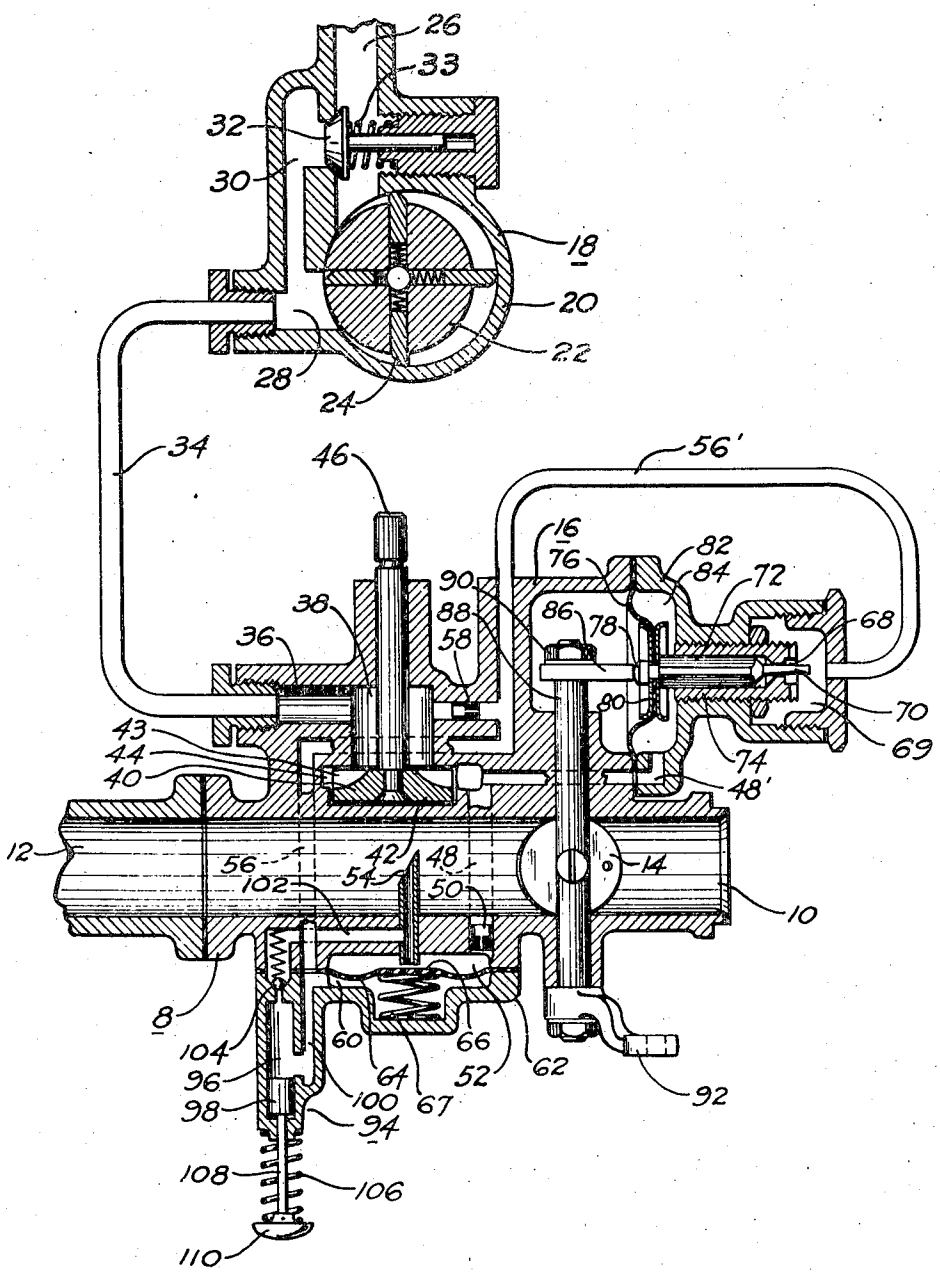
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FUEL SUPPLY SYSTEM

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INVENTORS.
FREDERIK BARFOD.
EMIL O. WIRTH.
BY M. A. Forbes
ATTORNEY.

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FUEL SUPPLY SYSTEM

Frederik Barfod and Emil O. Wirth, South Bend, Ind., assignors to Bendix Aviation Corporation, South Bend, Ind., a corporation of Delaware

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This invention relates to fuel supply systems for internal combustion engines, burners or the like and more particularly to systems in which liquid fuel is supplied under superatmospheric pressure.

An object of the present invention is to provide an improved simplified fuel supply system of the pressure feed type for controlling the ratio of fuel-to-air mixture in accordance with the engine requirements under all normal engine operating conditions.

Another object of the present invention is to provide a fuel supply system for an internal combustion engine or the like, wherein the ratio of fuel-to-air mixture is regulated in accordance with engine speed as modified by a manually actuated control.

Still another object of the invention is to provide a fuel supply system wherein the discharge of fuel into the induction passage of the engine is regulated in accordance with engine speed and throttle position.

Still another object of the invention is to provide a fuel supply system wherein a controlled supply of fuel to the engine is obtained by regulating the effective fuel metering head across a metering jet in accordance with variations in engine speed and air throttle position.

Another object of the invention is the incorporation of an improved simplified priming device in fuel supply systems of the aforesaid type to facilitate starting of the engine.

To realize these and other objects which will be apparent from the following description, the present invention includes, in a fuel supply system, a conduit in which are disposed an engine-driven centrifugal pump for varying the pressure of unmetered fuel in the conduit in accordance with engine speed, a jet for metering the fuel delivered by the pump and a metering head control unit communicating with the inlet and outlet passages of the centrifugal pump, the pressure of the fuel in the control unit being regulated by the throttle valve actuating means. A fuel discharge nozzle is provided in which the effective area of the nozzle is automatically varied to maintain the metered fuel pressure in accordance with the pressure in the control unit, the metered fuel pressure as determined by the control unit pressure and the unmetered fuel pressure as determined by the centrifugal pump jointly controlling the quantity of fuel supplied to the engine. The fuel system disclosed in this case is claimed broadly in our copending application Serial No. 607,290.

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The fuel supply system hereinafter more fully described is not limited to the particular embodiment disclosed in the specification and drawing but is understood to be available in many cases where a fuel supply system for controlling the ratio of fuel-to-air mixture in accordance with engine requirements is desirable. It is our intention to utilize any or all variations that properly fall within the scope of the appended claims.

A diagrammatical view of the fuel system is shown in the figure wherein 8 designates a carburetor body, 10 an induction passage, 12 an intake manifold, 14 a throttle valve, 16 a fuel regulator unit and 18 a pump for delivering the fuel to the system at a substantially constant pressure. A supercharger may be included in the system between the induction passage 10 and intake manifold 12 or as an alternative, it may be connected to the intake side of the induction passage. The pump generally indicated at 18 is provided for supplying liquid fuel from a source to the system preferably at a substantially constant predetermined pressure and consists of a stator 20, a rotor 22 disposed therein and having, as shown in the drawings, four spring loaded vanes 24 for contacting the peripheral surface of the stator 20. In operation, the fuel is drawn into the pump through intake 26 and discharged through outlet 28, the pressure being controlled by a by-pass conduit 30 regulated by a pressure responsive valve 32, so situated as to control communication between inlet conduit 26 and by-pass 30, urged to its closed position by calibrated spring 33. The fuel is delivered from the outlet 28 of the pump through conduit 34 to inlet passage 36 of the regulator unit 16.

The fuel entering regulator unit 16 from pump 18 passes through conduit 36 and passage 38 to pump 40. The pump which is of the centrifugal type consists of an impeller 42 having blades 43 disposed in chamber 44 and a shaft 45 rotatably mounted in body of regulator unit 16, joined to the impeller and connected by any suitable means to the engine which, though not shown in the drawing, rotates the impeller at a speed in direct proportion to the R. P. M. thereof to build up an outlet pressure for the metering head of the system. The outlet of pump 40 is connected to conduit 48 which through metering jet 50 communicates with chamber 52 in the wall of body 8. The pressure in chamber 52 is at all times during engine operation less than the pressure anterior to the metering jet 50, the difference therebetween being the effective metering head across the metering jet 50. Chamber 52 communicates

with the discharge nozzle 54 extending into the induction passage posterior to the throttle valve 14. A passage 56 leading from the intake side of the impeller and having restriction 58 therein communicates with chamber 60 in casing 62 which is separated from chamber 52 by a fuel impermeable flexible diaphragm 64, preferably having a substantially inflexible central portion 66 provided with a flat side adjacent the inlet to nozzle 54. The central portion 66 is adapted to fluctuate with the diaphragm in response to variations in pressure on either side thereof and to variably regulate the effective area of the inlet to nozzle 54 to thereby regulate the discharge of fuel according to said pressure variations. A relatively weak calibrated spring 67 seated in a cup-shaped portion of casing 62 is provided to yieldingly urge the central portion 66 of diaphragm 64 toward the inlet of nozzle 54 and to close the nozzle when the engine is not running to prevent the discharge of fuel. The diaphragm is marginally clamped in position between casing 62 and the periphery of chamber 52 on the carburetor body 8 by any conventional securing means, for example, machine screws which are not illustrated in the drawing.

The pressure of the fuel in passage 56 is controlled by varying the effective area of orifice 68 which permits more or less high pressure fuel from the outlet of pump 40 to enter the passage 56, the path for flow of said fuel being from pump 40, through extension 48' of passage 48, to orifice 68, and through chamber 69 into the extension 56' of passage 56. The means for varying the effective size of orifice 68 comprises a tapered valve 70 adapted to move longitudinally in orifice 68 and connected to or formed integrally with fluted valve stem 72 which is adapted to move longitudinally in guide 74, said stem being secured at its outer end to a flexible diaphragm 76 by the deformation of the outer end 78 of stem 72 around the apertures in the diaphragm 76 and stiffening members 80. The stiffening members which are provided to render the central portion of diaphragm 76 inflexible consist of a metal plate secured to either side of the diaphragm by the outer end of stem 72, the edges of said plates being rolled outwardly to prevent the diaphragm from being punctured or otherwise injured by sharp edges or burs on the plate. In the assembled fuel system, diaphragm 76, which is of rubber-like material impermeable to fuel is secured in place by the marginal edge thereof being clamped between the edge of casing 82 and the body of regulator 16. Chamber 84 communicates with passage 48' and is therefore subjected to the unmetered fuel pressure posterior to impeller 42; thus, during the operation of the engine, diaphragm 76 is urged outwardly and valve 70 is urged toward its open position.

The position of valve 70 in orifice 68 is controlled in accordance with the position of throttle valve 14 through cam 86 mounted on throttle shaft 88 and secured rigidly thereto by nut 90. The effective area of orifice 68 is decreased by the movement of valve 70 and valve stem 72 to the right, as shown in Figure 1, when the throttle valve is opened by the operator. The throttle valve is actuated by the accelerator pedal lever or any equivalent thereof or controlled by a governor through any well known connecting means, which may be joined to lever 92 mounted on the outer end of throttle shaft 88.

A priming means may be included in the fuel system to give an enriched mixture while the engine is being started. A manually operated primer is shown generally at 94 and consists of a cylinder 96, piston 98, fuel passage 100 connecting cylinder 96 to the passage 56 and a discharge passage 102 leading from the end of cylinder 96 to discharge nozzle 54 and having a spring loaded ball check valve 104 disposed therein. The piston is urged to the position shown in the drawing by spring 106 mounted on rod 108 between the end of cylinder 96 and control nob 110. Fuel drawn from the fuel supply line 36 through passages 56 and 100 into the cylinder is entrapped in the forward end of the cylinder as the forward movement of piston 98 closes passage 100 and is forced through passage 102 and discharge nozzle 54 into the induction passage 10. The spring in the check valve is sufficiently strong to prevent the flow of fuel in either direction through passage 102 except when piston 98 is delivering fuel to passage 102.

The operation

In the normal operation of the internal combustion engine employing the present fuel system, liquid fuel is delivered by pump 18 or any suitable equivalent thereof to inlet passage 36 of the fuel regulator unit and thence through passage 38 to the impeller 42 of pump 40. The fuel received by pump 40 is discharged under increased pressure into passage 48 from which it flows through metering orifice 50 and into the chamber 52 urging diaphragm 64 away from the inlet of nozzle 54 to permit the fuel to discharge into induction passage 10.

Due to the inherent characteristics of the centrifugal pump 40, the pressure of the fuel in the outlet of the pump will be greater than the pump inlet pressure by an amount directly proportional to the square of the speed of the pump and therefore proportional to the square of the engine speed.

When throttle 14 is partially opened, the effective size of orifice 68 is restricted to a value less than that at closed throttle by tapered valve 70, said valve and adjoining valve stem being held in a partially opened position by cam 86 contacting head 78 of the valve stem. As a result, the flow of fuel through orifice 68 into passage 56, which is in communication with chamber 60 behind diaphragm 64, will be such that the pressure in said chamber will be of a value intermediate the fuel pressure on the inlet and outlet sides of the impeller of pump 40. The value of this intermediate pressure in reference to said inlet and outlet pressures will depend upon the effective areas of orifice 68 relative to orifice 58. Consequently, if orifice 68 has an effective area equal to orifice 58, the pressure in passage 56 will remain substantially half-way between the pressure of the fuel anterior to the impeller and that of the unmetered fuel posterior to the impeller irrespective of variations in the speed of impeller 42. The difference between the pressure of the unmetered fuel posterior to the impeller and the pressure in passage 56 therefore will vary as the square of the engine speed for any fixed setting of valve 70.

The pressure of the metered fuel in chamber 52 on one side of diaphragm 64 and the pressure of the fuel in chamber 60 on the other side of the diaphragm will be maintained substantially equal throughout the operation of the engine. In the event the pressure of the metered fuel in chamber 52 should tend to exceed the pressure of that behind diaphragm 64 as a result of increased fuel delivered by the impeller, the diaphragm will

move away from the nozzle inlet permitting the excess fuel to discharge into the induction passage at an increased rate such that the pressures on either side of the diaphragm will again become substantially equalized. Should the pressure of the fuel behind the diaphragm in chamber 60 exceed that of the metered fuel, the diaphragm will move toward the nozzle inlet restricting the discharge of fuel from chamber 52 and consequently permitting the pressure in chamber 52 to increase until it is equal to the pressure behind the diaphragm. It is therefore apparent that the difference between the pressure in chamber 52 and the pressure in passage 48 likewise will vary as the square of the engine speed for a given setting of valve 70.

It is well known that the quantity of fuel which will flow through a given size metering orifice such as metering jet 50 will vary in proportion to the square root of the differential between the pressures of the unmetered fuel and the metered fuel on the opposite sides of the metering jet, and since this differential varies as the square of the engine speed the quantity of fuel flowing through orifice 50 for a given setting of valve 70 will vary directly as the engine speed. In view of the fact that the weight of air flowing into an engine at a given throttle position varies substantially in direct proportion to the engine speed, except for variations caused by variables such as exhaust back pressure and intake air, the device herein described will supply fuel to the engine in accordance with air flowing thereinto as modified by throttle position.

Upon decrease in the effective area of orifice 68 with opening movement of the throttle, pressure in passage 56 will be reduced so as to more nearly approach the pressure anterior to impeller 42 and as a result, the diaphragm 64 will shift away from nozzle 54 to permit discharge of fuel into the induction passage at a greater rate such that the pressure in chamber 52 will be reduced to equal the new pressure in passage 56. In other words, reducing pressure in passage 56 reduces the pressure in chamber 52 and thereby increases the differential between the metered and unmetered fuel in conduit 48. The fuel therefore is delivered through jet 50 at a greater rate to compensate for the increase in air flow which results when the throttle is opened. By properly shaping valve 70 or cam 84 the effective area of orifice 68 may be so controlled as to obtain any desired fuel-to-air relationship for variations in engine operating conditions. The variations, such as power or idle enrichment, may be accomplished by contouring the valve 70 to give the desired flow of fuel through orifice 68 when the throttle valve is moved either to its wide open position or to its substantially closed position to thereby provide whatever mixture richness is desired. Further, certain variations can also be accomplished by varying the contour of cam 86. For example, the cam can be provided with a peripheral lobe at the point contacting the end of stem 72 when the throttle is wide open, thus nearly closing valve 70 and consequently decreasing the pressure in passage 56. This therefore would cause an increase in the supply of fuel to the engine to provide a rich mixture while the engine is operating at high speed or pulling under heavy load.

It is contemplated that other elements or devices than those shown in the drawing may be included in the present fuel system to obtain various desired fuel-to-air relationship under diverse engine operation conditions. The economizer for

power enrichment, the acceleration device for giving temporary enrichment when the throttle is opened, and the temperature control for modifying the richness of the fuel mixture in accordance with temperature of the engine, all of which are shown and described in detail in our copending application Serial No. 607,290, filed July 27, 1945, may be included in the present fuel system either separately or together, in any combination of the three devices, without departing from the scope of the present invention. Further, the fuel distributor and a plurality of fuel discharge nozzles such as those disclosed in our copending application Serial No. 609,230, filed August 6, 1945, may be substituted for the single nozzle arrangement shown in the present drawing. A mechanism responsive to variations in atmospheric pressure for varying the speed of the impeller relative to the engine speed may also be included in combination with the fuel system to obtain a fuel leaning or enriching effect for maintaining proper fuel-to-air ratio under substantial variations in atmospheric pressure, such as those occurring as a result of changes in altitude. Means for conveniently obtaining variations in the speed of the impeller relative to engine speed are well known to those skilled in the art; for example, the impeller may be driven by the engine through a fluid drive or by variable speed pulleys.

From the foregoing description of the present invention it is apparent that a comparatively simple fuel system has been developed to give, throughout the normal operating range, a substantially constant fuel-to-air mixture ratio subject to such modification as may be required to effect variations in said ratio for maximum economy and power and idle enrichment. Although only one specific embodiment of the present invention has been given herein, it will be understood that many variations may be made without departing from the scope of the invention.

We claim:

1. In a fuel supply system for an engine, a conduit having a discharge nozzle for delivering fuel to the engine, a means driven by said engine for varying the pressure of the fuel in said conduit in accordance with engine speed, a restriction in said conduit posterior to said first mentioned means for metering the fuel delivered to said engine, and a means communicating with the inlet and outlet sides of the first mentioned means for controlling the metering head across said restriction, said last mentioned means being regulated in accordance with throttle position.

2. A fuel feeding device for an engine, comprising a conduit adapted to receive fuel from a source and to deliver the fuel to said engine, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a metering orifice in said conduit for metering the fuel delivered to said engine, a means communicating with the conduit anterior to said pressure varying means and with unmetered fuel posterior thereto for controlling the metering head across said orifice, said last mentioned means being regulated in accordance with throttle position.

3. In a fuel supply system for an engine, a conduit having a discharge nozzle for delivering fuel to the engine, a means for supplying fuel to said conduit at a substantially constant pressure, means for varying the pressure of the fuel in said conduit in accordance with engine speed, an orifice in said conduit posterior to said pressure

varying means for metering the fuel delivered to said engine, and a means communicating with the conduit anterior to said pressure varying means and with unmetered fuel posterior thereto for controlling the metering head across said orifice, said last mentioned means being regulated in accordance with throttle position.

4. A fuel feeding device for an engine having an induction passage with a throttle valve therein, comprising a conduit having a discharge nozzle in said induction passage for delivering fuel to the engine, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a restriction in said conduit for metering the fuel delivered to said nozzle, and a means regulated by the throttle actuating means and communicating with the inlet and outlet sides of the first mentioned means for controlling the metering head across said restriction.

5. In a fuel supply system for an engine having an induction passage with a throttle valve therein, a conduit having a discharge nozzle in said induction passage for delivering fuel to the engine, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, a restriction in said conduit posterior to said pressure varying means for metering the fuel to said nozzle, and a means regulated by the throttle actuating means and communicating with the conduit anterior to said pressure varying means and with unmetered fuel posterior thereto for controlling the metering head across said restriction.

6. In a fuel supply system for an engine having an induction passage with a throttle valve therein, a conduit having a discharge nozzle in said induction passage, a means driven by said engine for varying the pressure of the fuel in said conduit in accordance with engine speed, an orifice in said conduit posterior to said pressure varying means for metering the fuel delivered to said nozzle, a means communicating with the inlet and outlet sides of the pressure varying means for controlling the metering head across said orifice and means regulated by the throttle actuating means for regulating the metering head controlling means.

7. A fuel feeding device for an engine having an induction passage with a throttle valve therein, comprising a conduit having a discharge nozzle in said induction passage for delivering fuel to the engine, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, an orifice in said conduit posterior to said pressure varying means for metering the fuel delivered to said engine, a means communicating with the conduit anterior to said pressure varying means and with unmetered fuel posterior thereto for controlling the metering head across said orifice, and a means regulated by the throttle actuating means for regulating the metering head controlling means.

8. In a fuel supply system for an engine having an induction passage with a throttle valve therein, a conduit having a discharge nozzle in said induction passage for delivering fuel to the engine, a means for varying the pressure of the fuel in said conduit in accordance with engine speed, an orifice in said conduit posterior to said pressure varying means for metering the fuel to said nozzle, a means regulated by the throttle actuating means and communicating with the conduit anterior to said pressure varying means and with unmetered fuel posterior thereto for controlling the metering head across said orifice, and a means communicating with said conduit for drawing fuel therefrom and discharging it into the induction passage to enrich the ratio of fuel-to-air mixture during engine starting.

9. In a fuel supply system for an internal combustion engine or the like having an induction passage with a throttle valve therein, a conduit having a discharge nozzle in said induction passage for delivering fuel to the engine, a pump for supplying fuel to said conduit at a substantially constant pressure, a means driven by said engine for varying the pressure of the fuel in said conduit in an amount proportional to the square of the engine speed, an orifice in said conduit posterior to said pressure varying means for metering the fuel delivered to said engine, a means communicating with the conduit anterior to said pressure varying means and with unmetered fuel posterior thereto for controlling the metering head across said orifice, and a means regulated by the throttle actuating means for regulating the metering head controlling means.

10. A fuel supply system for an engine having an induction passage with a throttle valve therein, a conduit having a discharge nozzle in said induction passage for delivering fuel to said engine, a pump for supplying fuel to said conduit at a substantially constant pressure, a centrifugal pump driven by said engine for varying the pressure of the fuel in said conduit in accordance with engine speed, an orifice in said conduit posterior to said centrifugal pump for metering the fuel delivered to said engine, a control passage communicating with the conduit anterior to said centrifugal pump and with a passage for unmetered fuel posterior thereto and having a fuel metering orifice near each end thereof and means regulated by the throttle actuating means for varying the effective size of one of said orifices to control the pressure in said conduit and thereby to control the quantity of fuel discharged into said induction passage.

11. A fuel supply system for an engine having an induction passage with a throttle valve therein comprising, a conduit having a discharge nozzle in said induction passage for delivering fuel to the engine, a means for supplying fuel to said conduit at a substantially constant pressure, a centrifugal pump driven by said engine for varying the pressure of the fuel in said conduit in an amount proportional to the square of the engine speed, an orifice in said conduit posterior to said centrifugal pump for metering the fuel delivered to said nozzle, a control passage communicating with the conduit anterior to said centrifugal pump and with the passage for unmetered fuel posterior thereto and having a metering orifice near each end thereof and means actuated by the throttle actuating means for varying the effective size of one of said orifices to regulate the pressure in said control passage, the metered fuel posterior to said centrifugal pump and the fuel in said control passage communicating with opposite sides of a diaphragm controlling the discharge nozzle, whereby the discharge of fuel into said induction passage is controlled in accordance with variations in the fuel pressure on either side of said diaphragm.

12. In a fuel feeding device for an engine, burner or the like, a centrifugal pump having an inlet adapted to receive fuel from a source and a fuel discharge passage, a metering restriction in the discharge passage, a valve in the passage posterior to the restriction, a passageway interconnecting the discharge passage and inlet of the pump and having two calibrated restrictions in series therein, means responsive to varia-

tions in the pressure in said passageway between the restrictions for controlling said valve, a main control element for controlling the output of the engine, burner or the like, and means operated by movement of said element for varying the effective size of one of said restrictions.

13. A fuel feeding device for an engine comprising an air supply conduit having a throttle therein, a centrifugal impeller adapted to be driven by the engine, a fuel inlet to the impeller, a fuel outlet from the impeller for supplying fuel to the engine, a metering orifice in the outlet, a by-pass from the outlet anterior to the orifice to the fuel inlet, said by-pass containing two restrictions in series therein, a valve in the outlet posterior to the metering restriction, means responsive to the pressure in said by-pass between the two restrictions for controlling said valve, an element for varying the effective size of at least one of said restrictions, and a mechanical

connection between the element and the throttle for controlling the position of said element.

FREDERIK BARFOD.
EMIL O. WIRTH.

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