United States Patent [19]

Eckert

[11] **3,919,992**

[45] **Nov. 18, 1975**

[54] **FUEL INJECTION SYSTEM**

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[22] Filed: **Sept. 12, 1974**

[21] Appl. No.: **505,214**

[30] **Foreign Application Priority Data**

Sept. 28, 1973 Germany............................ 2348859

[52] **U.S. Cl.**.... **123/139 AW;** 123/119 R; 261/50 A

[51] **Int. Cl.²**.. **F02M 69/00**

[58] **Field of Search**................ 123/139 AW, 119 R; 261/50 A

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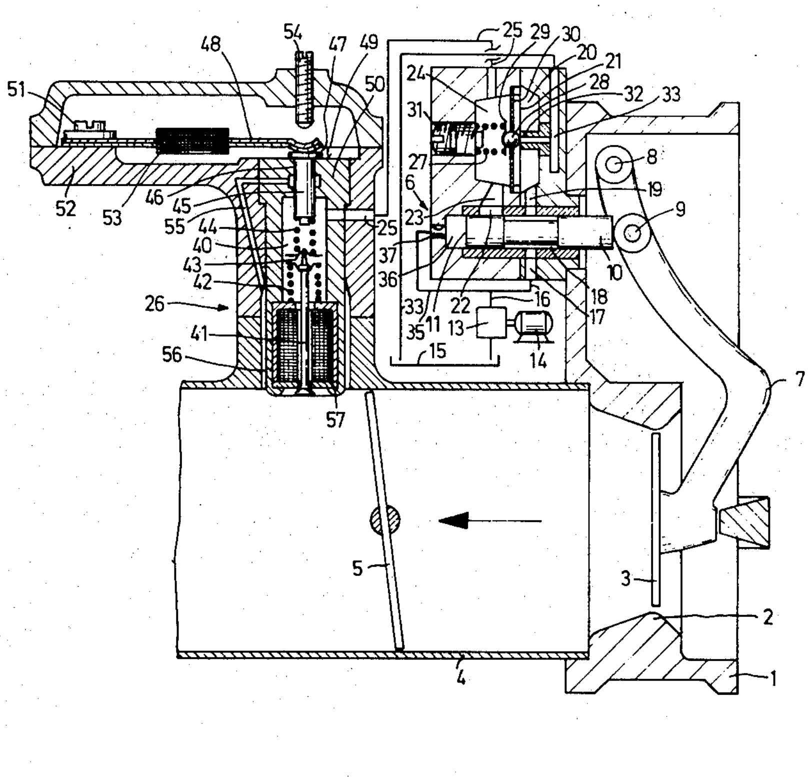
[57] **ABSTRACT**

A fuel injection system for externally ignited, gas internal combustion engines. The system involves the continuous injection of fuel into an induction tube section of an intake manifold. A measuring member and a randomly activatable throttle valve are arranged in series in the induction tube section upstream from the point of fuel injection. The measuring member is displaced by an operating member against a restoring force in accordance with the amount of air flowing through. In the course of its displacement, the measuring member adjusts a mobile part of a valve which is disposed in the fuel line and meters out a quantity of fuel proportional to the quantity of air, when there is constant pressure difference. The restoring force on the measuring member is produced by a pressure fluid which acts on the operating members at least indirectly. Means are provided for adjusting fuel pressure downstream from the metering valve for influencing pressure of the pressure fluid.

13 Claims, 2 Drawing Figures



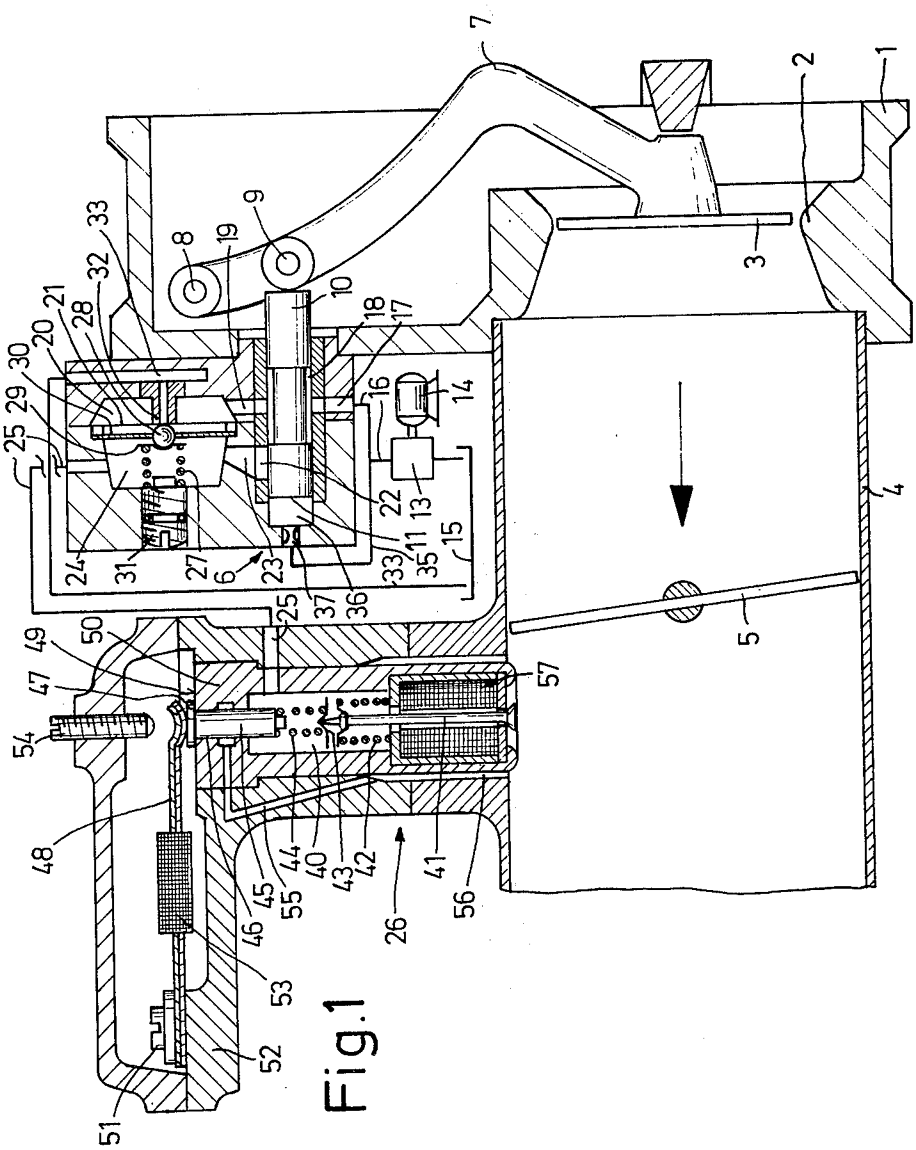

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Fig.1

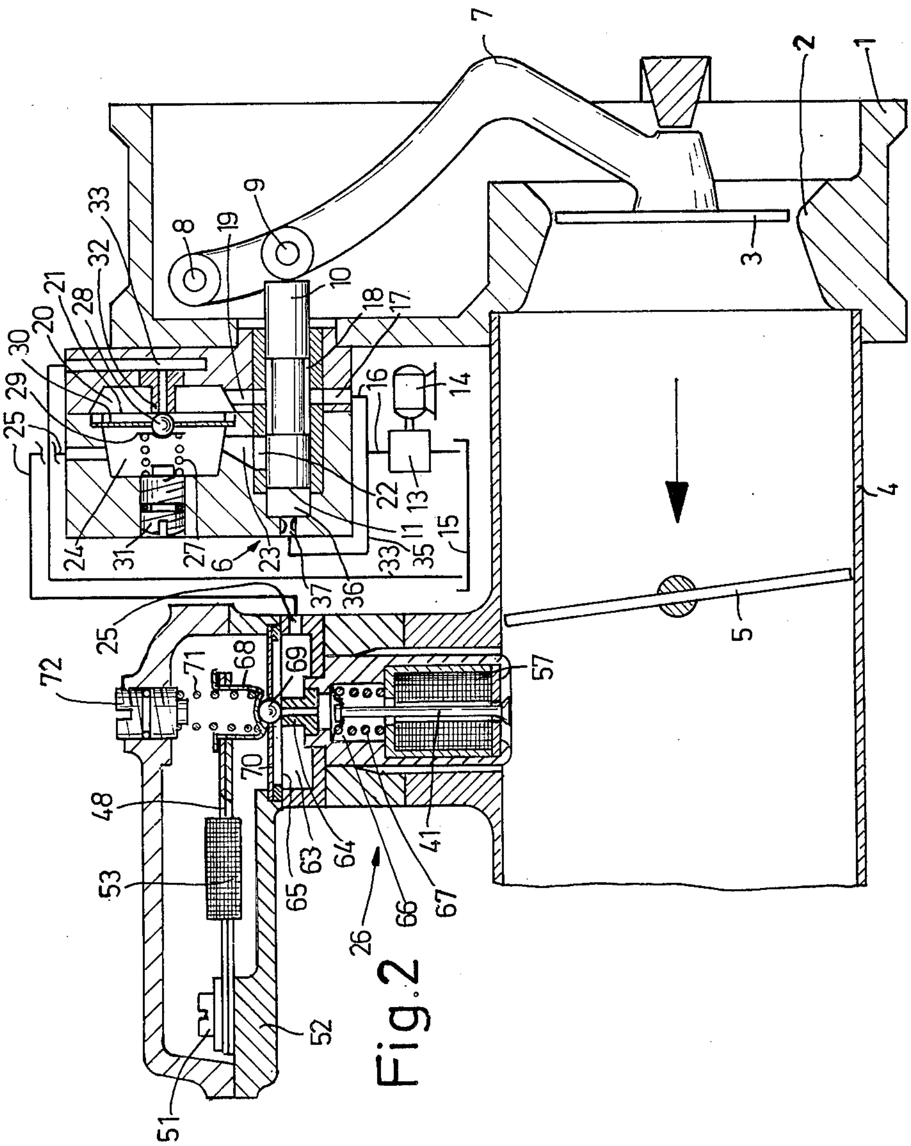
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Fig. 2

FUEL INJECTION SYSTEM

The invention relates to a fuel injection system for externally ignited, gas internal cumbustion engines, which involve continuous injection into an induction tube section, in which a measuring member and a randomly activatable throttle valve are arranged in series. In particular, the present invention relates to such a system in which the measuring member is displaced by an operating member against a restoring force in accordance with the amount of air flowing through. In the course of the displacement, the measuring member adjusts a mobile part of a valve which is disposed in the fuel line and which, when there is constant pressure difference, meters out a quantity of fuel proportional to the quantity of air. The restoring force on the measuring member is produced by a pressure fluid which acts on the operating member at least indirectly.

Fuel injection systems of this type are intended to provide automatically an advantageous fuel-air mixture for all operating conditions of the internal combustion engine to obtain maximum combustion of the fuel and thereby prevent noxious exhaust gases from being produced or at least reduce considerably these gases while obtaining maximum performance of the internal combustion engine, that is, minimum fuel consumption. The amount of fuel must therefore, be very accurately proportioned to meet the requirements of every operating state of internal combustion engine.

In the case of fuel injection systems of this type, the quantity of air flowing through the induction tube is determined by a measuring member. The fuel is metered out in proportion to this quantity of air and injected directly into the induction tube by injection valves in the proximity of each cylinder of the internal combustion engine. The proportionality between the quantity of air and amount of fuel metered out can be varied as a function of the engine characteristics such as the rate of revolutions, the load and temperature, by varying the restoring force acting on the measuring member. The restoring force, acting on the measuring member is the pressure of a pressure fluid circulation which is obtained from the circulation system of the fuel injection system.

SUMMARY OF THE INVENTION

The principal object of the present invention is to provide a fuel injection system of the above-mentioned type at a substantially lower construction cost, while satisfying the requirement of keeping the quantity of noxious constituents in the exhaust gas to a minimum.

The foregoing object, as well as others, which are to become clear from the text below, is achieved in accordance with the present invention in a fuel injection system for separately ignited, internal combustion engines involving continuous injection into an induction tube section of an intake manifold. A measuring member and a randomly activatable throttle valve is arranged in series in the induction tube section, the measuring member being displaceable against a restoring force by an operating member, according to the amount of air flowing. A mobile part of a metering valve, which is disposed in a fuel line and which, with a constant pressure difference, meters out a quantity of fuel proportional to the amount of air is coupled to the operating member. The restoring force for the measuring member is produced by pressure fluid which acts at least indirectly on

the operating member. Means are provided for adjusting fuel pressure downstream from the metering valve for influencing pressure of the pressure fluid.

It is a salient feature of the present invention to provide that the pressure of the pressure fluid is adapted to be influenced by varying the fuel pressure downstream of the metering valve.

An advantageous feature of the invention consists in that fuel is used as the pressure fluid, the pressure of which is determined by the pressure in the circulation system downstream of the metering valve. The pressure in the circulation system may be varied by means of a valve, the spring force of which acting in the closing direction is adapted to be reduced during the heating up period of the internal combustion engine by a heatable bi-metal spring and fuel injection is effected by an injection valve disposed directly downstream of the throttle valve.

Another advantageous feature of the present invention consists in that the valve and bi-metal spring are disposed in the injection valve and in that a first spring, keeping the valve needle of the injection valve in the closing position, works against a second spring, the initial stressing of which is variable by the heatable bimetal spring via an adjusting piston, the piston being displaceable between two stops defining its end positions. The fuel leaking through in the region of the adjusting piston is adapted to be supplied to the induction tube via a duct downstream of the throttle valve.

Another advantageous feature of the present invention consists in that the injection valve also acts as a valve for varying the fuel pressure downstream of the metering valve and the fuel is adapted to be heated in the region of the injection valve.

Another advantageous feature of the invention consists in that the valve for varying the fuel pressure downstream of the metering valve is in the form of a flat seat valve comprising a diaphragm as the displaceable part of the valve which is adapted to be acted on in the closing direction by a spring and the force of the spring of the pressure system valve on the diaphragm is adapted to be reduced by the bimetal spring.

Two illustrative embodiments of the present invention are represented in the drawings and these will be described in more detail hereinafter.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatic, partially sectional view of a first embodiment of a fuel injection system according to the present invention.

FIG. 2 is a diagrammatic, partially sectional view of a second embodiment of the fuel injection system according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the fuel injection system according to FIG. **1**, the the combustion air flows in the direction of the arrow-headed line through an air filter housing **1**, a hollow manifold section in the form of a cone **2**, in which a measuring member **3** is disposed, and an induction tube section **4** within which a randomly activatable throttle valve **5** is disposed. The induction tube section **4** leads one or more cylinders (not shown) of an internal combustion engine. The measuring member **3** is a plate disposed at a right angle to the flow direction. The plate is displaced in the cone **2** according to a generally linear function of the air flowing through the induction tube section 4 and to provide a constant restoring force which acts upon the measuring member 3 and a constant air pressure in front of the measuring member 3, the pressure between the measuring member 3 and the throttle valve 5 also remains constant.

The measuring member 3 directly controls a metering valve 6. The adjusting movement of the measuring member 3 is transferred to a control slide 10 of the metering valve 6 via a roller 9 by a lever 7, which is connected to the measuring member 3 and which is pivotable about a pivot point 8. The fuel pressure acts on the front face 11 of the control slide 10 facing away from the roller 9 and thereby provides the restoring force acting on the measuring element 3.

The fuel is supplied via a fuel pump 13 driven by an electromotor 14. The fuel pump 13 draws the fuel from a fuel tank 15 and supplies it to the metering valve 6 via a line 16. From the line 16, the fuel passes to a duct 17 in the housing of the metering valve 6. The duct 17 leads to an annular groove 18 in the control slide 10 and via a duct 19 to a chamber 20 so that one side of a diaphragm 21 is acted on by this fuel pressure. Depending on the position of the control slide 10, the annular groove 18 opens to a greater or lesser extent a control slit 22 which leads to a chamber 24 via a duct 23. The chamber 24 is separated from the chamber 20 by the diaphragm 21. From the chamber 24, the fuel passes via a line 25 to an injection valve 26 which is disposed directly downstream of the throttle valve 5 in the induction tube section 4. The diaphragm 21 acts as a movable part of a flat seat valve which is acted on in the closing direction by a spring 27, via a spring washer 29 connected to a spherical member 28. The spherical member 28 is guided by a protective plate 30. The initial stressing of the spring 27 can be varied by means of a screw 31. The fuel flowing out via a valve seat 32 passes back into the fuel tank 15 via a line 33.

The siphon diaphragm formed by the chambers 23 and 24 has the effect of keeping the pressure difference at the metering valve 6 largely constant independent of the covering between the annular groove 18 and the control slit 22, that is, independent of the fuel flowing to the injection valve 26. This ensures that the adjustment path of the control slide 10 and the metered quantity of fuel are proportional when the control slit 22 is a uniform width.

When the lever 7 effects a pivoting movement, the measuring member 3 is moved into the cone 2 and thus, the varying annular cross-section between the plate-like measuring member 3 and the inner surface of the cone 2 is proportional to the adjustment path of the measuring member 3. In this manner, a quantity of fuel proportional to the quantity of air flowing through the induction pipe section 4 is always metered out.

The pressure fluid producing the restoring force on the control slide 10 is fuel. For this purpose, a line 35 branches off from the line 16 and discharges into a chamber 36 into which projects the front face 11 of the control slide 10 facing away from the lever 7. The chamber 36 is acted on by pressure by means of a damping throttle 37.

The metered quantity of fuel passes from the chamber 24 of the differential pressure metering valve 6 via the line 25 into a chamber 40 of the injection valve 26. The end of a valve needle 41 facing away from the induction pipe section 4 projects into the chamber 40 and is kept in the closing direction by a first spring 42. A second spring 44 works against the first spring 42 via a spring washer 43. The second spring 44 is supported on the adjusting piston 45 by its end facing away from the nozzle needle. The adjusting piston 45 is displaceably situated in a bore hole 46. On its end facing away from the second spring 44, the adjusting piston 45 has a flange 47 which acts as a stop, the adjusting piston 45 with its flange 47 being pushed against a front face 49 of bushing 50 when a bi-metal spring 48 is in the unheated state. The bi-metal spring 48 is regidly connected at its end facing away from the adjusting piston 45 to a housing 52 by a spring 51 and is surrounded along a portion of its length by an electrical heating element 53. The electrical heating element 53 is designed so that on termination of the heating up period of the internal combustion engine, the bi-metal spring 48 reduces its force on the adjusting piston 45 such that it moves away from the adjusting piston and comes to rest against a screw 54, acting as a stop. The adjusting piston 45 follows the movement of the bi-metal spring 48 and the second spring 44 and the fuel pressure, acting on the same, presses the adjusting piston 45 against the bi-metallic spring 48 resting on the stop 54. Fuel which leaks between the adjusting piston 45 and the bushing 50 is supplied to an annular groove 56 via a line 55 in the housing 52. The annular groove 56 discharges directly downstream of the throttle valve 5 into the induction tube section 4.

The valve needle 41 is surrounded along a portion of its length by an electric heating element 57 and thus the fuel can be heated before injection into the induction pipe section 4.

The fuel injection system described above, operates as follows:

when the internal combustion engine is in operation, fuel is drawn from the tank 15 by the fuel pump 13 driven by the electromotor 14 and supplied to the metering valve 6 via the line 16. The internal combustion engine simultaneously draws air via the induction manifold defined by the filter housing 1, the cone 2 and the induction tube section 4 which causes the measuring member 3 to be deflected to a certain extent from its rest position. The control slide 10 of the metering valve 6 is displaced, via the lever 7, according to the deflection of the measuring member 3 and thereby opens a greater cross-sectional area of the control slit 22. The direct connection between the measuring member 3 and the control slide 10 produces a constant relationship of the quantity of air and the amount of fuel metered out.

The quantity of fuel metered out by the metering valve 6 is supplied, via a line 25, to the injection valve 26 which is disposed directly downstream of the throttle valve 5 on the induction tube section 4 and injects the fuel in a continuous manner into the induction tube section 4. The injection valve 26 simultaneously determines the pressure of the fuel downstream and upstream of the metering valve 6 in the fuel injection system.

The fuel displaced by the fuel pump 13 passes from the line 16 into the line 35 which discharges into the chamber 36 via the damping throttle 57. The front face 11 of the control slide 10 projects into the chamber 36. In this manner, the fuel pressure produces a constant restoring force on the measuring member 3 upstream of the metering valve 6.

To increase (enrich) the fuel-air mixture during warming up of the internal combustion engine, it is necessary to reduce the restoring force on the measuring member 3 and thus the fuel pressure upstream of the metering valve 6. To effect this, the first spring 42 retaining the valve needle 41 in the closing direction acts against the second spring 44, the initial stressing of which is increased during the warm-up period by the flange 46 of the adjusting piston 45 being pressed by the bi-metallic spring 48 onto the front face 49 of the bushing 50.

The increase in the initial stressing of the second spring 44 simultaneously causes a reduction in the opening pressure of the injection valve 26 and a corresponding reduction in the fuel pressure in the fuel injection system. As a result, the restoring force on the control slide 10 and, thus, on the measuring member 3 is also reduced which results in greater deflection of the measuring member 3 with the same amount of suction air and a greater quantity of fuel is metered out. The electrical heating element 53 arranged on the bi-metallic spring 48 is designed in such a way that on termination of the warm-up period of the internal combustion engine, the bi-metallic spring 48 has bent in the direction of the stop 54 such that the second spring 44 displaces the adjusting piston 45 in the direction of the stop 54. The reduction in the initial stressing of the second spring 44 results in that the injection valve 26 only opens with a higher fuel pressure and thus the fuel pressure in the fuel injections system and hence the restoring force on the measuring member 3 are increased.

In FIG. 2, the reference numbers refer to the same parts as in FIG. 1. A constant pressure difference is maintained at the metering valve 6 by the differential pressure valve (constituted by chamber 20, diaphragm 21, a chamber 24, seat 32), a spring 27 acting on the differential pressure valve 20, 21, 24, 32 in the closing direction enabling the fuel to pass, via the line 25, into a chamber 63 of the injection valve 26. From the chamber 63, the fuel is able to pass to a chamber 66 via a valve seat 64, which is adapted to be closed by a diaphragm 65. A spring 67 holding the valve needle 41 in the closing position is arranged in the chamber 66. The valve constituted by the diaphragm 65 and the valve seat 64 is adapted to be acted upon by a spring 71 in the closing direction via a spherical member 69, which is connected to a spring washer 68 and which is guided by a protective plate 70. The end of the spring 71 facing away from the spring washer 68 is supported on a screw 72 which is adapted to adjust the initial stressing of the spring 71. During the warm-up stage of operation of the internal combustion engine, the force of the spring 71 on the diaphragm 65 is reduced owing to the fact that the bi-metallic spring 68 engages on the spring washer 69 and counteracts the force of the spring 71. When the warm-up has terminated, the electrically heated bi-metallic spring 48 has curved in the direction of the diaphragm 65 and is thus out of engagement with the spring washer 68 so that the full spring force of the spring 71 can act on the diaphragm 65.

In the embodiment according to FIG. 2, the reduction of the force of the spring 71 on the diaphragm 65 effects that the fuel pressure in the fuel injection system is lowered which results in a reduction of the restoring force on the measuring member 3 during the warm-up stage of operation of the internal combustion engine and an increased quantity of fuel is metered out.

Through combining the warm-up valve and the valve for adjusting the fuel pressure in the fuel injection system in the injection valve, the embodiment according to FIG. 1 has the advantage that a separate warm-up valve and a separate pressure system valve are not required. Neither is it necessary to provide an additional pressure circulation system for controlling the restoring force on the measuring member as the pressure in the system upstream of the metering valve serves this purpose and with simple means, it is possible to reduce the pressure in the system and thus increase the fuel-air mixture during the warmup stage of operation of the internal combustion engine.

The embodiment of the invention represented in FIG. 2 has the advantage of reducing the quality requirements of the injection valve while retaining the advantageous combination of the warm-up valve and the valve for adjusting the fuel pressure in the injection valve.

While illustrative, exemplary embodiments have been illustrated and described above, it is to be appreciated that these embodiments are set out by way of example not by way of limitations. Numerous other embodiments and varients are possible within the spirit and scope of the invention, the scope being defined by the appended claims.

What is claimed is:

1. In a fuel injection system for separately ignited, internal combustion engines involving continuous injection into an induction tube section of an intake manifold, a measuring member and a randomly activatable throttle valve being arranged in series in the induction tube section, the measuring member being displaceable against a restoring force by an operating member according to the amount of air flowing through, a mobile part of a metering valve which is disposed in a fuel line and which, with a constant pressure difference, meters out a quantity of fuel proportional to the amount of air being coupled to the operating member, the restoring force for the measuring member being produced by pressure fluid which acts at least indirectly on the operating member, the improvement comprising means for adjusting fuel pressure downstream from said metering valve for influencing pressure of the pressure fluid.

2. An improved fuel injection system as claimed in claim 1, wherein said pressure fluid is fuel, the pressure of which is determined by pressure in the system downstream from said metering valve.

3. An improved fuel injection system as defined in claim 2, including a heatable bi-metallic spring and valve means having spring means; the spring force, which acts in the closing direction, is reduced during the warm-up stage of operation of the engine by means of said heatable bi-metallic spring, said valve means being operatively arranged to vary pressure in the system upstream from said metering valve.

4. An improved fuel injection system as defined in claim 3, including an injection valve disposed immediately downstream from said throttle valve for injecting fuel into said induction tube section.

5. An improved fuel injection system as defined in claim 4, including electrical heating means disposed in the vicinity of said injection valve for heating the fuel.

6. An improved fuel injection system as defined in claim 4, wherein said spring means includes a first spring holding a valve needle of the injection valve in the closing position acts against a second spring which is also part of said spring means.

7. An improved fuel injection system as defined in claim 6, including an adjustable piston and wherein initial stressing of said second spring is varied by said heatable bi-metallic spring via said adjusting piston.

8. An improved fuel injection system as defined in claim **7,** including two stops, and wherein said adjusting piston is displaceable between two stops defining its end positions.

9. An improved fuel injection system as defined in claim **8,** including a duct connected between said induction tube section and a region adjacent said adjusting piston for introducing leaking fuel from the adjusting piston into said induction tube section downstream of said throttle valve.

10. An improved fuel injection system as defined in claim **4,** wherein said valve means and said spring means are arranged within said injection valve.

11. A fuel injection system as claimed in claim **10,** wherein said injection valve is operatively arranged to act as a valve for varying fuel pressure downstream from said metering valve.

12. A fuel injection system as claimed in claim **10,** including a closing spring, and wherein said valve for varying fuel pressure downstream from said metering valve comprises a flat seat valve with a diaphragm as its displaceable valve part, said diaphragm being positioned to be acted on by said closing spring in the closing direction.

13. A fuel injection system as claimed in claim **12,** wherein the force of said closing spring on said diaphragm is reduced by action of said bi-metallic spring.

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