

Aug. 16, 1938.

C. R. ALDEN

2,126,709

FUEL INJECTION SYSTEM

Filed April 29, 1932

4 Sheets-Sheet 1

Fig. 1

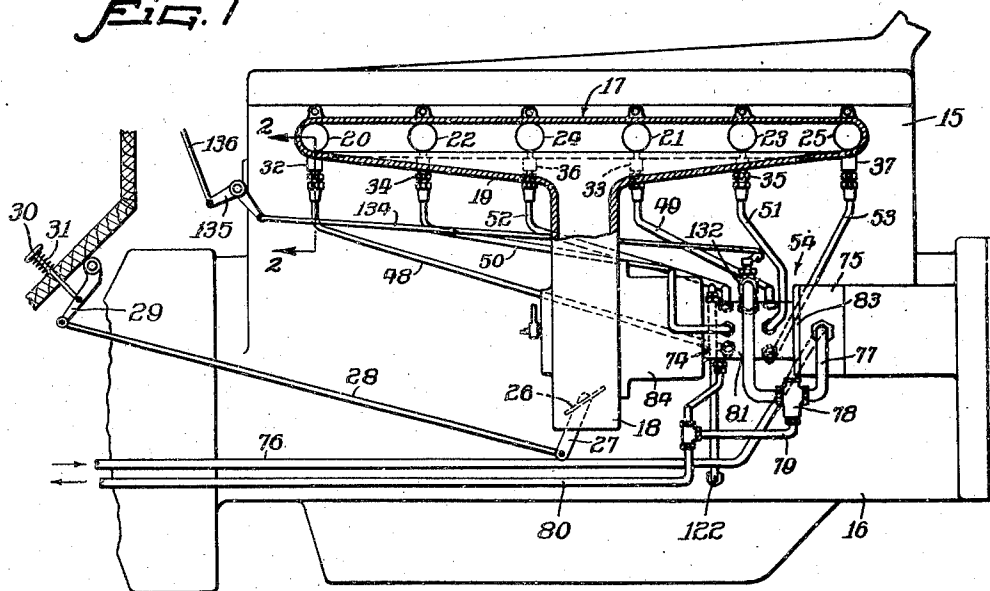


Fig. 3

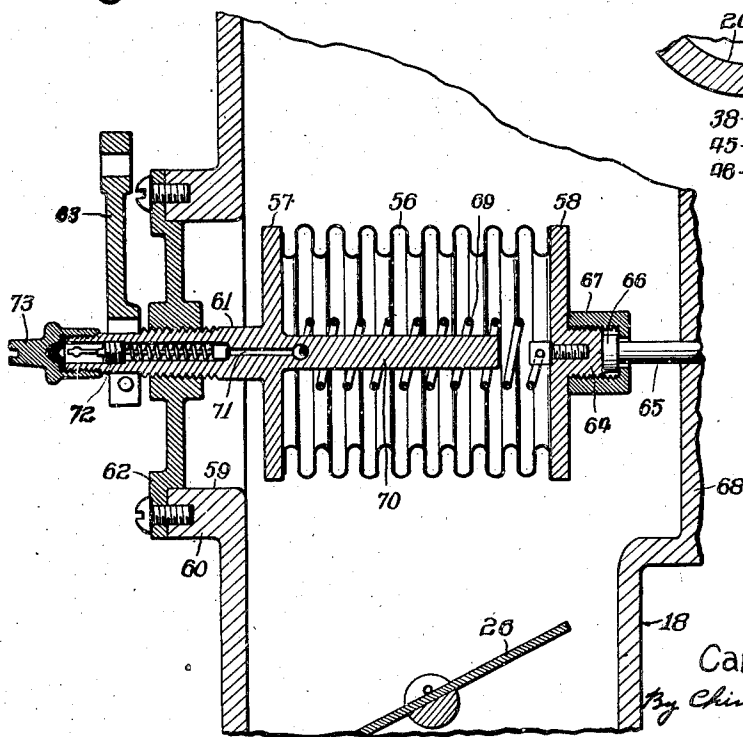
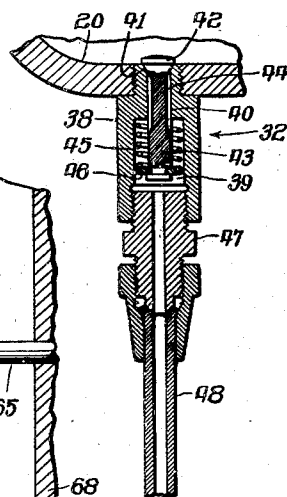


FIG. 2



Inventor
Carroll R. Alden
Chindahl, Parker & Carlson
Attorneys

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C. R. ALDEN

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FIG. 4

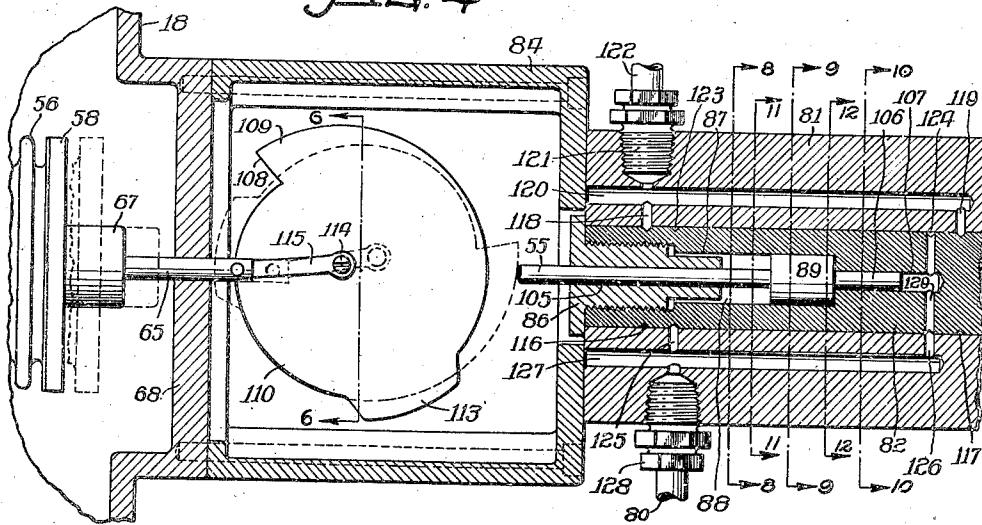


FIG. 5

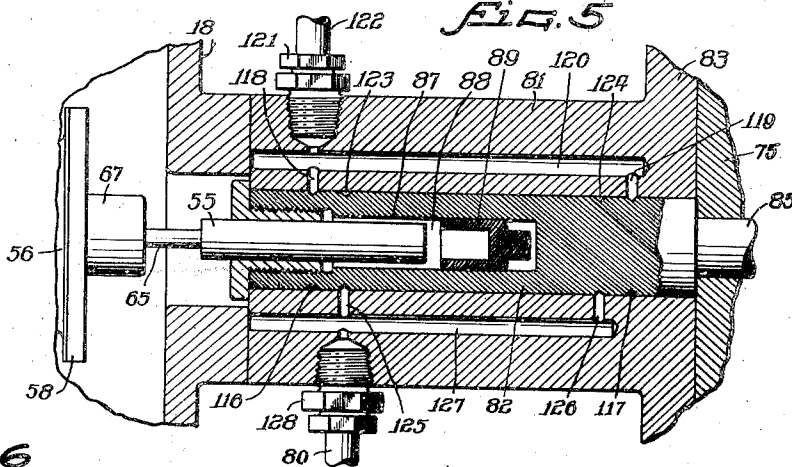


FIG. 6

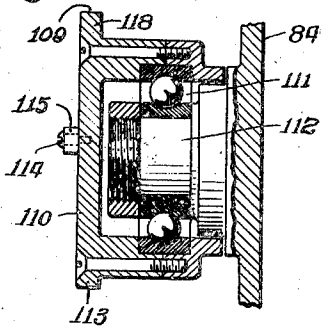
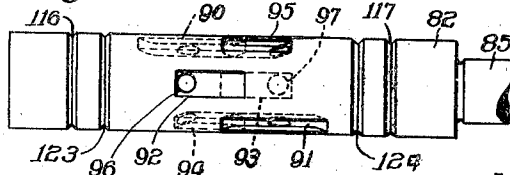


FIG. 7



Inventor
Carl R. Alden
By *Chindahl, Parker & Carlson*
Attorneys

Aug. 16, 1938.

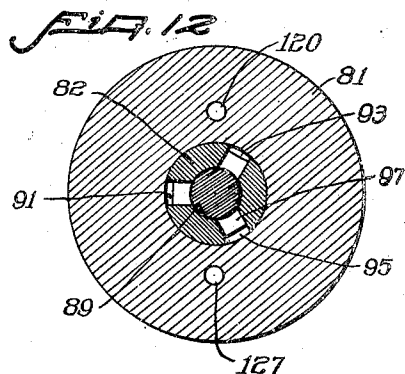
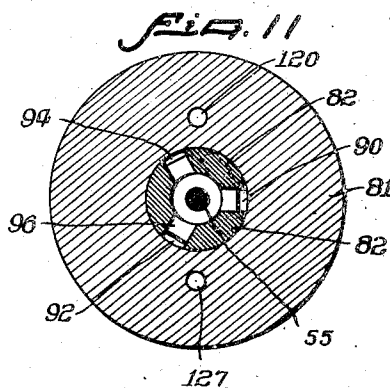
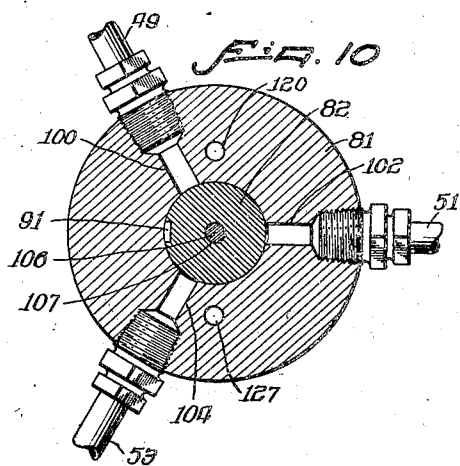
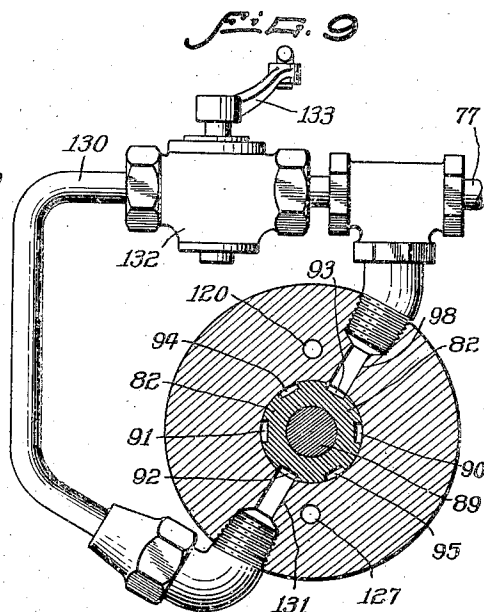
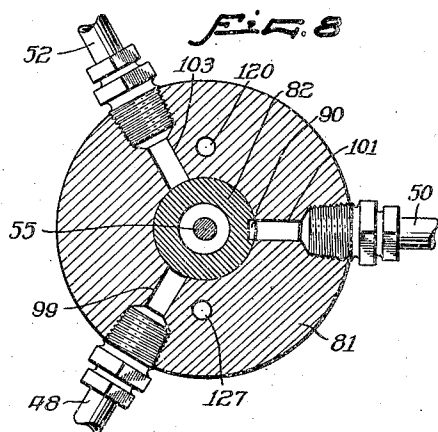
C. R. ALDEN

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FUEL INJECTION SYSTEM

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4 Sheets-Sheet 3



Inventor
Carroll R. Alden
By Chindahl, Parker & Carlson
Attorneys

Aug. 16, 1938.

C. R. ALDEN

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Fig. 13

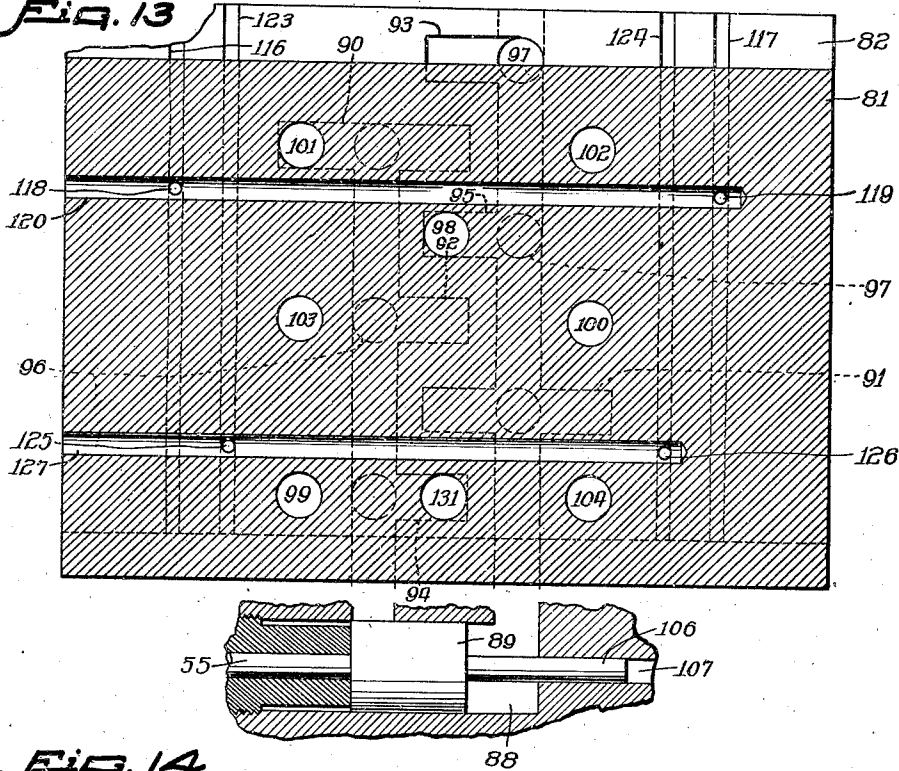
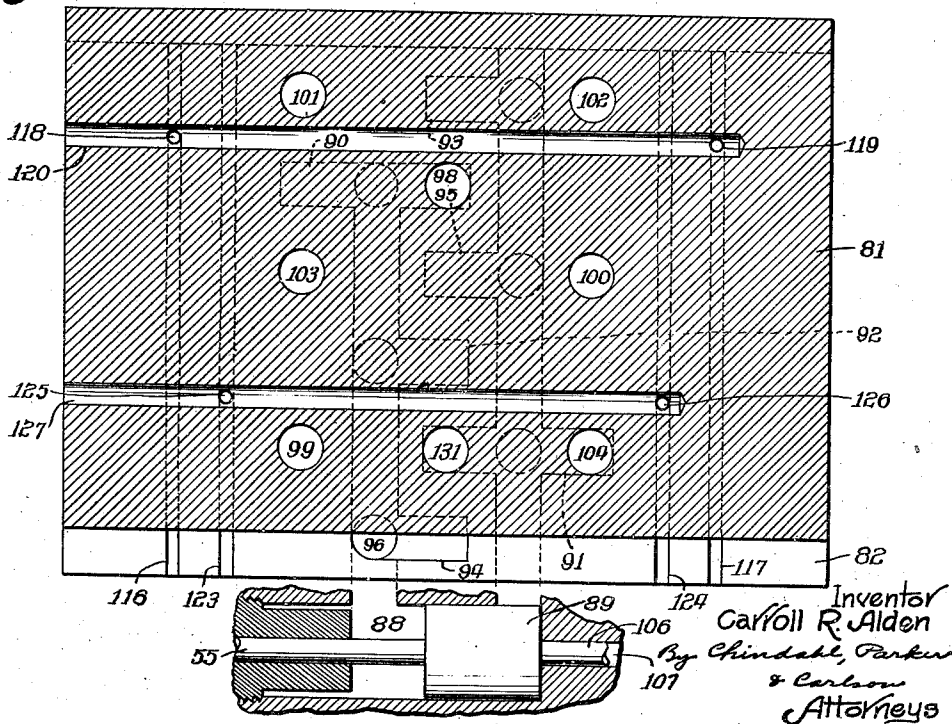


Fig. 14



UNITED STATES PATENT OFFICE

2,126,709

FUEL INJECTION SYSTEM

Carroll R. Alden, Detroit, Mich., assignor to Excell-O Corporation, a corporation of Michigan

Application April 29, 1932, Serial No. 608,211

22 Claims. (Cl. 123—138)

The present invention relates generally to improvements in fuel injection systems, and has particular reference to such systems that are well adapted to inject fuel into the air intake manifolds of internal combustion engines.

One of the primary objects of the present invention is to provide a new and improved fuel injection system in which any desired predetermined fuel-air ratio is substantially maintained regardless of changes in atmospheric temperature and/or pressure, and/or of variations in the amount of fuel-air mixture supplied.

Another and more specific object resides in the provision of a novel fuel injection system for internal combustion engines in which the quantity of fuel to be injected is under the control of the temperature and/or pressure in the air intake manifold.

A further object is to provide a novel fuel-air ratio control for manifold injection systems which is adjustable without having to overcome any substantial forces, such for example as the fuel pressure or mechanical resistances, and which in general is simple in construction and reliable, accurate and sensitive in operation.

In carrying out the foregoing objects, I provide a manifold injection system which comprises a throttle or volume control member, a wedge member for defining the adjustment of the throttle, and a pressure responsive element for automatically adjusting the wedge member so as to vary the amount of fuel injected in accordance with temperature and pressure conditions in the manifold.

A more specific object is to provide a novel rotary distributor which will direct fuel under pressure from a constant source to a plurality of nozzles in time sequence, and which will accurately meter each charge of fuel without regard to speed of operation.

Another object of the invention resides in the provision of novel means whereby the rotor of the fuel distributor is properly lubricated regardless of the pressure and lubricating characteristics of the fuel.

Further objects and advantages will become apparent as the description proceeds.

In the accompanying drawings, Figure 1 is a side view, partially in section, of an internal combustion engine to which a fuel injection system embodying the features of my invention has been applied.

Fig. 2 is a longitudinal sectional view, on an enlarged scale, of one of the injection valves.

Fig. 3 is a fragmentary sectional view on an enlarged scale of the fuel-air ratio control.

Fig. 4 is a fragmentary sectional view of the rotary fuel distributor and the fuel-air ratio control in operative relation.

Fig. 5 is a fragmentary sectional view generally similar to Fig. 4, but of a modified form of distributor and control.

Fig. 6 is a detail sectional view taken along line 6—6 of Fig. 4.

Fig. 7 is a side elevational view of the distributor rotor.

Figs. 8 to 12 are transverse sectional views of the distributor taken respectively along lines 8—8 to 12—12 of Fig. 4.

Fig. 13 is a diagrammatic view of the distributor with a development of the casing superimposed on a development of the rotor in one relative position of rotation.

Fig. 14 is a view similar to Fig. 13 but showing the rotor and the casing in a different relative position of rotation.

While the invention is susceptible of various modifications and alternative constructions, I have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that I do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

Referring more particularly to the drawings, the fuel injection system generally is adapted for use in connection with various kinds of internal combustion engines, and for purposes of illustration is herein disclosed as applied to an engine having six cylinders in line and operating on a mixture of vaporized fuel and air.

The engine (see Fig. 1) comprises a cylinder block 15, a crank case 16 and an intake manifold 17. In the present instance, the manifold 17 is of the usual T-shaped form, having a vertical inlet arm 18 and a horizontal distributing arm 19 with connections 20 to 25 opening to the respective cylinders. It will be understood that the arm 18 of the manifold 17 serves to supply the air for the combustible fuel mixture from the atmosphere. The amount of air supplied is under the control of a suitable throttle which is herein shown as a butterfly valve 26 pivotally mounted in the inlet end of the arm 18, and operatively connected through a crank arm 27, a link 28 and a lever 29 to a pedal or hand actuator 30. A spring 31 engaging the actuator 30 acts in a di-

rection tending to effect closing of the air throttle 26.

The fuel, such as naphtha or gasoline, is introduced into the manifold 17 in proportion to the volume of air supplied so as to obtain the desired air-fuel ratio. Preferably, the fuel is injected into the manifold 17 in successive charges in timed relation to the sequential operation of the engine cylinders, and comprising a charge for each cycle of each cylinder. In the present instance, a series of injection valves 32 to 37 are mounted to discharge the fuel respectively into the connections 20 to 25 opening to the engine cylinders.

The injection valves 32 to 37 may be of any preferred form, and preferably are alike. Each valve (see valve 32 in Fig. 2) comprises a casing 38 mounted on the manifold 17 and having a chamber 39 opening through a bore 40 past a valve seat 41 to the interior of the connection to the associated engine cylinder. A valve member 42 of the mushroom type is adapted to coact with the valve seat 41 and has a stem 43 extending slidably through the bore 40 into the chamber 39. Longitudinal flutes or grooves 44 are formed in the stem to establish communication between the chamber 39 and the discharge end of the bore 40. A coiled compression spring 45 in the chamber 39 impinges at its outer end against a washer 46 on the free end of the stem 43 and tends to urge the latter outwardly to close the injection valve. The outer end of the casing 38 is closed by a removable conduit fitting 47.

The valves 32 to 37 are connected by means of their fittings 47 respectively to fuel conduits or tubes 48 to 53 leading to a suitable charging device, indicated generally at 54, for supplying metered charges of fuel under pressure. Obviously, a charge of fuel upon being supplied to the nozzle chamber 39 will lift the valve member 42 and be injected into the manifold 17.

The fuel charging device 54 has a throttle element, herein shown in the form of a plunger 55 (see Figs. 4 and 5), which is adjustable to vary the amount of fuel injected, and more particularly to vary the size of each charge of fuel as desired. Obviously, upon adjusting the air throttle 26 for the purpose of varying the amount of combustible mixture being supplied to the engine, the fuel throttle 55 should also be adjusted to effect a corresponding variation, in accordance with a predetermined fuel-air ratio, in the amount of fuel being injected.

In many instances, it is very desirable that the predetermined fuel-air ratio be accurately maintained. However, where the fuel and air throttles are interrelated mechanically for proportional movement, or where the supply of fuel is responsive to the induction action of the entering air, the fuel-air ratio does not remain fixed over the entire range of variations in the operating characteristics of the engine. Thus, a change in the speed of the engine due to a fluctuating load, or a change in the position of the throttle 26, will result in a corresponding change in the pressure drop across the throttle. As a result, while the fuel-air ratio may be unchanged as to volume, the weight of the air will be different than in the correct ratio.

For a given adjustment of the throttle 26, changes in the temperature and/or barometric pressure of the incoming air result in changes in weight which cause a departure from the theoretical correct fuel-air ratio. This is particularly noticeable in aircraft where frequent and substantial changes in elevation are necessary.

One of the primary features of the present injection system resides in the provision of novel means for automatically adjusting the fuel throttle 55 to compensate for changes in the condition of the air tending to cause a departure from the desired fuel-air ratio. In the preferred embodiment of the invention, this means (see Fig. 3) comprises a member, preferably in the form of a cylindrical corrugated bellows diaphragm 56, responsive to the temperature and pressure of the air in the intake manifold 17.

Opposite ends of the diaphragm 56 are sealed respectively by a fixed plate 57 adjustably mounted in the manifold 17, and a movable plate 58 operatively associated with the plunger 55. In the present instance, one wall of the manifold 17 is formed with an opening 59 having a peripheral flange 60 and being of sufficient size to permit insertion of the diaphragm 56. The plate 57 has an outer axial stem 61 adjustably threaded centrally through a plate 62 removably secured to the flange 60 to close the opening 59. An adjusting element 63, adapted for manual actuation, is secured to the outer end of the stem 61, and affords means whereby the diaphragm 56 can be rotated to adjust its axial position. The plate 58 on the free end of the diaphragm 56 has an external axial boss 64. A stem 65 has a head 66 secured to the boss 64 by means of a flange nut 67, and extends slidably out of the manifold 17 through a flattened section 68 of the wall opposite the plate 62 for its operative connection with the throttle 55.

The diaphragm 56 is made of resilient material. Preferably, a coiled tension spring 69 is provided to supplement the inherent resiliency of the diaphragm 56, the spring being anchored respectively at opposite ends to the end plates 57 and 58 and loosely encircling an axial guide stem 70 on the inner face of the plate 57.

The diaphragm 56 also is filled with an expansible fluid at a predetermined temperature and pressure. To provide means for introducing the desired amount of fluid into the diaphragm 56, the stem 61 is formed with an axial passage 71 opening to the exterior of the stem 70. The outer end of the passage 71 is enlarged to receive a spring-seated valve 72 and is securely sealed by an end cap 73.

It will be evident that changes in the air pressure in the manifold 17, whether resulting from adjusting of the air throttle 26 or from variations in barometric pressure, will effect proportionate changes in the length of the diaphragm 56, and therethrough a compensatory adjustment of the fuel throttle 55. Since the diaphragm 56 is mounted directly within the manifold 17, it will also suffer adjustments through changes in the temperature of the air in the manifold, and compensate the fuel supply for such changes. Thus, the control diaphragm 56 compensates the fuel supply for all temperature and pressure conditions tending to cause a departure from the desired air-fuel ratio. This ratio may, of course, be adjusted by means of the actuator 63.

The fuel supply means 54 in its preferred form comprises a metering distributor 74 of which the fuel throttle 55 forms a part, and which is connected to the respective feed tubes 48 to 53, and a pressure source, such as a fuel pump 75 for supplying fuel under a constant pressure to the distributor. The pump 75 has a fuel inlet line 76 leading from a suitable fuel supply (not shown), and a discharge line 77 leading to the distributor 74. Interposed in the line 77 is a

relief valve 78 for maintaining a constant predetermined pressure, and discharging excess fuel through a bleed line 79 connected to a drain line 80. The pump 75 is mounted on the cylinder block 15, and is driven from the engine. Details of the pump 75 and its drive per se form no part of the present invention and hence are not disclosed herein.

The fuel distributor 74 (see Figs. 4 to 12) preferably is of the rotary type, and comprises a stator 81 in the form of a cylindrical casing and a rotor 82 rotatably disposed therein. The casing 81 has an external peripheral flange 83 on one end mounted on one end of the pump 75, and at the other end is connected to a rectangular housing 84 mounted on the wall section 68 of the manifold 17. One end of the rotor 82 is connected to a shaft extension 85 of the pump 75 for a drive in properly timed relation with the operation of the engine cylinders, and abuts against the end of the pump casing. A flanged plug 86 is threaded into an axial bore 87 opening into the other end of the rotor 82 and engages the end of the casing 81.

In the preferred form of the distributor 74, the inner end of the bore 87 extends substantially through the central portion of the rotor 82 and constitutes a fuel charging chamber 88. Reciprocally disposed in the chamber 88 is a metering plunger or piston 89 which is periodically operable to admit a measured charge of fuel and then to displace the charge to effect injection.

The number of fuel charges handled in one revolution of the rotor is dependent on the number of injection valves that are to be used. The distributor 74 may be provided in a form suitable for any particular number of injection valves, and in the present instance in order to adapt it to the engine selected for illustration, is constructed to serve an even number of nozzles, namely the six nozzles 32 to 37. Thus, the opposite ends of the chamber 88 are alternately connected to the fuel pressure line 77 to effect six movements of the piston 89 during one revolution of the rotor 82, and while either end is connected to the line 77 to receive a charge of fuel, the other end is connected selectively to one of a group of three nozzles for the displacement of the preceding charge.

To provide for the foregoing, the rotor 82 (see Fig. 7) is formed in its periphery intermediate its ends with six longitudinal uniformly peripherally spaced slots 90 to 95 arranged in two groups of three, with the slots of these groups being alternated and partially staggered peripherally. The slots 90, 92 and 94 of one group (see Fig. 11) open through radial passages 96 to the left end of the chamber 88, and the slots 91, 93 and 95 of the other group (see Fig. 12) open through similar passages 97 to the right end of the chamber. The fuel pressure line 77 opens to the interior of the casing 81 through a port 98 (see Fig. 9) in the path of the longitudinally overlapping ends of the slots 90 to 95 for successive communication therewith.

Two diametrically opposed primary slots of the two groups, namely the slots 90 and 91, are elongated outwardly beyond the ends of the other slots. The fuel feed tubes 48 to 53 are arranged in two groups opening to the interior of the casing 81 respectively through uniformly peripherally spaced feed ports 99, 101 and 103 in the path of the outer end of the slot 90 (see Fig. 8) and similar ports 100, 102 and 104 in the path of the outer end of the slot 91 (see Fig. 10). The

two groups of feed ports 99 to 104 are also arranged in pairs of longitudinally aligned ports, and the fuel pressure port 98 is located peripherally midway of two pairs. Thus, the feed ports of each group are connected successively to the associated end of the chamber 88, the feed ports of the two groups are alternately connected to the chamber, and when any one port of either group is connected to the associated end of the chamber, the pressure port 98 is connected to the other end of the chamber.

Assuming that the rotor 82 is in the rotary position shown in Fig. 13, the feed ports 100, 102 and 104 are closed, the port 101 leading to the nozzle 34 is connected to slot 90, and the pressure port 98 is open to the slot 95 so that the inlet fuel pressure has forced the metering piston 89 into its left-hand position, thereby injecting a charge of fuel through the nozzle 34 and charging the right end of the chamber 88 preparatory for the next injection. Upon rotation of the rotor 82 into its next position shown in Fig. 14, the feed ports 99, 101 and 103 are closed, the port 104 leading to the nozzle 37 now is open to the slot 91, and the pressure port 98 communicates with the slot 90 so that the piston 89 is moved into its right-hand position to eject the previous charge and simultaneously charge the left end of the chamber 88.

The volume of fuel in each charge, and hence the amount of fuel injected into the manifold 17 in proportion to a given amount of air is dependent on the displacement effected by the piston 89 in each of its movements. The fuel throttle 55 is utilized to adjust the range or extent of reciprocation of the piston 89, and preferably comprises a plunger extending slidably through an axial bore 105 in the plug 86 into one end of the chamber 88. In the form shown in Fig. 4, the plunger 55 is rigid with one end of the piston 89. To provide equal end areas, the other end of the piston 89 is rigid with an axial plunger 106 of the same diameter as the plunger 55 and extending slidably into a reduced extension bore 107 opening from the chamber 88.

Preferably, means is disposed between the fuel-air ratio control 56 and the throttle 55 to prevent the reaction of the fuel pressure from influencing the operation of the control. In the present instance, this means comprises a rotary cam member 108 having a spiral face 109 adapted in its different position of adjustment for engagement with the outer end of the plunger 55 to define a variable limit for movement of the piston 89 to the left. The member 108 is formed on the periphery of a crank disk 110 (see Figs. 4 and 6) mounted on a ball bearing 111 on a stub shaft 112 in the housing 84. A counterweight 113 is mounted on the disk 110 diametrically opposite the member 108. The disk 110 has an eccentric crank pin 114 connected through a crank arm 115 to the free end of the stem 65 movable with the end plate 58 of the diaphragm 56.

The member 108 is shown in full outline in the position corresponding to maximum pressure in the manifold 17. Upon movement of the member 108 progressively into the position indicated in dotted outline corresponding to minimum pressure in the manifold 17, the range of reciprocation of the piston 89 will be correspondingly restricted to gradually reduce the amount of fuel injected until ultimately the fuel throttle is closed. It will be noted that the plunger 55 engages the wedge 108 less than one-half of the time, and that when it engages the wedge the

angle of engagement is less than a sliding angle so that the end pressure of the fuel on the plunger is not transmitted to the diaphragm 56. The disk 110 being balanced and mounted on the anti-friction bearing 111 is operable by very little power. Hence, the temperature and pressure responsive diaphragm 56 affords an accurate, sensitive and reliable control of the fuel-air ratio and the volume of fuel-air mixture supplied to the engine cylinders under widely varying operating conditions.

In the modified form shown in Fig. 5, the plunger 55 is connected directly to the stem 65 but is separate from the piston 89, and the plunger 106 and extension bore 107 are not needed and hence dispensed with. In all other respects the two forms of distributors are alike, and hence corresponding parts are identified by like reference characters.

Motor fuel is a poor lubricant, and because of its low viscosity has a very thin fluid film. Hence, the fuel affords poor protection against wear between the casing 81 and the rotor 82 of the distributor, and has but little tendency to balance or stabilize the rotor for ease and smoothness of operation. To compensate for these deficiencies, and also to prevent leakage of the highly inflammable fuel from the ends of the distributor into uncontrolled channels, the ends of the rotor 82 are floated in a heavy film of a non-volatile and non-inflammable lubricating fluid, as for example oil from the lubricating system of the engine. The means for providing this film of lubricating oil preferably comprises two annular peripheral grooves 116 and 117 formed respectively in opposite ends of the rotor 82 outwardly a substantial distance beyond the slots 90 to 95. Two ports 118 and 119 formed in the casing 81 at longitudinally spaced points open to the interior in registration respectively with the grooves 116 and 117 for all positions of rotation of the rotor 82. A longitudinal passage 120 formed in the casing 81 interconnects the ports 118 and 119, and opens through a fitting 121 to the discharge end of a line 122 connected at its other end to the engine crank case 16 for a supply of lubricating oil under pressure. By enveloping the ends of the rotor 82 with a film of lubricating oil, which is thicker than the natural fuel film, the central portion of the rotor is accurately centralized or located and never comes into actual wearing contact with the casing 81.

To prevent the pressure of the fuel, when in excess of the oil pressure, from overcoming the oil film and thereby impairing the lubrication and the leakage-preventing seal, two annular peripheral drain grooves 123 and 124 are formed respectively in opposite ends of the rotor 82 between and in spaced relation to the outer oil grooves 116 and 117 and the slots 90 to 95. Two ports 125 and 126 formed in the casing 81 diametrically opposite the ports 118 and 119 communicate with the drain grooves 123 and 124 for all rotary positions of the rotor 82. A longitudinal passage 127 formed in the casing 81 interconnects the ports 125 and 126, and opens through a fitting 128 to the drain line 80. In Fig. 4, the groove 124 opens through radial passages 129 to the inner end of the bore 107. Some fuel will leak outwardly and some oil will leak inwardly into the drain grooves 123 and 124 from where the fluid is withdrawn. Hence, the pressure of the fuel cannot build up beyond the grooves 123 and 124, and good lubrication is assured.

Means is provided for short-circuiting the

metering piston 89 to pass fuel from the pressure line 77 directly to the various feed tubes 48 to 53. This means (see Figs. 1 and 9) comprises a by-pass line 130 branching from the line 77 and opening to the interior of the casing 81 through a port 131 diametrically opposite the pressure port 98, and hence in alignment longitudinally of the rotor 82 with some of the feed ports 99 to 104. A valve 132 is interposed in the line 130 and is adapted to be opened or closed at will, as for example through a linkage comprising a crank arm 133, a link 134, a bell-crank lever 135 and an actuator 136. Normally, the valve 132 is closed. However, when it is desired to free the feed tubes 48 to 53 of air, or in starting of the engine to provide an excess amount of fuel for priming purposes, the valve 132 is opened. The pressure fuel will then be supplied to the port 131, and hence will in Fig. 13 pass through the slot 94, the passages 96, and the slot 90 to the feed tube 50, and in Fig. 14 pass through the slot 91 to the feed tube 53. Opening of the by-pass valve 130 eliminates the charge-limiting and metering characteristics of the distributor 74.

The detailed operation of the system will be understood from the foregoing description. In general, the amount of fuel mixture supplied to the engine is controlled by adjusting the air throttle 26 to vary the supply of air to the manifold 17. This results in a variation in pressure in the manifold, and the pressure responsive member 56 immediately reacts thereto to make a corresponding adjustment in the amount of fuel supplied so that for a given temperature and barometric pressure a predetermined fuel-air ratio will be accurately maintained. The fuel-air ratio is subject to adjustment by means of the actuator 63 which serves to vary the range of reciprocation of the metering piston 89. Changes in temperature and pressure tending to cause a departure from the desired fuel-air ratio because of the change in air density are compensated for by the control device 56. The control may be rendered ineffective temporarily by opening the priming valve 132 to by-pass the metering piston 89.

By injecting each charge of fuel into a branch of the manifold 17, directly at the associated intake valve in timed relation with the air flow through said valve, and by reason of the metered character of the charge, good distribution of fuel is obtained even when a small amount of fuel mixture is being supplied to the engine.

I claim as my invention:

1. In a fuel injection system for an internal combustion engine having an intake manifold, an air throttle for controlling the admission of air to said manifold, and means including a throttle for supplying an adjustable amount of fuel to said engine for mixture with said air, a throttle control comprising, in combination, means responsive to the pressure in said manifold, and a rotatable cam mounted on an anti-friction bearing and having a crank connection with said pressure responsive means for adjustment in accordance with changes in said pressure, said cam being adapted for engagement at a non-sliding angle by said last mentioned throttle.

2. A fuel injection system for an internal combustion engine having a plurality of cylinders, an air intake manifold with branches leading respectively to said cylinders and an air throttle for controlling the admission of air to said manifold, said system comprising, in combination, a plurality of fuel injection valves mounted in spaced relation to discharge fuel into said manifold at

points adjacent the respective cylinders, a fuel pump for supplying fuel at a constant pressure, a rotary distributor for connecting said pump successively to said respective nozzles, said distributor comprising a reversibly movable displacement member for metering the amount of fuel in each charge, an adjustable stop for coacting with said member to define its range of movement, and a sealed pressure and temperature responsive diaphragm operatively connected to said stop and mounted in said manifold in the path of and in direct contact with the air flowing therethrough between said air throttle and said valves so as to be subject to the velocity influence of the air stream at a point in advance of the fuel supply.

3. In a fluid distribution system, a rotary distributor having, in combination, a casing, a rotor in said casing, said rotor having a charging chamber, a metering element reversibly movable in said chamber, a fluid inlet port opening to said casing, two fluid outlet ports opening to said casing, and means formed in said rotor for periodically connecting said inlet port to one end of said chamber and one of said outlet ports simultaneously to the other end of said chamber and at alternate periods connecting said inlet port to said other end of said chamber and the other of said outlet ports simultaneously to said one end of said chamber.

4. In a fluid distribution system, a rotary distributor having, in combination, a casing, a rotor in said casing, said rotor having a charging chamber, a metering element reversibly movable in said chamber, a fluid inlet port opening to said casing, two fluid outlet ports opening to said casing, means formed in said rotor for periodically connecting said inlet port to one end of said chamber and one of said outlet ports simultaneously to the other end of said chamber and at alternate periods connecting said inlet port to said other end of said chamber and the other of said outlet ports simultaneously to said one end of said chamber, and stop means extending into said chamber in the path of said element, and being adjustable to vary the range of movement of said element.

5. In a fluid distribution system, a rotary distributor having, in combination, a casing, a rotor in said casing, said rotor having a charging chamber, a metering element reversibly movable in said chamber, a fluid inlet port opening to said casing, two fluid outlet ports opening to said casing and spaced peripherally relative to said inlet port, and two peripherally spaced recesses formed in said rotor and communicating respectively with opposite ends of said chamber, said recesses being movable in sequence across said inlet port and respectively across said outlet ports, each recess communicating with its outlet port when the other recess is open to said inlet port.

6. In a fluid distribution system, a rotary distributor having, in combination, a casing, a rotor in said casing, said rotor having a charging chamber, a metering element reversibly movable in said chamber, a fluid inlet port opening to said casing, two fluid outlet ports opening to said casing and spaced peripherally relative to said inlet port, a by-pass port opening to said casing, a passage including a cut-off valve connecting said inlet and by-pass ports, and two peripherally spaced recesses formed in said rotor and communicating respectively with opposite ends of said chamber, said recesses being movable in uniformly timed sequence across said inlet port and respectively

across said outlet ports, each recess communicating with its outlet port and said by-pass port when the other recess is open to said inlet port.

7. In a fluid distribution system, a rotary distributor having, in combination, a casing, a rotor in said casing, said rotor having an axial chamber, a metering piston reciprocally mounted in said chamber, a plunger extending into one end of said chamber for adjusting the extent of reciprocation of said piston, a fluid pressure line, fluid outlet means, and coacting means formed in said casing and said rotor for alternately connecting opposite ends of said chamber to said inlet line, and for connecting each end of said chamber to said outlet means when the other end of said chamber is connected to said inlet line.

8. In a fluid distribution system, a rotary distributor having, in combination, a casing, a rotor in said casing, said rotor having an internal measuring chamber, a metering element reversibly movable in said chamber, a fluid inlet port opening to said casing, an even number of peripherally spaced slots formed in said rotor for movement in uniformly timed sequence across said inlet port, alternate slots being arranged respectively in two sets communicating respectively with said chamber at opposite sides of said element, and two sets of outlet ports opening to said casing and associated respectively with said sets of slots, each set of slots having one slot movable in sequence across the associated outlet ports, the ports of each set corresponding in number and relative peripheral spacing with the associated set of slots, said inlet port being staggered peripherally relative to said outlet ports by the distance between two adjacent slots.

9. In a fluid distribution system, a unitary power operable distributor having, in combination, a measuring chamber, a metering element reversibly movable in said chamber, two passages opening to said chamber at opposite sides of said element, a fluid pressure line, two fluid outlet lines, and means rotatable on an axis extending in the direction of movement of said element and for reversibly connecting said passages respectively first to said pressure line and one of said outlet lines, and then to the other of said outlet lines and said pressure line so as to alternately charge opposite sides of said chamber and in charging either one side of said chamber actuating said element to discharge the previously introduced fluid from the other side of said chamber.

10. In a fluid distribution system, a distributor having, in combination, a measuring chamber, a metering element reversibly movable in said chamber, two passages opening to said chamber at opposite sides of said element, a fluid pressure line, two fluid outlet lines, means for reversibly connecting said passages respectively first to said pressure line and one of said outlet lines, and then to the other of said outlet lines and said pressure line so as to alternately charge opposite sides of said chamber and in charging either one side of said chamber actuating said element to discharge the previously introduced fluid from the other side of said chamber, and means selectively available for by-passing said chamber to supply fluid from said pressure line alternately directly to said outlet lines.

11. In a fuel injection system for an internal combustion engine having means for introducing fuel into said engine, and a source of fuel, a timing device for periodically establishing a supply connection between said means and said source, said device having charge-metering

means for delivering a metered charge of fuel to said first mentioned means during each of said connections, and manually operable means for by-passing fuel from said source past said charge-metering means to said first mentioned means.

12. A fuel admission system for an internal combustion engine having an intake manifold, said system comprising, in combination, a housing mounted on one side of said manifold, a rotary fuel distributor mounted on said housing, said distributor being operable periodically to supply a metered charge of fuel to said manifold, said distributor having an axially adjustable member for determining the amount of fuel in each charge, said member extending into said housing, a sealed resilient pressure responsive diaphragm mounted in said manifold, one side of said diaphragm being free from movement and having a stem extending into said housing, a stop means in said housing adapted for engagement by said member, said stop means being adjustable to adjust said member, and means operatively connecting said stop means to said stem for adjustment in accordance with the movements of said diaphragm.

13. In a fluid distribution system, a distributor having, in combination, a casing having an elongated chamber, a pressure fluid source opening to said chamber intermediate its ends, a valve member adjustably mounted in said chamber, two spaced labyrinth grooves formed in the wall of said chamber adjacent each end of said member, a line for directing a lubricating fluid under pressure to the outer grooves, and a drain line opening from the inner grooves.

14. In a fluid distribution system, a rotary distributor having, in combination, a casing having a chamber, a pressure fluid port opening to the periphery of said chamber, a rotor in said chamber, two spaced annular labyrinth grooves formed in the wall of said chamber at one end of said rotor and beyond said port, a line for directing lubricating oil under pressure to the outermost groove, and a drain line opening from the innermost groove.

15. In a fuel injection system, in combination, a rotary distributor having an axially adjustable control member, a pressure responsive device axially spaced from and movable in the same general direction as said member, and a rotatable cam having a crank connection with said pressure responsive device and being adapted for engagement at a non-sliding angle by said control member.

16. In a fuel injection system for an internal combustion engine, in combination with an intake manifold, a housing mounted on said manifold, a rotary distributor mounted on said housing, and having an axially adjustable control member extending into said housing, a pressure responsive member operable in response to pressure changes in said manifold and extending into said housing for movement in the same general direction as said control member, and an adjustable stop in said housing for said control member, said stop being adjustable by said pressure responsive member.

17. In a fuel injection system, in combination with an intake manifold, a rotary metering distributor having an axially adjustable volume control member, a sealed resilient bellows diaphragm mounted in said manifold with one end in fixed position and the other end free to move in the same general direction as said control

member, said free end of said diaphragm and said control member being operatively associated.

18. A fuel injection system for an internal combustion engine having an intake manifold and an air throttle for controlling the admission of air to said manifold, said system comprising, in combination, metering and distributing means including an adjustable throttle and for supplying a variable amount of fuel in charges to different parts of said engine, means including an element movable reversibly in accordance with pressure and temperature changes in the air charge, and a one-direction locking wedge connection between said element and said throttle operable to adjust said throttle in synchronism with said element and to prevent back pressure of said throttle from influencing said adjustment or effecting an adjustment of said element.

19. In a fuel injection system, in combination, a rotary distributor having an axially adjustable control member, a pressure responsive device axially spaced from and movable in the same general direction as said member, and means including an adjustable cam member for transmitting the movement of said device to said control member, said last mentioned means being ineffective to transmit movement from said control member to said device.

20. In an engine fuel injection system, a movable member for varying the amount of fuel injected, a cam engageable with said member and having a cam face movable across said member in a plane substantially normal to the plane of movement of said member, means for moving said cam in said plane responsive in its action to changes in the condition of the air charge for the engine, and adjustable means for effecting a change in the phase relation of said cam and said last mentioned means, whereby either of said last two mentioned means is operable to vary the amount of fuel injected into said engine.

21. A fuel injection system for an internal combustion engine having an air inlet passage and an adjustable air throttle in said passage, said system comprising, in combination, a device for injecting fuel for combustion in said engine, and a temperature and pressure responsive element for adjusting the delivery of said device and operatively disposed in said passage directly in the path of the air flowing therethrough in advance of the region of fuel injection by said device, whereby said element is influenced by atmospheric humidity and the velocity of the air stream, but is not influenced by the air-fuel mixture.

22. A fuel injection system for an internal combustion engine having an atmospheric air inlet passage and an adjustable air throttle in said passage, said system comprising, in combination, a device for injecting metered quantities of liquid fuel without air by positive fuel pressure into said engine for mixture with the atmospheric air entering past said throttle, and a sealed temperature and pressure responsive element for automatically adjusting said device in accordance with temperature and absolute pressure changes in the air within said manifold, said element being operatively mounted in said passage directly in the path of and in contact with the air stream between said throttle and the region in which the fuel is injected by said device, whereby said element is influenced by the atmospheric humidity and the velocity of the air stream before carburization of the air.

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