

Sept. 27, 1949.

E. O. WIRTH ET AL

2,482,956

FUEL SUPPLY SYSTEM

Filed Aug. 10, 1946

3 Sheets-Sheet 1

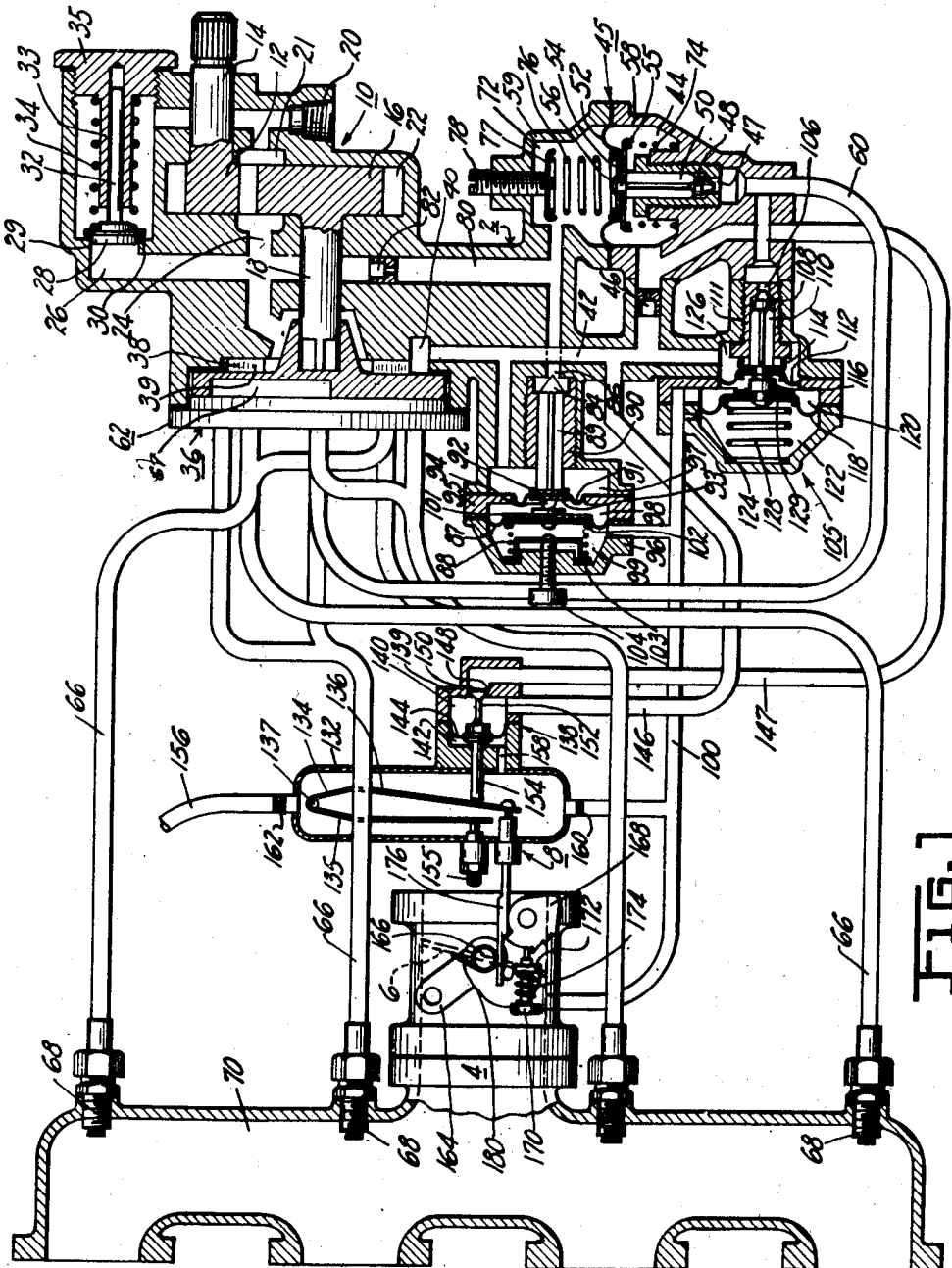


FIG. 1

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3 Sheets-Sheet 2

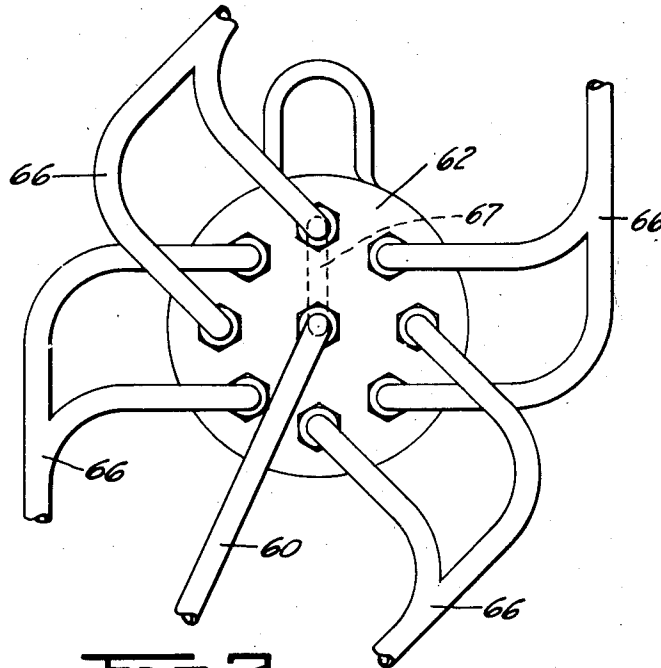


FIG. 2

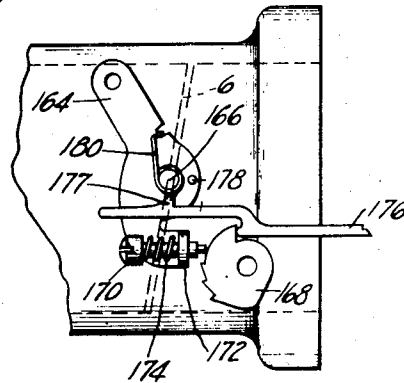


FIG. 3

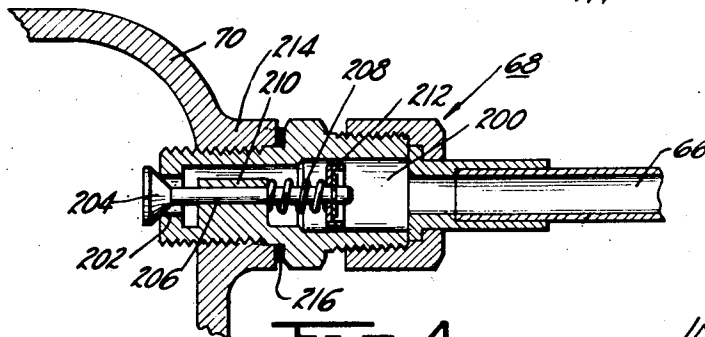


FIG. 4

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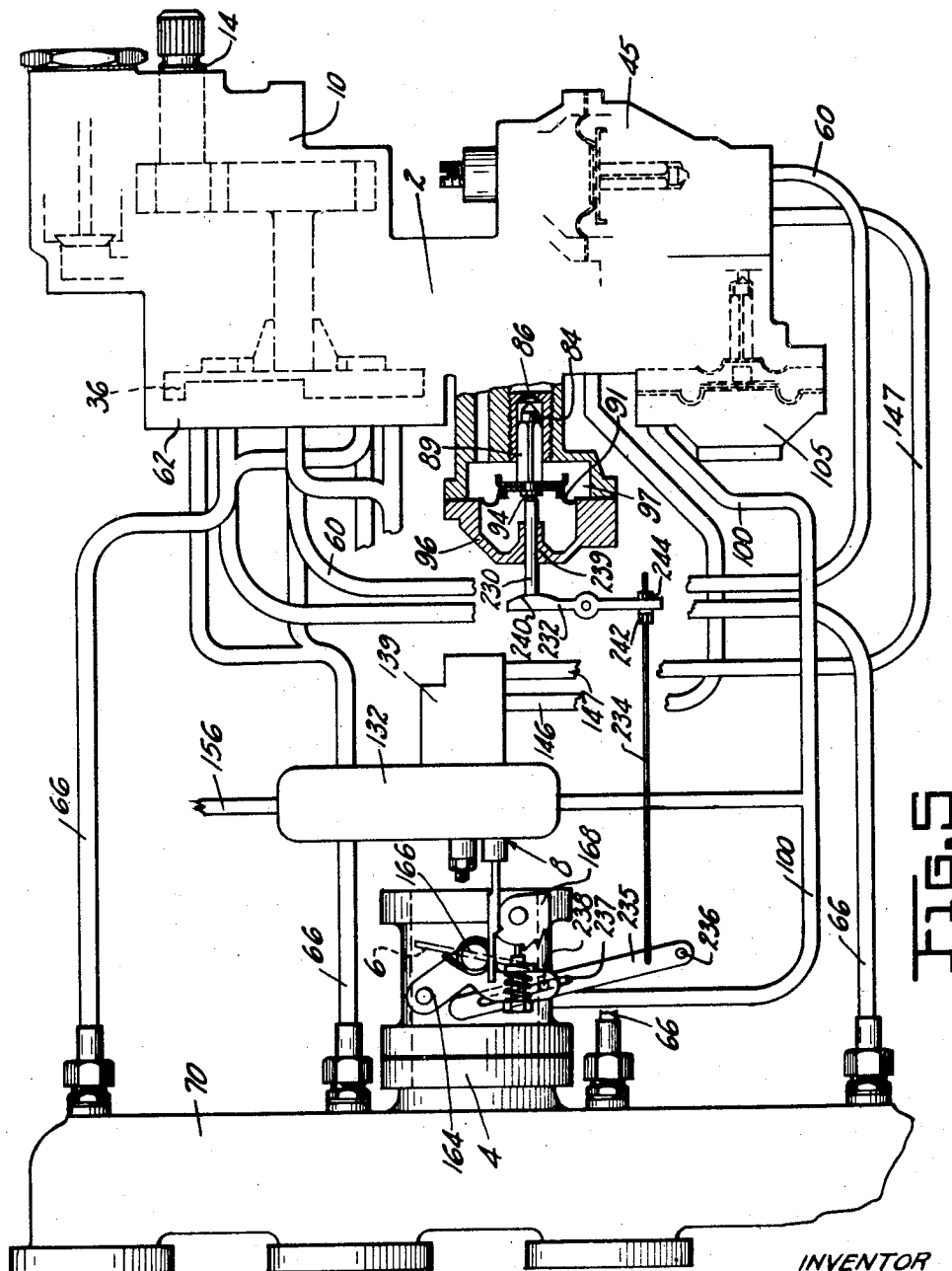
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UNITED STATES PATENT OFFICE

2,482,956

FUEL SUPPLY SYSTEM

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Application August 10, 1946, Serial No. 689,711

26 Claims. (Cl. 123—119)

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The present invention relates to a fuel system and more particularly to a fuel supply system for internal combustion engines wherein the fuel is supplied under superatmospheric pressure.

An object of the present invention is to provide a fuel supply system of the pressure feed type wherein the ratio of fuel-to-air is controlled in accordance with certain engine operating variables.

Another object of the invention is to provide a fuel supply system for an internal combustion engine or the like in which the ratio of fuel-to-air is controlled in response to the same engine operating variables that control the quantity of air entering the engine.

Another object of the invention is to provide a fuel supply system for an internal combustion engine in which a controlled supply of fuel to the engine is obtained by regulating the effective fuel metering head across a metering orifice in accordance with speed and temperature of the engine and pressure of the air in the induction passage or intake manifold thereof.

Still another object of the present invention is to provide a fuel supply system for an internal combustion engine capable of distributing the fuel uniformly to several cylinders of the engine under all normal engine operating conditions.

Still another object is to provide a fuel supply system for supplying fuel at superatmospheric pressure in accordance with engine speed and temperature and intake manifold pressure wherein a device is included to provide temporary fuel-to-air enrichment during acceleration of the engine.

Another object is to provide in a fuel supply system of the aforesaid type a means for correcting the fuel-to-air ratio in accordance with variations in volumetric efficiency of the engine.

Another object is to provide a compact, accurate fuel supply and metering device for delivering fuel to the engine in accordance with certain engine variables.

In order to obtain the foregoing objects and other objects which will be apparent from the following description, the present invention includes, in a fuel supply system of an internal combustion engine, a centrifugal pump driven at a speed directly proportional to the speed of the engine to provide a fuel metering head which varies in accordance with the square of the engine speed, and a fuel metering control unit having a regulating valve actuated in response to the pressure in the induction passage or intake manifold for controlling the fuel-to-air ratio relative

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to said pressure. A fuel distributor preferably formed integrally with the impeller of the aforementioned centrifugal pump is included to supply fuel to a plurality of discharge nozzles disposed in the intake manifold, the discharge of fuel through the several nozzles being synchronized with the firing of the various cylinders adjacent thereto. To provide for certain special operating conditions the fuel supply system also includes a device for giving temporary enrichment to the mixture when the throttle valve is opened, and a mechanism having a temperature responsive element incorporated therein for enriching the fuel-to-air mixture while the engine is cold.

From the detailed description which follows, modifications of and additions to the present invention will be apparent to those skilled in the art. It is to be understood that although only the preferred embodiment of the invention is disclosed in detail, many variations employing the principles of the invention are possible, and we contemplate the use of any such variations in structure, arrangement and mode of operation that properly fall within the scope of the appended claims.

Figure 1 of the drawings is a diagrammatic view of the present fuel system showing in cross section the various elements comprising the system and their position in relation to each other therein;

Figure 2 is a plan view of a fuel distributor showing the various fuel discharge conduits disposed in the marginal area of the distributor cover and a fuel inlet conduit leading to the center thereof;

Figure 3 is an enlarged view of the throttle control mechanism shown in Figure 1;

Figure 4 is a cross section through a discharge nozzle and a portion of the intake manifold taken on line 4—4 of Figure 1; and

Figure 5 is a diagrammatic view of a modification of the present fuel system.

Referring to Figure 1 of the drawings, in which various elements are shown diagrammatically, the present charge forming system broadly consists of a fuel metering device 2, an induction passage 4 having disposed therein a throttle valve 6 and an automatic choke and fast idle arrangement generally showing at 8. The expression "induction passage" as used throughout the specification and in the appended claims embraces any or all air intake passageways leading to the engine, as for example, the intake manifold and the passageway in which a throttle valve is disposed.

In Figure 1, a gear pump shown generally at 10 is provided for delivering fuel to a metering unit at a substantially constant pressure, in which pump gear 12 is mounted on shaft 14 and meshes with gear 16 mounted on shaft 18, said gears being driven by the engine, not shown, through any suitable and well known coupling means connected to the free end of shaft 14. Any other type of pump may be used in place of the gear pump; however, the gear pump is especially suitable for the fuel delivery means in the present metering device. A fuel inlet 20 and passage 21 introduce the fuel into the fuel supply system and to pump 10 where it is carried by the meshing gears 12 and 16 around the periphery of chamber 22 and discharged into pump outlet passage 24. A valve regulated pump by-pass 26 communicating with outlet passage 24 and inlet passage 20 is provided to maintain the fuel supply at a substantially constant pressure. The valve which regulates the pump by-pass, generally shown at 28, consists of a beveled disc 29 adapted to close orifice 30, a valve stem 32 slidably mounted in valve guide 33, and a calibrated spring 34 adapted to react between disc 29 and a cap 35 to urge the valve towards its closed position.

Pump 10 delivers fuel through a passage 24 to a centrifugal pump, generally shown at 36, consisting of an impeller 38 having blades 39 mounted on one end of the aforementioned gear pump shaft 18 and adapted to rotate therewith, and a spiral annular passage 40 around the impeller, said spiral passage communicating with conduit 42. The fuel which is discharged from the impeller 38 is delivered to chamber 44 of the pressure regulating unit 45 through a metering jet or orifice 46 disposed in conduit 42. The fuel pressure in chamber 44 is controlled by poppet valve 48 mounted on a valve stem 50 which is secured to a flexible diaphragm 52 and spring retainers 54 and 55 by pin 56 inserted in the end of stem 50. The diaphragm 52 which forms one wall of chamber 44 is secured in place by being marginally clamped between casings 58 and 59 of the pressure control unit.

A conduit 60 carries the fuel discharged from the metering unit through orifice 47 to a distributor, shown generally at 62, disposed in the lower side of the centrifugal pump and preferably formed integrally therewith. The distributor as well as the pump is driven by shaft 18. The rotor for distributing the fuel from intake conduit 60 to a plurality of discharge conduits 66 contains a radial groove 67 communicating with intake conduit 60 and intermittently with the several discharge conduits 66 as the rotor is driven by shaft 18. The fuel discharge conduits communicating with the distributor are provided with nozzles 68 so disposed in the intake manifold 70 as to provide maximum fuel distribution in the air entering the cylinders adjacent the several nozzles. Each nozzle is adapted to supply fuel to two adjacent cylinders and is connected with two alternately disposed outlet ports in the distributor cover as shown in Figures 1 and 2, to provide charges of fuel to two cylinders in timed relation with the cycle of the respective cylinders.

The valve 48 which controls the effective size of orifice 47 maintains the pressure in chamber 44 substantially equal to the pressure in chamber 72 situated in the pressure control unit 45 with the side of diaphragm 52 opposite chamber 44 comprising one wall of said chamber 72. A spring 74 provided in chamber 44 and adapted to react between spring retainer 55 and one wall of said

chamber, and a spring 76 provided in chamber 72 and adapted to react between spring retainers 54 and 77 are so calibrated as to close valve 48 when the engine is not running, thereby preventing the discharge of fuel through orifice 47 and conduit 60 to the engine. It is to be noted that the spring retainers are so disposed on opposite sides of the diaphragm 52 as to comprise stiffening members therefor and that the peripheral edge portions are turned outwardly relative to said diaphragm, both to prevent their damaging the diaphragm in any way and to retain the springs in their proper positions. A means may be provided such as screw 78, for modifying the tension in springs 74 and 76, thereby modifying the pressure of fuel discharged through valve 48 and consequently the amount of said fuel.

The pressure in chambers 44 and 72 is determined by the pressure in control passage 80 which communicates with the unmetered fuel posterior to the impeller 38 and with fuel anterior to the impeller through orifice 82. A pressure responsive poppet valve 84 controlling orifice 86 is provided for regulating the pressure in control passage 80, the effective size of said orifice being regulated in accordance with the pressure in the induction passage acting on diaphragm 87 in opposition to a spring 88 tending to close the valve. Valve 84 is supported by valve stem 89 slidably received in valve guide 90 and secured to diaphragm 91 and stiffening members 92 and 93 by pin 94 seated in the end of stem 89. Diaphragm 91 is secured in place by being marginally clamped between the body of the regulator unit and a spacer ring 95 and diaphragm 87 between said spacer ring and casing 96, thus forming chamber 97 for the unmetered fuel posterior to the impeller, chamber 98 vented to the atmosphere for air at barometric pressure and chamber 99 communicating with the induction passage through conduit 100 for air at the pressure in said induction passage. Stiffening members 101 and 102 are secured to either side of diaphragm 87 by a rivet inserted in centrally located holes in said members and diaphragm. Stiffening member 102 serves as a spring retainer for calibrated spring 88 disposed in chamber 99 and adapted to react between said spring retainer and a second spring retainer 103 mounted on the end of screw 104. The two diaphragms are held in fixed relationship to one another, and, as shown in the drawings, diaphragm 91 is substantially smaller than diaphragm 87. The size of diaphragm 91 is selected relative to the size of diaphragm 87 such that the pressure of the unmetered fuel urging diaphragm 91 and valve 84 to the left will best correct the rate of fuel supply to compensate for variations in volumetric efficiency, as will be more fully explained hereinafter.

An accelerating mechanism generally shown at 105 communicating directly with conduit 60 leading to distributor 62 is included in the fuel system to provide temporary enrichment of the fuel-to-air mixture when the throttle valve is opened. This enriching mechanism consists of an orifice 106 controlled by poppet valve 108 formed integrally with valve stem 110 which is slidably received in valve guide 111 and secured to flexible diaphragm 112 and stiffening members 114 by a pin 116 seated in the end of stem 110. Diaphragm 112 and a somewhat larger diaphragm 118 held in spaced relation thereto form chamber 120 which communicates with the induction passage through conduit 100 to open valve 108 when the pressure in said induction passage is suddenly

increased. Another chamber 122 is provided behind diaphragm 118 and communicates with the induction passage through a restricted port 124 and conduit 100. Port 124 permits the gradual equalization of pressure on either side of diaphragm 118, thereby permitting the seating of valve 108 over orifice 106. A chamber 126 on the side of diaphragm 112 opposite chamber 120 communicates with orifice 106 and with passage 42 for the unmetered fuel posterior to the impeller. A spring 128 disposed in chamber 122 reacts between spring retainer 129 and one wall of said chamber in opposition to the pressure in chambers 120 and 126 to urge poppet valve 108 to a position restricting the flow of fuel through orifice 106 and to passage 60. It may be seen that upon opening movement of the throttle, the resulting increase in pressure in the induction passage and in conduit 100 and chamber 120 will exert a greater total force on the large diaphragm 118 than on the small diaphragm 112, tending to compress spring 128 and to relieve to some degree the pressure urging poppet valve 108 to its closed position. The pressure of the unmetered fuel acting on diaphragm 112 urges said diaphragm in the direction required to open poppet valve 108, thus permitting a temporary increase in the discharge of fuel through orifice 106, conduit 60, and distributor 62 into the intake manifold 70.

The present invention includes an automatic mechanism for enriching the fuel-to-air mixture under abnormal engine operating conditions, such as cold starting or running during the warming-up period. In Figure 1 the mechanism for producing an enrichment in the mixture while the engine is cold is shown generally at 8 and consists of a casing 132 having disposed therein a bi-metallic heat responsive element 134 including arms 135 and 136 hinged on pin 137 in one end of casing 132. Although in the drawings a leaf type thermostat has been employed, it is understood that any equivalent heat responsive means, for example, a coiled bi-metallic element, may be substituted therefor, said elements being conventional and often employed as control elements in internal combustion engine fuel systems. Adjacent casing 132, though not necessarily mounted thereon as shown in the drawings, is a control valve unit 138 consisting of a housing 139, a fuel chamber 140 and a gas chamber 142, said chambers being separated by a fuel impermeable flexible diaphragm 144 secured in position by being marginally clamped between two halves of housing 139. Unmetered fuel from passage 42 enters chamber 140 through conduit 146 and is discharged into conduit 147 through orifice 148, the effective size of which is controlled by poppet valve 150 carried by a valve stem 152 and flexible diaphragm 144. Stem 154 is secured to the diaphragm on the side opposite valve stem 152 and extends into casing 132 to engage arm 136 of the thermostat 134. Diaphragm 144 is constantly urged to the left as shown in the drawings, when the engine is operated, by the pressure of the unmetered fuel in chamber 140 and thus tends to close valve 150 and to force arm 136 of the thermostat to the left. Thermostat 134 may be adjusted laterally in casing 132 to increase or decrease the force tending to open poppet valve 150 by adjusting the position of screw 155. Casing 132 is connected through conduit 156 with a source of heated air, for example, with a stove on the exhaust manifold, and through conduit 100 with the induction passage. By this arrangement, air of a temperature variable in accordance

with that of the engine is drawn into casing 132 around the thermostat, which expands when cooled to force poppet valve 150 to its open position and contracts as shown in the drawings when heated to permit said valve to close. It can readily be seen that when the engine is cold, valve 150 is held open by the thermostat, permitting fuel to flow from the unmetered passage 42 into chamber 44 to increase the discharge of fuel through orifice 47, conduit 60, distributor 62 and discharge nozzle 68. Chamber 142 is vented through passage 158 to the air passages of the control unit, and consequently diaphragm 144 is subjected to the intake manifold or induction passage suction through conduit 100. Restrictions 160 and 162 are provided in conduits 100 and 156 adjacent casing 132 for limiting the air flow in the heated air passages to prevent the suction in passage 100 from being dissipated to a point where it would be ineffective to operate the control valve 84 or accelerating unit 105 and to reduce the bleeding of air into the engine manifold so as to avoid adversely affecting the operation of the engine.

The throttle valve control assembly consists of a manually operated lever 164 mounted on one end of throttle valve shaft 166, a conventional fast idle cam shown at 168 provided with a plurality of steps, and a stop screw 170 for engaging the fast idle cam inserted in arm 172 of lever 164 and held in the desired adjusted position by spring 174. The position of the several steps on cam 168 is determined by the position of the thermostat 134 acting through rod 176 against an abutment on said cam. A torsion spring, not shown, may be used to lightly urge cam 168 in a clockwise direction, as shown in Figure 3. An extension of rod 176 having lug 177, and a pin 178 on lever 164, as shown in Figures 1 and 3, are provided to withdraw arm 136 of thermostat 134 from stem 154 and permit valve 150 to close when the throttle valve is wide open. The pin 178 on lever 164 does not engage lug 177 until the throttle valve is wide open and overtravel of lever 164 is effected. The overtravel is permitted by a yieldable connection consisting of a spring 180 curved around shaft 166 and having one end anchored in said shaft and the other end secured to the throttle valve lever 164. By this arrangement, in the event the engine becomes flooded, the inrush of air when the throttle valve is in wide open position and fuel valve 150 in closed position removes the excess fuel from the intake manifold and engine cylinders.

A cross section of one of the discharge nozzles together with a portion of the intake manifold 70 and discharge conduit 66 is shown in Figure 4 in which are included an outlet passage 200 and an orifice 202 controlled by valve 204 mounted on reciprocable stem 206 and urged to its closed position by a calibrated spring 208 reacting between bearing 210 supporting stem 206 and collar 212 secured to stem 206 near the end thereof opposite valve 204. Valve 204 remains closed until the pressure in conduit 66 and passage 200 builds up to a predetermined minimum. The nozzle, which has an externally threaded portion, is inserted into an internally threaded boss 214 formed in the intake manifold and held in a leak-proof relationship thereto by gasket 216.

Operation

In the normal operation of the present fuel metering device, fuel enters gear pump 10 through inlet 20 and passage 21 and is delivered thereby

through passage 24 to impeller 38, the pressure of said fuel between the gear pump and impeller being maintained at a substantially constant pressure by valve 28 and a calibrated spring 34 in pump by-pass 26. The fuel delivered to the impeller of the centrifugal pump 36 is discharged therefrom into passage 42 at an increased pressure. The pressure of the fuel discharged from the centrifugal pump will be greater than the pump inlet pressure by an amount which is directly proportional to the square of the speed of the impeller and thus directly proportional to the square of the engine speed.

The fuel from the impeller flows under increased pressure through metering orifice 46 into chamber 44 wherein it urges diaphragm 52, valve stem 50 and valve 48 from orifice 47 permitting the fuel of chamber 44 to discharge into conduit 60. The fuel in conduit 60 is delivered intermittently by revolving groove 67 of the distributor to the several discharge conduits 66 and nozzles 68 disposed in intake manifold 70.

The discharge of fuel through orifice 47 is regulated by the variable pressure in chamber 72 and passage 80 which communicate through orifice 82 with passage 24 anterior to the impeller and through valve controlled orifice 86 with the unmetered fuel in passage 42, creating a pressure in passage 80 and chamber 72 which will be of a value intermediate to the fuel pressures in passage 42 and in passage 24. The value of the pressure in passage 80 relative to the pressures anterior and posterior to the impeller will depend upon the effective size of valve controlled orifice 86 relative to the size of orifice 82. For example, if orifice 86 has an effective area equal to the orifice 82, the pressure in passage 80 will be substantially half way between the pressures anterior and posterior to the impeller, irrespective of the speed of said impeller. It is seen, therefore, that the differential between the pressure of the unmetered fuel posterior to the impeller and the pressure in passage 80 will vary as the square of the engine speed for any particular setting of the valve 84.

In the control unit, springs 74 and 76 are substantially in balance and are preferably so adjusted by screws 78 that valve 48 will close orifice 47 when the engine is not operating, thus preventing the discharge of fuel except when the engine is being cranked or operating under its own power. The pressures of the fuel, therefore, in chambers 44 and 72 will be maintained substantially equal during the operation of the engine, inasmuch as any increase in pressure in chamber 44, however slight, will cause valve 48 to open wider and permit the fuel to discharge through orifice 47 at a greater rate until the pressures in the two chambers are again equal. Should the pressure in fuel chamber 72 increase, the force thereof on diaphragm 52 will urge valve 48 toward its closed position, restricting the discharge of fuel through orifice 47, thus permitting the pressure in chamber 44 to increase until it is equal to the new pressure in chamber 72. Since the pressure of the metered fuel in chamber 44 is equal to control pressure in chamber 72 and the differential between the pressure of the unmetered fuel in conduit 42 and the control pressure varies as the square of the engine speed, the differential between the pressure in chamber 44 and that of said unmetered fuel likewise varies as the square of the engine speed for a given setting of valve 84. From the following, it is apparent that variations in pressure in chamber 72 result

in an increase or a decrease as the case may be in the quantity of fuel discharged through metering orifice 46.

The quantity of fuel which will flow through a given size metering orifice, such as metering orifice 46, will vary in proportion to the square root of the differential in the pressure between the fuel in passage 42 and in chamber 44 on opposite sides of said orifice, and since this differential varies as the square of the engine speed, it is apparent that the quantity of fuel which will flow through orifice 46 for a given setting of valve 84 will vary directly as the engine speed. Since the weight of air flow to an engine at a given manifold pressure varies substantially in direct proportion to engine speed, the fuel metering device described herein will supply fuel to the engine in accordance with air flow into the engine.

If the weight of air supplied the engine for any given speed should increase by increase in manifold pressure, the quantity of fuel delivered thereto will be increased accordingly by the effect of the increased pressure in the induction passage on diaphragm 87 urging valve 84 toward its closed position. As valve 84 moves toward closed position, the pressure in the control conduit 80 and chamber 72 is reduced as to more nearly approach the pressure in passage 24 anterior to the impeller, and as a consequence, valve 48 will open to permit fuel to discharge to the engine at a greater rate such that the pressure of the metered fuel in chamber 44 will be reduced to equal the reduced pressure in the control passage 80 and chamber 72. In other words, reducing the pressure in control passage 80 and chamber 72 reduces the pressure in chamber 44 and thereby increases the differential between the pressure of the unmetered fuel in passage 42 and the metered fuel in chamber 44. The fuel is therefore delivered through orifice 46 at a greater rate to compensate for the increased weight of air entering the engine.

In the present metering device, the valve for regulating the control pressure is adapted to operate to enrich the fuel mixture at high speeds to satisfy engine requirements. When the engine is idling, the pressure of the air in the manifold is relatively low, and as a result, the unmetered fuel pressure in chamber 97 and the atmospheric pressure in chamber 98 urge diaphragms 87 and 91 to the left and valve 84 to its open position, thereby increasing the effective area of orifice 86. With the valve in this position, the pressures in passage 80 and chamber 72 are relatively high and, by acting on diaphragm 52 and valve 48, create an equally high pressure in chamber 44 and a low differential across metering orifice 46, resulting in a low discharge of fuel through said metering orifice to the engine as previously described. When the engine is operating at relatively high speeds, which normally require an enriched fuel-to-air-mixture, the vacuum in induction passage will be relatively low, and valve 84 will be urged toward its closed position, restricting fuel in passage 42 and chamber 97 from entering passage 80. As a result, the pressure in passage 80, chambers 72 and 44 will approach the lower pressure in passage 24, causing an increase in the differential across orifice 46 and consequently an increase in the flow of fuel there-through to the engine as previously mentioned.

It is well known that as the speed of an internal combustion engine is increased, the volumetric efficiency thereof gradually decreases

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throughout most of the operating range, this decrease being particularly manifest at relatively high speeds. Since the present metering device delivers fuel to the engine at a rate directly proportional to the speed of the engine and consequently to the theoretically maximum volumetric efficiency of the engine, the fuel-to-air ratio would, unless corrected, become richer as the volumetric efficiency became less. To maintain the correct fuel-to-air ratio regardless of variations in volumetric efficiency, the present metering device includes small diaphragm 91 which forms one wall of chamber 97 and is thus subject to the pressure of the unmetereed fuel posterior to the impeller. By this arrangement, said unmetereed fuel pressure, which varies as the square of the engine speed, urges diaphragm 91 and valve 84 to the left permitting the pressure in control passage 80 and chamber 72 to change at a slightly greater rate than that effected by change in impeller speed. As previously explained, an increase in pressure in chamber 72 causes an equal increase in pressure in chamber 44 and a smaller differential across metering orifice 46. The fuel discharged, therefore, is reduced to approximately the amount required to compensate for the decrease in volumetric efficiency.

In the acceleration of the engine, the throttle valve is normally opened rapidly, resulting in a substantial decrease in the vacuum in the induction passage and a corresponding increase in the weight of air entering the engine. At this point in the operation of the engine it is generally desirable to increase the ratio of fuel-to-air to give a temporary high power output to the engine. In the mechanism for accomplishing this temporary enrichment, the increase in pressure in the induction passage which results when the throttle valve is opened is transmitted through conduit 100 to chamber 120 and urges diaphragm 118 to the left as shown in Figure 1, thereby compressing spring 128 and consequently decreasing the force tending to close valve 108. During the interval of increased pressure in chamber 120, the pressure of the unmetereed fuel in chamber 126 urges diaphragm 112 and valve 108 to the left, opening said valve and permitting additional fuel to be delivered to the distributor and thence to the engine. A relatively small port 124 permits the pressure in chamber 122 to gradually build up and to equalize the pressures in chambers 120 and 122 so that the original effective force of spring 128 tending to close valve 108 is again obtained. The valve 108 then closes and remains closed until the pressure in the induction passage is again increased.

During starting and warming-up of the engine, a higher ratio of fuel-to-air is required than during normal operation of the engine. In the present fuel metering device, this higher fuel ratio is accomplished by a thermostatically controlled valve 150 which admits fuel while the engine is cold from the unmetereed fuel passage through conduit 146 to conduit 147 communicating with the metered fuel passage anterior to valve 48, thus tending to increase the pressure in chamber 44 and consequently the discharge of fuel through orifice 47. When the engine becomes warm, the heated air drawn through casing collapses thermostat 134 permitting the pressure on diaphragm 144 to close valve 150.

The fast idle cam 168 which prevents the throttle valve from completely closing when the engine is cold is regulated by the thermostat 134 through rod 176 secured to arm 136 of the

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thermostat, said rod being adapted to rotate said cam in accordance with the position of said arm. The wide open kick arrangement which is adapted to close valve 150 when overtravel of the throttle valve lever is effected permits the removal of excess fuel from the induction passage, intake manifold and cylinders when the engine has become flooded in starting.

Figure 5

In the modification of the present invention shown in Figure 5, in which elements found in the preceding figures retain their original numbers, the ratio of fuel-to-air is regulated in accordance with engine speed and temperature and with the pressure in the induction passage as determined by the position of the throttle valve. In this arrangement, the position of valve 84, which regulates the pressure in control passage 80, is coordinated with the movement of the throttle valve 6 by any suitable connecting mechanism. The mechanism shown in the Figure 5, which is included only for the purpose of illustrating one possible connecting arrangement, consists of a rod 230, a centrally pivoted lever 232, a rod 234 and a lever 235 pivoted at 236 and having a longitudinal slot 237 in which a pin 238 seated in the throttle lever 164 is adapted to slide during the movement of the throttle valve 6. Shaft 230 is adapted to move longitudinally in guide 239 and to engage the head of pin 94 and indirectly valve stem 89 in order that valve 84 may be urged toward its closed position by the opening movement of the throttle valve 6, said valve 84 being urged toward its open position by the pressure of the unmetereed fuel in chamber 97 urging diaphragm 91 and valve 84 to the left. Lever 232 is provided with a cam 240 for engaging the free end of shaft 230, said cam preferably being so contoured as to produce certain desired fuel-to-air relationships for various engine operating conditions. For example, the cam can be provided with a peripheral hump at the point contacting the end of shaft 230 when the throttle is wide open, causing a relatively small opening through orifice 86 and consequently an increase in the discharge of fuel to the engine to provide a rich mixture while the engine is operating at high speed and pulling under heavy load.

Rod 234 which connects the end of lever 232 opposite the cam end with lever 235 is provided with nuts 242 and 244 on either side of lever 232 to permit adjustment of said levers relative to one another. From the foregoing description, it is seen that the construction and operation of the fuel metering device shown in Figure 5 are similar in most respects to those of the device shown in the preceding figures, the only variations in construction and operation between the two embodiments being those mentioned in the description of Figure 5.

Although only two specific examples of our invention have been included in the description, it will be understood that many variations may be made without departing from the scope of the invention. It is contemplated that other elements or devices than those shown in the drawing may be included in the present metering device to obtain satisfactory fuel-to-air mixtures under all engine operating conditions. A mechanism responsive to variations in atmospheric pressure may be included in the present metering device for varying the fuel-to-air ratio to maintain proper charging mixtures under sub-

stantial variations in atmospheric pressure. A supercharger may also be included in the air intake passage disposed either anterior or posterior to the throttle valve. The modifications necessary to include the foregoing elements in the present device will be apparent to those skilled in the art.

We claim:

1. In a fuel supply system for an engine, a fuel supply conduit, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, a means for varying the effective size of one of said orifices, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said valve for delivering metered fuel to the air entering the engine, and a temperature responsive means for controlling the richness of the fuel-to-air mixture.

2. In a fuel supply system for an engine having an induction passage, a conduit for delivering fuel to said induction passage, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, means for varying the effective size of one of said orifices in response to changes in the pressure in said induction passage, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said valve for discharging metered fuel intermittently into said induction passage, and a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature.

3. In a fuel supply system for an engine having an induction passage, a conduit for delivering fuel to said induction passage, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on the inlet and outlet sides of said pressure varying means and having two calibrated orifices therein, a means for varying the effective size of the orifice adjacent said outlet side in response to pressure changes in said induction passage thereby creating a variable pressure in said passageway, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the variable pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said valve for discharging metered fuel intermittently into said induction passage and a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature.

4. In a fuel supply system for an engine having an induction passage with a throttle valve therein, a conduit for delivering fuel to said induction passage, means for varying the pressure of said fuel in the conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure vary-

ing means and having two calibrated orifices therein, means for varying the effective size of one of said orifices with variations in the pressure in said induction passage accompanying change in throttle position thereby creating a variable pressure in said passageway, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the variable pressure in said passageway between said orifices, a plurality of fuel discharge nozzles communicating with said valve for delivering metered fuel to the induction passage posterior to said throttle valve, a fuel distributor between said nozzles and said valve for synchronizing the discharge of fuel with the firing of the cylinders adjacent the respective nozzles, and a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature.

5. In a fuel supply system for an engine having an induction passage with a throttle valve therein, a conduit for delivering fuel to said induction passage, means for varying the pressure of said fuel in the conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, means for varying the effective size of one of said orifices in response to pressure changes in said induction passage thereby creating a variable pressure in said passageway, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the variable pressure in said passageway between said orifices, a plurality of fuel discharge nozzles communicating with said valve for delivering metered fuel to the induction passage posterior to said throttle valve, a fuel distributor between said nozzles and said valve for synchronizing the discharge of fuel with the firing of the cylinders adjacent the respective nozzles, a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature, and a means controlled by the pressure in the induction passage for causing temporary enrichment in the fuel-to-air mixture when said throttle valve is opened.

6. In a fuel supply system for an engine having an induction passage with a throttle valve therein, a conduit for delivering fuel to said induction passage, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, means actuated by the movement of said throttle valve for varying the effective size of one of said orifices, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said valve for discharging metered fuel intermittently into said induction passage, and a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature.

7. In a fuel supply system for an engine having an induction passage with a throttle valve therein, a conduit for delivering fuel to said induction passage, means for varying the pressure of said fuel in the conduit in accordance with engine

speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, means actuated by the movement of said throttle valve for varying the effective size of one of said orifices thereby creating a variable pressure in said passageway, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the variable pressure in said passageway between said orifices, a plurality of fuel discharge nozzles communicating with said valve for delivering metered fuel to the induction passage posterior to said throttle valve, a fuel distributor between said nozzles and said valve for synchronizing the discharge of fuel with the firing of the cylinders adjacent the respective nozzles, and a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature.

8. In a fuel supply system for an engine, a fuel supply conduit, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a means for delivering fuel from a source to said pressure varying means, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, a means for varying the effective size of one of said orifices, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said valve for delivering metered fuel to the air entering the engine, and a temperature responsive means for controlling the richness of the fuel-to-air mixture.

9. In a fuel supply system for an engine having an induction passage, a conduit for delivering fuel to said induction passage, means for varying the pressure of the fuel in said conduit in accordance with engine speed, a means for delivering fuel from a source to said pressure varying means, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, a means for varying the effective size of one of said orifices in response to the pressure changes in said induction passage, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the variable pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said valve for delivering metered fuel to the air entering the engine, a fuel distributor in said conduit between said valve and said discharge means for synchronizing the discharge of fuel with the firing of the cylinders adjacent to the respective nozzles, a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature, and a means controlled by the pressure of air in the induction passage for causing temporary enrichment in the fuel-to-air mixture when the throttle valve is opened.

10. In a device for supplying fuel to an engine under superatmospheric pressure, said engine having an induction passage, a conduit, a means driven by said engine for varying the pressure of the fuel in the conduit by an amount proportional to the square of the engine speed, a means for supplying fuel from a source to said pressure varying means at a substantially con-

stant pressure, a passageway communicating with said conduit on the inlet and outlet sides of said pressure varying means and having two calibrated orifices therein, a means for varying the effective size of the orifice adjacent the outlet side of said pressure varying means in response to pressure changes in the induction passage, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to the metering jet regulated by the pressure in said passageway between said orifices, a plurality of discharge means communicating with said valve for delivering metered fuel to the air entering the engine, a fuel distributor between said discharge means and said valve for synchronizing the discharge fuel with the firing of cylinders adjacent the respective nozzles, a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature, and a means controlled by the pressure in the induction passage for causing temporary enrichment of the fuel-to-air mixture when the throttle valve is opened.

11. In a fuel supply system for an engine having an induction passage with a throttle valve therein, a fuel supply conduit, a means for varying the pressure of the fuel in said conduit in accordance with the engine speed, a means for delivering fuel from a source to said pressure varying means, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, a means actuated by the movement of said throttle valve for varying the effective size of one of said orifices, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said induction passage, a distributor for delivering metered fuel intermittently from said valve to the several discharge means, and a temperature responsive means for controlling the richness of the fuel-to-air mixture.

12. In a fuel supply system for an engine having an induction passage, a conduit for delivering fuel to said induction passage, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, means for varying the effective size of one of said orifices in response to the pressure changes in said induction passage, means responsive to the pressure variations produced by the first mentioned means for correcting for variations in volumetric efficiency of the engine, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said valve for discharging metered fuel intermittently into said induction passage, and a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature.

13. In a fuel supply system for an engine having an induction passage, a conduit for delivering fuel to said induction passage, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two

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calibrated orifices therein, means for varying the effective size of one of said orifices in response to the pressure changes in said induction passage, means responsive to the pressure variations produced by the first mentioned means for correcting for variations in volumetric efficiency of the engine, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices, and a plurality of fuel discharge means communicating with said valve for discharging metered fuel intermittently into said induction passage.

14. In a fuel supply system for an engine having an induction passage with a throttle valve therein, a conduit for delivering fuel to said induction passage, means for varying the pressure of said fuel in the conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, means for varying the effective size of one of said orifices in response to pressure changes in said induction passage thereby creating a variable pressure in said passageway, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the variable pressure in said passageway between said orifices, a plurality of fuel discharge nozzles communicating with said valve for delivering metered fuel to the induction passage posterior to said throttle valve, a fuel distributor between said nozzles and said valve for synchronizing the discharge of fuel with the firing of the cylinders adjacent the respective nozzles, a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature, and a means controlled by said temperature responsive means for preventing said throttle valve from completely closing when the engine is cold.

15. In a device for supplying fuel to an engine under superatmospheric pressure, said engine having an induction passage with a throttle valve disposed therein, a conduit for delivering fuel to said induction passage, a centrifugal pump driven by said engine for varying the pressure of the fuel in said conduit by an amount substantially proportional to the square of the engine speed, a passageway communicating with said conduit on the inlet and outlet sides of said centrifugal pump and having two calibrated orifices therein in spaced relation to one another, a valve for varying the effective size of the orifice adjacent the outlet side of said pump in response to the changes in pressure in the induction passage, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices, a plurality of discharge nozzles connected with the second mentioned valve for delivering metered fuel to the engine posterior to said throttle valve, a fuel distributor between said nozzles and said second mentioned valve for synchronizing the discharge of fuel with the firing of the cylinders adjacent the respective nozzles, a thermostat, a valve controlled by said thermostat for by-passing fuel around said metering jet to increase the richness of the fuel-to-air mixture when the engine is cold, and an accelerating mechanism actuated by increases in pressure in the induction passage for temporarily increasing

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the richness of the fuel-to-air mixture when the throttle valve is opened.

16. In a device for supplying fuel to an internal combustion engine under superatmospheric pressure, said engine having an induction passage with a throttle valve disposed therein, a conduit for delivering fuel to said induction passage, a centrifugal pump for varying the pressure of the fuel in the conduit by an amount substantially proportional to the square of the engine speed, a gear pump for delivering fuel from a source to said centrifugal pump at a substantially constant pressure, a passageway communicating with said conduit on the inlet and outlet sides of said centrifugal pump, and having two calibrated orifices therein, a valve for varying the effective size of the orifice adjacent the outlet side of the centrifugal pump in response to the changes in pressure in the induction passage, a metering jet disposed in the conduit downstream from said passageway, a valve in said conduit posterior to the metering jet regulated by the pressure in said passageway between said orifices, a plurality of discharge nozzles disposed in said induction passage and communicating with the second mentioned valve, a fuel distributor between said nozzles and said second mentioned valve for synchronizing the discharge of fuel with the firing of the cylinders adjacent the respective nozzles, a thermostat, a valve controlled by said thermostat for controlling the richness of the fuel-to-air mixture in accordance with engine temperature, and a fast idle cam, the position of which is controlled by said thermostat for preventing said throttle valve from completely closing when the engine is cold.

17. For use in a fuel supply system of an engine, a disc adapted to be rotatably driven by the engine, impeller blades on one side of the disc for receiving fuel from a source and delivering it to a fuel metering unit under an increased pressure, a radial slot on the other side of said disc adapted to receive fuel at its central portion from the fuel metering unit and to deliver it to a plurality of nozzles in intermittent communication with the outer portion of said slot.

18. For use in a fuel supply system for an engine, the combination of a centrifugal pump and a fuel distributor comprising a disc-like member adapted to be rotatably driven by the engine, impeller blades on one side of the disc for creating a fuel pressure variable with engine speed, and a radial slot on the other side of the disc for receiving metered fuel and delivering it intermittently to a plurality of conduits in timed relation with the engine.

19. In a fuel supply system for an engine having an induction passage, a conduit for delivering fuel to the engine, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, means for varying the effective size of one of said orifices with change in a condition selected from the group consisting of throttle position and induction passage pressure, a metering jet in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet, a movable wall connected to said valve and urged in valve closing direction by a pressure varying with the pressure in said passageway between said orifices and in a valve opening direction by a pressure varying with the pressure in said conduit between the valve and

metering jet, a plurality of fuel discharge means communicating with said valve for delivering fuel to said engine, and a means adapted to respond to an engine variant for varying the fuel delivery obtained by the remainder of said supply system.

20. For use in a fuel system of an engine, the combination of a centrifugal pump, a fuel distributor and a fuel supply pump, comprising a casing, a stator having at least one rotatable pump member therein mounted on a rotatable shaft, said shaft adapted to be driven by said engine, a second stator having an impeller therein, a fuel distributor having a radial slot for delivering fuel to a plurality of conduits communicating with said engine, a drive connecting said rotatable pump member and said impeller and a second drive connecting said impeller and said distributor whereby said rotatable member, impeller and distributor are driven together.

21. For use in a fuel system of an engine, the combination of a centrifugal pump and a fuel supply pump, said combination comprising a casing, a stator having at least one rotatable pump member therein mounted on a rotatable shaft, said shaft being adapted to be driven by said engine, a second stator having an impeller therein adapted to receive fuel from said fuel supply pump and to discharge the fuel at an increased pressure, and a drive connecting said rotatable pump member and said impeller whereby said rotatable member and impeller are driven together and a fuel pressure regulating means between said pumps.

22. In combination with an engine fuel system adapted to supply fuel at superatmospheric pressure to an induction passage of said engine, a conduit for delivering fuel to said induction passage, a pump means for varying the pressure in said conduit by an amount substantially proportional to the square of the engine speed, and a pump for receiving fuel from a source and for delivering it to said pressure varying means at a substantially constant pressure, the operation of said pressure varying means and said pump being synchronized.

23. In a fuel supply system for an engine having an induction passage, a conduit for delivering fuel to said induction passage, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on the inlet and outlet sides of said pressure varying means and having two calibrated orifices therein, means for varying the effective size of one of said orifices upon change in manifold pressure resulting from change in throttle position, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the variable pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said valve for discharging metered fuel intermittently into said induction passage and a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature.

24. In a fuel supply system for an engine, a fuel supply conduit, a means for varying the

pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, means responsive to change in load for varying the size of one of said orifices, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said valve for delivering metered fuel to the air entering the engine, and a temperature responsive means for controlling the richness of the fuel-to-air mixture.

25. In a fuel supply system for an engine having an induction passage with a throttle valve therein, a conduit for delivering fuel to said induction passage, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, means for varying the effective size of one of said orifices upon variations in load resulting from variations in throttle position, a metering jet disposed in said conduit downstream from said passageway, a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices, a plurality of fuel discharge means communicating with said valve for discharging metered fuel intermittently into said induction passage, and a temperature responsive means for controlling the richness of the fuel-to-air mixture in accordance with engine temperature.

26. In a fuel supply system for an engine having an induction passage, a conduit for delivering fuel to said induction passage, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a passageway communicating with said conduit on either side of said pressure varying means and having two calibrated orifices therein, means for varying the effective size of one of said orifices in response to the changes in pressure in said induction passage, means responsive to the pressure variations produced by the first mentioned means for correcting for variations in volumetric efficiency, a metering jet disposed in said conduit downstream from said passageway, and a valve in said conduit posterior to said metering jet regulated by the pressure in said passageway between said orifices.

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