

[54] **FUEL INJECTION SYSTEMS**  
 [75] Inventor: **Brian Carol Silvester**, Leamington Spa, England  
 [73] Assignee: **Associated Engineering Limited**, Leamington Spa, Warwickshire, England  
 [22] Filed: **Sept. 30, 1971**  
 [21] Appl. No.: **185,090**  
 [30] **Foreign Application Priority Data**

Sept. 30, 1970 Great Britain..... 46594/70

[52] U.S. Cl..... **123/139 AW, 123/140 MP**  
 [51] Int. Cl..... **F02m 39/00**  
 [58] Field of Search..... 123/119 R, 32 EA, 123/32 AE, 139 AW, 140 MP

[56] **References Cited**

**UNITED STATES PATENTS**

2,924,206 2/1960 Groves..... 123/119 R

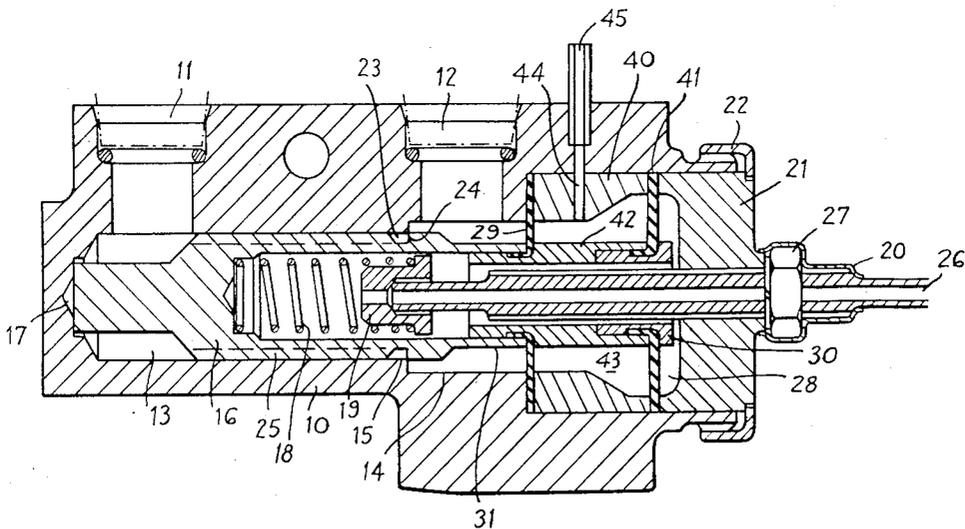
3,319,613 5/1967 Begley et al..... 123/32 EA  
 3,543,739 12/1970 Mennesson..... 123/32 EA  
 3,596,640 8/1971 Bloomfield..... 123/32 EA

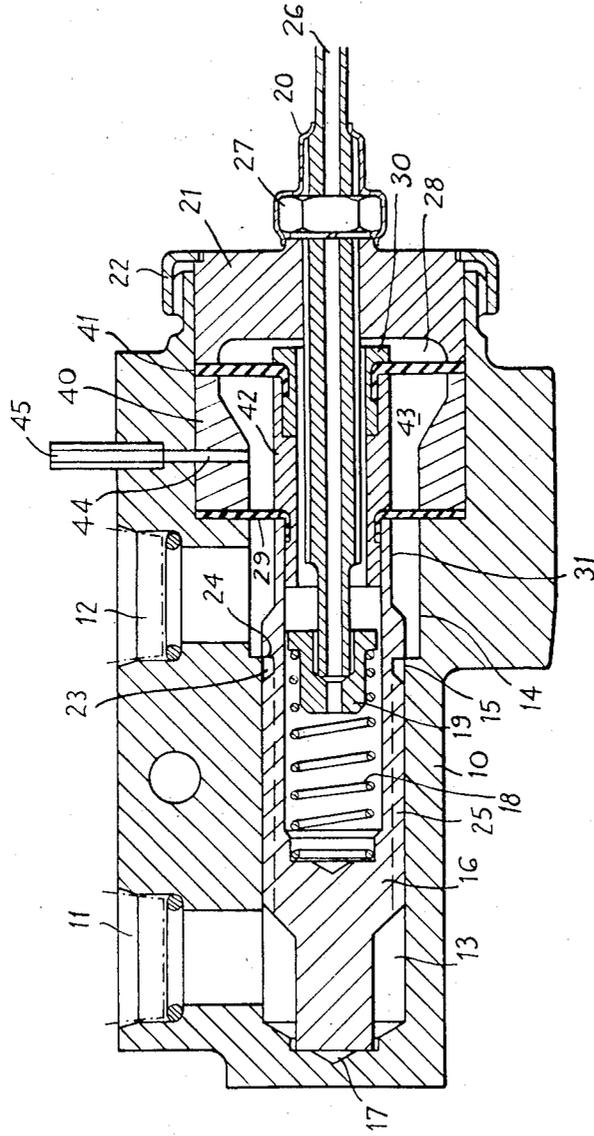
*Primary Examiner*—Laurence M. Goodridge  
*Assistant Examiner*—Cort Flint  
*Attorney*—Holcombe, Wetherill & Brisebois

[57] **ABSTRACT**

This invention relates to a fuel injection system and to a fuel pressure regulator therefor. A fuel injection system, for injecting pressurised fuel into an inlet duct or manifold of an engine includes a fuel-flow metering orifice which is fed with the pressurised fuel and which is exposed on its downstream side to the pressure obtaining in the inlet duct or manifold, and a fuel pressure regulator is arranged to regulate the fuel to a pressure which exceeds the inlet duct pressure by an amount which increases with increasing inlet duct absolute pressure.

**5 Claims, 1 Drawing Figure**





## FUEL INJECTION SYSTEMS

This invention relates to a fuel injection system and to a fuel pressure regulator therefor.

According to one aspect of the invention there is provided a fuel injection system, for injecting pressurised fuel into an inlet duct or manifold of an engine, including a fuel-flow metering orifice to be fed with the pressurised fuel and to be exposed on its downstream side to the pressure obtaining in the inlet duct, and including a fuel pressure regulator arranged to regulate the fuel to a pressure which exceeds the inlet duct pressure by an amount which increases with increasing inlet duct absolute pressure.

Conveniently the supply of fuel to the orifice is periodically interrupted for predetermined times to control the flow of fuel.

Suitably the interruption of fuel supply is effected by a solenoid operated injector valve.

According to another aspect of the invention there is provided a fuel pressure regulator, for use in a fuel injection system of the type arranged to inject pressurised fuel into an air duct or manifold of an engine, including a member having an area subject to the pressure of fuel to be regulated, the fuel pressure generating a force on the member tending to move it to open an aperture so as to reduce fuel pressure, and another area in the regulator exposed to the pressure of the air in the duct, the said other area being connected to the member in a manner which would generate a greater force on the member than the opposing force generated on the member by the first-mentioned area if both areas were subject to the same pressure. Preferably the two areas are directly connected but the said other area is greater than the first-mentioned area.

The invention is described, by way of example only, with reference to the accompanying drawing which is an axial section through one embodiment of the invention.

In the drawing a valve, for regulating the pressure of liquid fuel fed to the injector in a fuel injection system of an internal combustion engine, has a body 10 in which are formed fuel inlet and outlet passages 11, 12, respectively. The passages 11, 12 are joined by a bore 13 which terminates in a larger concentric bore 14 adjacent the outlet passage 12. The junction of the bores 13, 14 is a shoulder having a sharp corner 15.

A hollow cylindrical plunger 16 is an accurate sliding fit in the bore 13 and is urged towards the blind end 17 of the bore 13 by a low rate pre-compressed helical spring 18.

The spring 18 reacts against a thimble 19 mounted on the end of an adjusting screw 20. The latter is screwed into an end cap 21 which is held to the body 10 by a nut 22 to close the outlet end of the bores 13, 14. The plunger 16 has a circumferential groove 23 formed with a sharp corner 24 which aligns with the sharp corner 15 when the plunger 16 is in contact with the blind end 17 of the body 10. The groove 23 communicates with the inlet passage 11 by longitudinal grooves 25 formed in the plunger 16.

When pressurised fuel is admitted through the inlet passage 11 it produces an axial force on the plunger 16 which moves it to the right in the FIGURE to open an aperture between the sharp corners 15, 24. Due to the low rate of the spring 18 the pressure of inlet fuel in-

creases this aperture until the fuel flowing therethrough has the desired regulated inlet pressure.

Fuel having passed through the regulating aperture escapes through the larger bore 14 and outlet passage 12.

The interior of the plunger 16 and the end space 28 of the bore 14 adjacent the end cap 21 is vented to inlet manifold pressure through a bore 26 in the adjusting screw 20 which is locked by a lock nut 27. The plunger 16 is sealed to the body 10 by a rubber-like or other suitable diaphragm 29. The diaphragm 29 is held against an end face of the body 10 by a spacer sleeve 40, which is trapped by a further rubber-like diaphragm 41 and the end cap 21. The diaphragm 29 is held against the right hand end face of the plunger 16 by a shouldered sleeve 42 screwed into the plunger 16, and the further diaphragm 41 is sealed by a shouldered sleeve 30, screwed into the shouldered sleeve 42.

Downstream of the regulating aperture the plunger 16 has a reduced diameter portion 31. Any back-pressure obtaining in the outlet passage 12 will act on the difference in area between the plunger 16 at the sharp shoulder 24 and at the reduced diameter portion 31 to produce force tending to urge the plunger 16 towards the left in the FIGURE. Simultaneously the outlet back-pressure acts on the diaphragm 29 to produce a force on the plunger 16 tending to move the latter to the right. By careful selection of the inner and outer diameters of that part of the diaphragm 29 exposed to the outlet back-pressure, it is possible to equate the opposing forces on the plunger 16 due to the outlet back-pressure. By this means the pressure regulating valve will adjust the pressure on its inlet passage 11 to a value which is substantially independent of any variations in the pressure of the fuel passing through the outlet passage 12.

The space 43 between the diaphragms 29 and 41 is connected by a passage 44 and pipe 45 to a source of pressure which is sufficiently constant in comparison with the fuel and inlet manifold pressures. Such a source of pressure may be a container having a high vacuum sealed within, or in some cases could be atmospheric pressure.

It will be apparent that the effective cross-sectional area of the diaphragm 29 is equal to the cross-sectional area of the sharp corners 15 and 24. It will also be apparent that the effective cross-sectional area of the diaphragm 41 and the attached plunger 16 which is exposed to the inlet manifold pressure is greater than the cross-sectional area of the sharp corner 15.

In operation, the pressure of fuel in the inlet 11 will move the plunger 16 until the force on the plunger due to fuel pressure balances the net force on the plunger due to other causes. The force due to the fuel equals the fuel pressure multiplied by the cross-sectional area of the shoulder 15. The net force due to other causes equals the force due to the spring 18 (substantially constant) plus the pressure in the space 43 multiplied by the difference in effective cross-sectional areas of the diaphragms 29, 41 (also substantially constant) plus the inlet manifold pressure multiplied by the effective cross-sectional area of the diaphragm 41 and plunger 16.

Due to the effective cross-sectional area of the diaphragm 41 being greater than the cross-sectional area of the shoulder 15, it will be seen that the fuel pressure in the inlet 11 will always be above the inlet manifold

absolute pressure and the fuel pressure will exceed the inlet manifold pressure by an amount which increases with increasing inlet manifold absolute pressure.

In this way the pressure difference across any fuel injector, fed from the inlet 11 and injecting into the inlet manifold, will increase with increasing inlet manifold absolute pressure.

Instead of the diaphragms 29 or 41 any other suitable type of axially-free seal could be used such as the sleeve 42 having an enlarged left-hand end and sliding in a corresponding bore in the body 10.

Furthermore, if preferred the areas subject to fuel pressure and inlet manifold pressure respectively could be of equal size but the area subject to the inlet manifold pressure could be connected to the plunger 16 by a force-multiplying lever or equivalent system.

I claim:

1. In a fuel pressure regulator for use in a fuel injection system arranged to inject fuel into a duct in an engine, said regulator comprising, means defining an aperture the degree of opening of which affects said fuel pressure, a member having a first area exposed to the pressure of the fuel to be regulated so that said fuel pressure generates a force on said member urging it to open said aperture and thereby reduce said fuel pressure, a surface in said regulator having a second area exposed to the pressure of air in said duct and positioned to generate a force on said member in response to said air pressure urging said member to close said aperture and thereby increase said fuel pressure, the improvement according to which the surface hav-

ing said second area transmits to said movable member a force which is greater in proportion to the pressure exerted by said air on said second area than the force generated by said fuel on said member in proportion to the fuel pressure to which said first area is exposed.

2. A fuel pressure regulator as claimed in claim 1, wherein said member is a plunger including the first area subject to the fuel pressure to be regulated and said surface having the second area is a diaphragm connected to said plunger and subjected to inlet duct pressure.

3. A fuel pressure regulator as claimed in claim 2, wherein said plunger operates in a bore and a corner of a shoulder formed on the plunger cooperates with a corner of said bore to define a fuel metering aperture between said corners, and a low rate spring tends to urge the plunger in a direction to close said aperture.

4. A fuel pressure regulator as claimed in claim 3, wherein a second diaphragm is connected to said plunger and is subjected to fuel outlet pressure and the space between said two diaphragms is connected to a source of substantially constant pressure with respect to fuel pressure and inlet duct pressure, and further wherein the effective cross-sectional area of said second diaphragm is equal to the cross-sectional area of said corners, and the effective cross-sectional area of said first diaphragm and of the plunger which is exposed to inlet duct pressure is greater than the cross-sectional area of the sharp corner on said bore.

5. A fuel pressure regulator as claimed in claim 1, wherein the two areas are directly connected but the said second area is greater than the first area.

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