via a passage 210 leading to a passage 212 connecting inlet port 56 with bore 190. Fuel is conducted from bore 190 to slots or passages 186 via an axial passage 214, radial passages 216 and an annular recess 218 in valve member 194. As shown in FIGURES 2 and 3, the annular recess 218 has a constant radial depth over a portion of its length and a decreasing radial depth over the remaining portion of its length. Thus, as the valve member 194 moves upward from the closed position of FIGURE 3, the annular recess 218 communicates with slots or passages 186 to provide a progressively increasing effective flow area until the valve member 194 has moved a predetermined distance whereupon the effective flow area of each of the slots or passages 186 is relatively large compared to the flow area of the nozzle downstream therefrom and the pressure drop across the valve member 194 is substantially zero. Beyond this point of operation the fuel distributor 12 is no longer effective as a flow control and the fuel distribution is dependent upon the nozzles 66 which, as shown in the drawings, are of the air-bleed type.

Referring to FIGURE 5 the slots or passages 186 are shown rectangular in cross sectional shape which shape is preferred in the case of the valve member 186 having the annulus 218 of varying radial depth shown in FIGURES 2 and 3. However, it will be understood that the identical flow control function of the valve member 184 may be obtained by utilizing slots or passages 186 which have a cross sectional shape similar to that identified by numerals 186' or 186'' in FIGURE 6 or FIGURE 7, respectively, for example, in which case the annulus 218 in valve member 184 would be modified to have a constant radial depth over its entire length instead of the variable depth shown in FIGURES 2 and 3.

Referring to FIGURE 4, the fluid seal device 137 is shown somewhat enlarged and includes an annular member 228 fixedly secured in spacing member 138 in any suitable manner such as a press fit. A flexible annular seal 230 is provided with a rim portion 232 which is forced into sealed engagement with flat surfaces formed on annular member 228 by an annular member 234 fixedly secured to annular member 228 by any suitable means such as a press fit. The annular members 228 and 234 are provided with beveled surfaces 236 which are adapted to be engaged by the seal 230 to thereby provide backing for the same. The radially innermost edges of the annular members 228 and 234 are curved as shown and are slidably engaged with the pin 150. Preferably, the annular members 228 and 234 are made of a synthetic material having a low coefficient of friction such as the commercially available plastic sold under the trade name "Delrin" and manufactured by the E. I. du Pont de Nemours and Company. The use of a material such as "Delrin" having a low coefficient of friction reduces the frictional resistance encountered by pin 150 to an extremely low level thereby minimizing undesirable hysteresis. Preferably, the flexible seal 230 is made from any suitable rubber compound capable of withstanding the effects of the liquid fuel and of sufficient flexibility

to permit flexing of the seal between adjacent beveled surfaces 236.

Operation

Assuming engine operation to be stable at a selected intermediate power setting corresponding to the set position of control lever 28, the throttle valve 24 will occupy a fixed position corresponding to the position of control lever 28. It will be understood also that a rich or lean mixture, as desired, is established by lever 80 which positions mixture control plate 38. The mixture may be visually noted by observing a flow meter 220 which communicates with the fuel pressure in one of the passages 192 via passage 222, port or coupling 224 and passage 226. Air pressure differential P_1-P_v which is a measure of mass air flow through induction passage 20 is applied against diaphragm 140 which, in turn, is urged into engagement with retainer 154 thereby loading pin 150 accordingly. The fuel pressure differential P_1-P_2 applied to diaphragm 128 produces a force equal and opposite to that derived from the air pressure differential P_1-P_v and spring 153 thereby stabilizing pin 150, member 124 and ball valve 118. Thus, fuel flow through the passage 52 is a function of the effective flow area of metering restriction 48 as modified by the setting of the mixture control plate 38 and the P_1-P_2 pressure drop across the resultant effective flow area. Fuel from passage 52 passes to the inlet port or coupling 58 of fuel distributor 12 thence to bore 190 and the underside of diaphragm 196 where it acts against the end portion of valve 194 and diaphragm 196 against the force of spring 204 and the air pressure P_a acting against the upper side of diaphragm 196. The valve 194 is biased upward in an opening direction in accordance with the pressure differential P_4-P_a to a position whereby annulus 218 communicates with radial slots 186. For a given pressure differential P_4-P_a , the position of valve 194 depends upon the rate of spring 204 which spring is selected to control the degree of opening of valve 194 such that at a predetermined fuel pressure P_4 which corresponds to approximately fifty percent of the maximum fuel flow delivered to the engine, the effective flow area defined by each of the slots 186 and the valve 194 is substantially greater than the flow area of a nozzle 66 whereupon the pressure drop P_3-P_4 across the valve 194 is substantially zero. Of course, further increases in the fuel pressure P_3 will cause the valve 194 to move accordingly in an opening direction but by virtue of the effective flow area of slots 186 remaining greater than that of the nozzle 66, the pressure drop P_3-P_4 across valve 194 remains substantially zero and fuel distribution is a function of the flow area of and the pressure drop across the fuel nozzles 66. Thus, fuel distribution to the various nozzles 66 depends upon the position of valve 194 and effective flow area of annulus 218 as defined by the increasing radial depth of annulus 218 until approximately fifty percent maximum fuel flow is reached whereupon the valve 194 becomes ineffective as a flow restriction and fuel flow distribution at subsequent higher pressure levels is undertaken by the nozzles 66.

The spring 164 is known as a "constant head spring" and is extended at low air flows when the air pressure differential P_1-P_v across the diaphragm 140 is correspondingly low which extension results in annular member 146 being biased against angular member 228 which acts as a stop. The opposite end of spring 164 which bears against spring retainer 154 serves to load the pin 150 in a direction to open ball valve 118. The pressure differential P_1-P_2 across diaphragm 128 required to balance the force of spring 164 is significant and results in a rich fuel mixture at idle speeds. At engine speeds above idle the air pressure differential P_1-P_v across diaphragm 140 becomes correspondingly greater whereupon the spring 164 is overcome allowing annular member 146 to engage spring retainer 154 which results in the effect of spring becoming negligible in comparison to the force derived from the air pressure differential P_1-P_v acting on diaphragm 140.

The spring 153 is known as a "constant effort" spring and functions to maintain a substantially constant pre-load against diaphragm 140 which pre-load assists the air pressure differential P_1-P_v across diaphragm 140 to thereby maintain a substantially constant linear relationship between the fuel pressure differential P_1-P_2 and the air pressure differential P_1-P_v at relatively low values of the latter differential. The force derived from a relatively low air pressure differential P_1-P_v is relatively weak and not entirely suitable for control purposes such that an augmenting force such as spring 153 is required. It will be understood that the percentage effect of the spring 153 on the force tending to open ball valve 118 decreases as the air pressure differential P_1-P_v increase and at relatively high value of the differential P_1-P_v the effect of spring 153 is negligible.

Referring to the curves of FIGURE 8 it will be noted that the solid line curve represents the pressure drop across the fuel distributor 12 and the dashed line represents the pressure drop across the fuel nozzles 66. While the solid line is intended to represent the total pressure drop which is the sum of the pressure drops across all of the slots 186 of the fuel distributor 12, the characteristics of the solid line are representative of the pressure drop-fuel flow relationship associated with each slot or passage 186. Similarly, the dashed line represents the total pressure drop which is the sum of the pressure drops across all of the nozzles 66 but is also characteristic of the pressure drop-fuel flow relationship associated with each nozzle 66. As shown by the solid line, the pressure drop across the fuel distributor 12 is maintained at a substantially constant value in excess of a predetermined minimum value up to a predetermined fuel pressure P_3 which corresponds to approximately fifty percent maximum fuel flow. The predetermined minimum value of the pressure drop as determined by spring 204 is made sufficiently high to eliminate maldistribution of fuel which normally occurs in the lower range of fuel flow as a result of variations in nozzle elevation and temperature. Upon reaching the higher values of fuel pressure P_3 in the upper fuel flow range, the nozzles 66 are sufficiently pressurized to eliminate any significant variation in fuel flow from one nozzle to another. As shown by the solid and dashed lines of FIGURE 8 the pressure drop-fuel flow relationship is a square function above the fifty percent fuel flow point. In the upper range of fuel flows it will be noted that a slight pressure drop exists across the fuel distributor 12 which imposes a slight restriction to the higher fuel flows. However, this slight pressure drop existing across the fuel distributor in the upper flow ranges is negligible.

Fuel flow to the engine ceases in response to movement of lever 80 to fuel cutoff position whereupon the mixture control plate 38 moves to a closed position blocking flow from chamber 34 to passage 40. In the cutoff position, the opening 172 moves out of registry with passage 170 thereby blocking fuel flow from chamber 34 to passage 170 which, in turn, results in the pressure differential P_1-P_2 across diaphragm 128 decreasing to zero. Thus, the diaphragm 128 is not subjected to undue stress by virtue of a high pressure differential P_1-P_2 during cutoff operation.

While only one embodiment of the present invention is shown and described, it will be understood by those persons skilled in the art that various modifications of the structure shown and described may be made without departing from the scope of applicant's invention.

I claim:

1. Fuel control apparatus for a combustion engine having a plurality of cylinders and a fuel injection nozzle associated with each cylinder, comprising a source of pressurized fuel, a fuel conduit connected to receive fuel from said source, valve means operatively connected to said fuel conduit for controlling fuel flow therethrough, a fuel distributor operatively connected to said fuel con-

duit downstream from said valve means and in series flow therewith, said fuel distributor including a casing having an inlet port and a plurality of outlet ports, a passage connecting each of the outlet ports with an associated fuel injection nozzle, an annular member fixedly secured in position in said casing and provided with a plurality of circumferentially spaced radially extending passages, each of said radially extending passages communicating with an associated outlet port, a valve member slidably carried by said annular member and movable relative to said plurality of radially extending passages to thereby vary the effective flow area of each of the radially extending passages simultaneously, pressure responsive means operatively connected to said valve member for controlling the position thereof, said pressure responsive means being vented to the fuel pressure at said inlet port and to ambient air pressure and being responsive to the pressure differential therebetween, and resilient means operatively connected to said valve member for biasing the same toward a closed position in opposition to said pressure differential.

2. Fuel control apparatus as claimed in claim 1 wherein said valve member is provided with an annular recess having a tapered portion which communicates with said plurality of radially extending passages and is movable relative thereto to effect the same degree of variation in effective flow area of each of said radially extending passages.

3. Fuel control apparatus as claimed in claim 1 wherein said valve member is operative to increase the effective flow area of said plurality of radially extending passages to a maximum value in response to a predetermined value of said fuel pressure acting upon said pressure responsive means whereupon a further increase in said fuel pressure has no effect on the effective flow area of said plurality of radially extending passages.

4. Fuel control apparatus for a combustion engine having a plurality of cylinders, a fuel injection nozzle associated with each cylinder, comprising a source of pressurized fuel, a fuel conduit connected to deliver fuel from said source to said fuel injection nozzles, first valve means operatively connected to said fuel conduit for controlling fuel flow therethrough, an air induction passage connected to supply air to the cylinders, second valve means operatively connected to said air induction passage for controlling the flow of air therethrough, a control lever operatively connected to said first and second valve means for actuating the same as a function of control lever position, third valve means operatively connected to said fuel conduit downstream from said first valve means, first pressure responsive means responsive to the fuel pressure differential across said first valve means, second pressure responsive means responsive to the differential between first and second air pressures derived from the air flowing through said air induction passage, said third valve means being operatively connected to and actuated by said first and second pressure responsive means to thereby control fuel flow through said fuel conduit as a function of mass air flow through said air induction passage, fourth valve means operatively connected to said fuel conduit downstream from said third valve means for diverting the fuel flow through said conduit to a plurality of passages each of which passages communicates with a separate fuel injection nozzle, said fourth valve means including a fixed annular valve member having a plurality of circumferentially spaced, radially extending passages communicating with said plurality of passages and a valve member slidably carried by said annular valve member, said last named valve member being operatively engaged with said plurality of radially extending passages and movable relative thereto to control the effective flow area of each of the radially extending passages simultaneously, and pressure responsive means responsive to the fuel pressure downstream from said third valve means operatively

connected to said last named valve member for controlling the position thereof.

5. Fuel control apparatus for a combustion engine having a plurality of cylinders and a fuel injection nozzle associated with each cylinder, comprising a source of pressurized fuel, a fuel conduit connected to supply fuel to said fuel injection nozzles from said source, valve means operatively connected to said fuel conduit for regulating fuel flow therethrough, a fuel distributor operatively connected to said fuel conduit downstream from said valve means and in series flow therewith, said fuel distributor including a casing having an inlet port and a plurality of outlet ports, a passage connecting each outlet port with an associated fuel nozzle, valve means having a plurality of variable area ports, each of said ports being in series flow with an associated one of said passages for controlling the fuel flow therethrough independently of the remaining variable area ports and passages associated therewith, means responsive to the pressure of the fuel regulated by said first named valve means operatively connected to said last named valve means for actuating the same to thereby cause a progressive increase in the flow area of each of said variable area ports and thus said passages simultaneously as said fuel pressure increases, and resilient means operatively connected to said last named valve means for biasing the same toward a closed position in opposition to said fuel pressure.

6. Fuel control apparatus for a combustion engine as claimed in claim 5 wherein said valve means having a plurality of variable area ports is operative over a first range of positions wherein said variable area valve ports are an effective restriction to fuel flow through said passages and operative over a second range of positions wherein said variable area valve ports are substantially ineffective as a restriction to fuel flow through said passages.

7. Fuel control apparatus for a combustion engine as claimed in claim 6 wherein said variable area valve ports provide the major restriction to fuel flow through said passages over said first range of positions of said valve means and said fuel injection nozzles provide the major restriction to fuel flow over said second range of positions of said valve means.

8. Fuel control apparatus as claimed in claim 1 and further including an air induction passage connected to supply air to said engine, valve means operatively connected to said induction passage for controlling flow therethrough, and a control lever, said valve means connected to said fuel conduit including first and second valves, said first valve and said induction passage valve means being operatively connected to said control lever and actuated thereby, a first pressure responsive means responsive to the fuel pressure differential across said first valve, a second pressure responsive means responsive to an air pressure differential derived from the air flowing through said induction passage, said second valve being operatively connected to and actuated by said first and second pressure responsive means to thereby control fuel flow through said fuel conduit as a function of mass air flow through said air induction passage.

9. Fuel control apparatus as claimed in claim 1 wherein said plurality of circumferentially spaced radially extending passages are each provided with a generally rectangular cross sectional area which is traversed by said valve member to cause a progressive increase in flow area of said passages as said pressure differential acting against said pressure responsive means increases.

10. Fuel control apparatus as claimed in claim 4 wherein said first and second pressure responsive means are separated by a fixed wall and operatively connected by a rod extending through and slidably carried by said fixed wall, said rod being provided with a fluid seal to prevent leakage of fuel past the sliding surfaces thereof including a first annular member fixedly secured to said wall through which said rod extends, a second annular member through which said rod extends fixedly secured

to said first annular member, a flexible annular seal through which said rod extends, said annular seal having its radially outermost portion clamped between said first and second annular members, said first and second annular members having first and second opposing surfaces, respectively, which diverge radially inwardly, said flexible seal being exposed to fuel and air pressures associated with said first and second pressure responsive means and urged by the pressure differential therebetween into engagement with one of said surfaces.

11. Fuel control apparatus as claimed in claim 10 wherein said rod is slidably carried by said first and

second annular members, said first and second annular members being formed of a material having a low coefficient of friction, and said flexible annular seal is formed of a rubber compound and capable of a limited degree of stretching.

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