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(54) Fuel pressure regulator for a fuel injection system of an internal combustion engine

(57) A fuel pressure regulator (20), comprises a fuel distributor pipe (22) having an inlet (26) and a plurality of outlets (30*a*—30*d*) for connection to fuel injectors, a casing (38) secured to a portion of the fuel distributor pipe, a diaphragm (42) which carries a valve member (48) being secured between said portion of the distributor pipe and the casing, and a fuel discharge nozzle (50) closable by the valve member (48) and disposed interior of the distributor pipe to discharge fuel from the distributor pipe. The interior of the casing (38) is connectible to an intake passageway of the engine so that the pressure therein regulates the fuel pressure.

FIG. 2

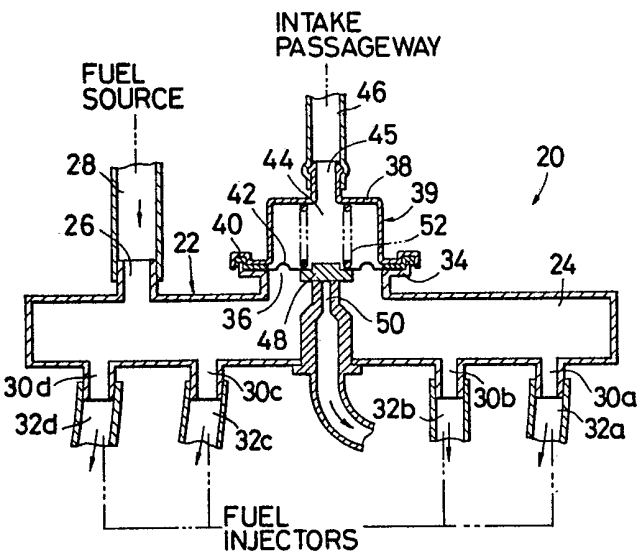

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FIG. 1 PRIOR ART

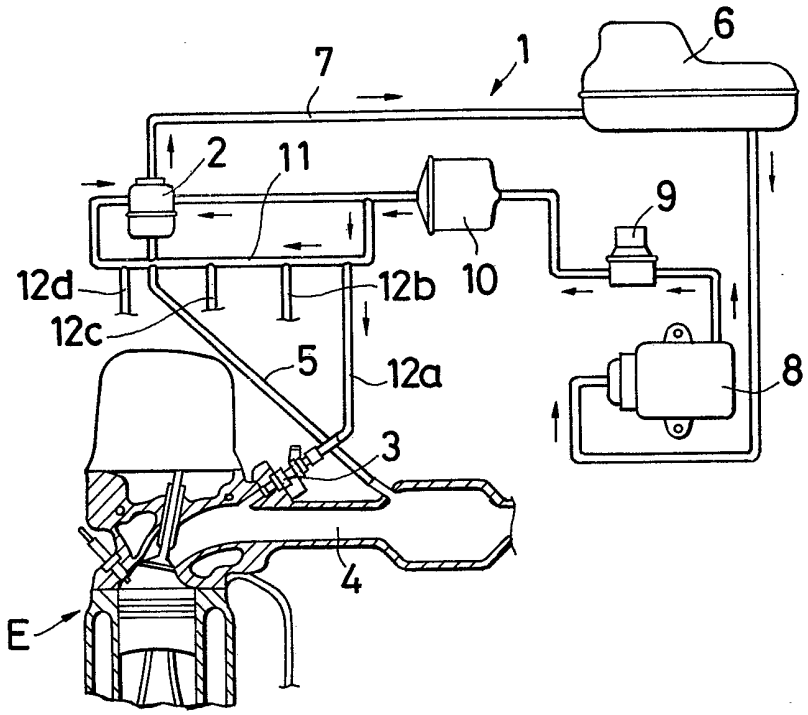

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FIG. 2

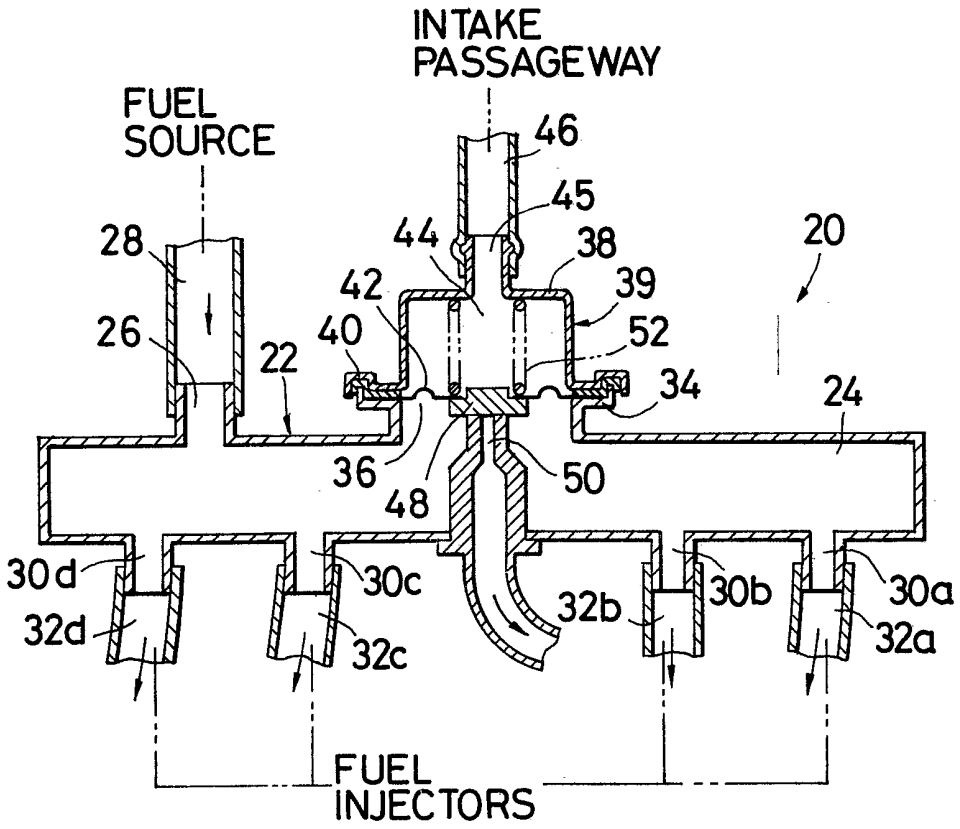
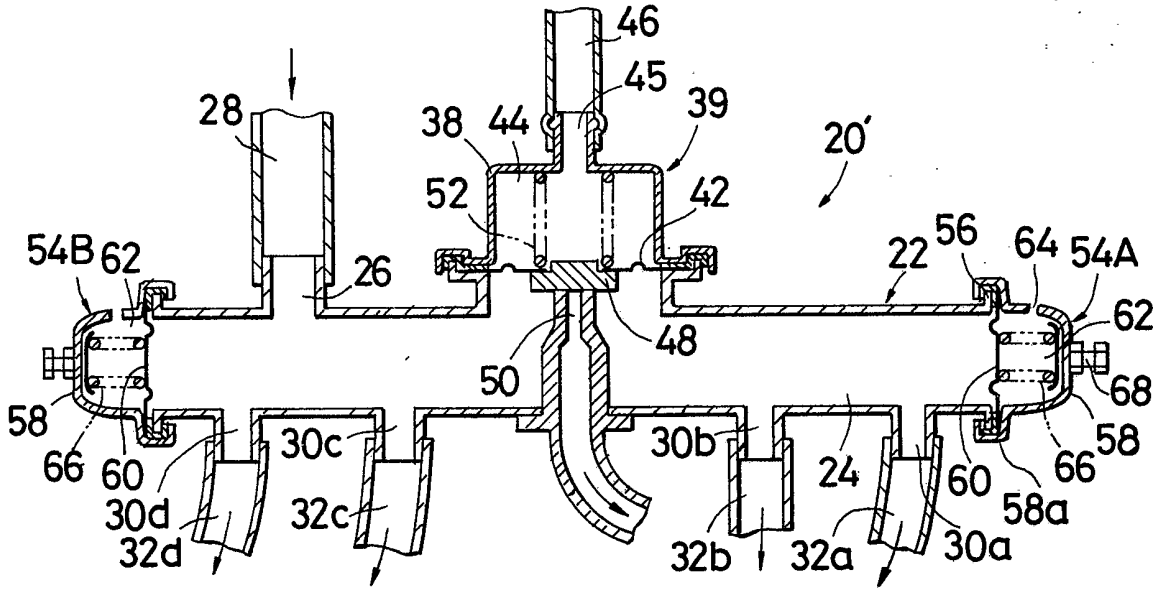


FIG. 3



SPECIFICATION

Fuel pressure regulator of fuel injection system

This invention relates to an improvement in a fuel injection system of a petrol fuelled internal combustion engine, and more particularly to a fuel pressure regulator for use in the fuel injection system, for controlling the pressure of the fuel to be injected from a fuel injector.

It is the main object of the present invention to provide an improved fuel pressure regulator for use in a fuel injection system, which can simplify the fuel piping of the fuel injection system, improving the durability of the system.

It is another object of the present invention to provide an improved fuel pressure regulator for use in a fuel injection system, by which the possibility of fuel leakage from the fuel piping of the fuel injection system is considerably decreased compared with a conventional fuel pressure regulator.

It is a further object of the present invention to provide an improved fuel pressure regulator for use in a fuel injection system, which improves the efficiency in assemblying the fuel injection system, and lowers the production cost fo the fuel injection system.

According to the present invention, there is provided a fuel pressure regulator for use in a fuel injection system of a petrol fuelled internal combustion engine, the fuel pressure regulator comprising: a fuel distributor pipe defining therein a fuel chamber, having a fuel inlet through which the fuel chamber communicates with a fuel source, and plurality of fuel outlets through which the fuel chamber communicates with fuel injectors; a casing securely connected to the fuel distributor pipe to define therein a vacuum chamber which is communicated with an intake passageway of the engine; a diaphragm member secured at a section where the distributor pipe and the casing is connected, to separate the fuel chamber and the vacuum chamber, the diaphragm member being provided with a valve member; and a fuel discharge nozzle through which the fuel in the fuel chamber is dischargeable, the nozzle being disposed in the fuel chamber and closable with the valve member to prevent the fuel in the fuel chamber from being discharged out of the fuel chamber.

These and other objects, features and advantages of the fuel pressure regulator according to the present invention will be more apparent from the following description when taken in conjunction with the accompanying drawings in which the same reference numerals are assigned to the corresponding part and elements throughout the embodiments, in which:

Fig. 1 is a schematic illustration of a fuel injection system of a petrol fuelled internal combustion engine, including a prior art fuel pressure regulator;

Fig. 2 is a cross-sectional view of a preferred embodiment of a fuel pressure regulator in accordance with the present invention; and

Fig. 3 is a cross-sectional view similar to Fig. 2, but showing another embodiment of a fuel pressure regulator in accordance with the present invention.

As shown in Fig. 1, a conventional fuel injection system 1 for a petrol fuelled internal combustion engine E is usually provided with a fuel pressure regulator 2 for maintaining the pressure of the fuel to be injected from a fuel injector 3 at a constant value in order to precisely control the amount of fuel supplied to the engine E. The amount of the fuel injected from the fuel injector 3 is in general proportional to the pressure differential between the fuel pressure and the intake vacuum generated in an intake passageway 4. Accordingly, the fuel pressure regulator 2 is constructed and arranged to receive the fuel pressure and the intake vacuum (introduced through a vacuum line 5) at the opposite sides of a diaphragm enclosed therein to compare these two pressures, and then return excess fuel into a fuel tank 6 through a return line 7 so that the pressure differential is always maintained at a constant value.

The fuel from a fuel pump 8 is supplied under pressure through a fuel damper 9 and a fuel filter 10 into a fuel pressure regulator 2, and introduced into a distributor pipe 11 which is formed in parallel with the fuel pressure regulator 2. The fuel introduced into the distributor pipe 11 is then supplied to a plurality of fuel injectors 4 (only one is shown) through branched lines 12a, 12b, 12c and 12d, respectively.

However, such a fuel injection system has been encountered the following problems: Since the piping in connection with the fuel pressure regulator 2 is considerably complicated as seen from Fig. 1, it is liable to cause leakage from the piping by loosening of the connections (clamping connections by clamp couplings and/or the screw connections by connectors) of the piping due to, for example, vibration of the fuel injection system 10. Furthermore, many connections in the piping unavoidably increase the number of constituting parts such as the clamp couplings and the connectors and the number of assembly steps, constributing to an increase in production cost and to deterioration in operational efficiency.

In view of the above, the present invention contemplates solving the problems encountered in the fuel injection system provided with a conventional fuel pressure regulator, by forming a pressure regulating section integrally with a fuel distributor pipe through which the fuel is distributed to a plurality of fuel injectors.

Referring now to Fig. 2, there is shown a preferred embodiment of a fuel pressure regulator 20 for use in a fuel injection system of a petrol fuelled internal combustion engine (not shown). The regulator 20 is composed of a straight elongate fuel distributor pipe 22 in which a fuel chamber 24 is defined. The pipe 22 is integrally provided with a fuel inlet 26 which is connected through a fuel supply line 28 to a fuel source such as a fuel pump (not shown). The pipe 22 is further integrally provided with four fuel outlets 30a to

30d which are connected through four fuel supply lines 32a to 32d to four fuel injectors (not shown), respectively. The outlets 30a to 30d are spaced apart certain distances. The pipe 22 is integrally formed with a flange portion 34 defining an opening 36.

A cup-shaped diaphragm casing 38 forming part of a pressure control section 39 is securely connected at its flange portion 40 with the flange portion 34 of the pipe 22, securely positioning a diaphragm member 42 between the flange portions 34 and 40. The connection between the two flange portions 34 and 40 is, in this instance, established by crimping the flange portion 40 of the casing 38 over the flange portion 34 of the pipe 22, interposing the diaphragm 42 therebetween. In this regard, it is preferable that the pipe 22 is formed of die-cast aluminum or cast brass, and the casing 38 is formed of a pressed steel plate.

The diaphragm member 42 is located to close the opening 36 and separates the fuel chamber 24 defined in the pipe 22 and a vacuum chamber 44 defined in the casing 38. The vacuum chamber 44 communicates through a vacuum inlet 45 and a vacuum supply line 46 with an intake air passageway (not shown) through which the engine cylinders of the engine are communicable with the atmosphere. The diaphragm member 42 is provided with a valve chamber 48 at the central portion thereof.

A fuel discharge nozzle 50 is secured through the wall of the pipe 22 so that the tip of the nozzle is disposed in the fuel chamber 24 of the pipe 22. As shown, the nozzle 50 is so positioned that the tip thereof is located opposite to and in close proximity to the valve member 48. Accordingly, nozzle 50 is closed when the valve member 48 urgingly contacts the tip of the nozzle 50 by the bias of a spring 52. The spring 52 is disposed in the vacuum chamber 44 and between the inner wall surface of the casing 38 the diaphragm member 42. The nozzle 58 is connected to, for example, a fuel tank (not shown).

With the thus arranged fuel pressure regulator 20, when the valve member 48 contacts the tip of the fuel discharge nozzle 50, the fuel introduced under pressure through the fuel inlet 26 is supplied through the fuel outlets 30a to 30d into the fuel injectors. When the valve member 48 separates from the tip of the fuel discharge nozzle 50, a part of the fuel introduced into the fuel chamber 24 of the pipe 22 is discharged out of the fuel chamber 24 through the fuel discharge nozzle 50.

It will be appreciated that the fuel pressure in the fuel chamber 24 is controlled by the action of the pressure control section 39 to maintain constant the pressure differential between the fuel pressure and the intake vacuum at the instant that the fuel is injected from the fuel injector. Accordingly, the diaphragm member 42 is movable in response to the pressure differential between the fuel pressure P_1 in the fuel chamber 24 and the intake vacuum P_0 introduced into the vacuum chamber 44, and floats and rests at a position where the fuel pressure P_1 and the intake vacuum P_0 balance.

Now, if the fuel pressure P_1 increases though the intake vacuum does not vary, the differential pressure between the fuel pressure and the intake vacuum increases and accordingly the amount of fuel injection from the fuel injector increases. To compensate this, the diaphragm member 42 moves upwardly in the drawing in response to the increase in the intake vacuum, by which the valve member 48 is separated from the tip of the fuel discharge nozzle 50. Hence, a part of the fuel in the fuel chamber 24 is discharged through the nozzle 50 and returned to the fuel tank. As a result, the fuel pressure within the fuel chamber 24 is lowered until the diaphragm member 42 is kept at the position where the fuel pressure and the intake vacuum balance in order to maintain the above-mentioned pressure difference (P_1—P_0). By virtue of the above-mentioned fuel pressure regulator, the fuel amount injected from the fuel injector is a function of the time duration at which the valve of the fuel injector opens to inject fuel, and therefore the injected fuel amount can become precisely proportional to the pulse width of the pulse signal supplied to the fuel injector. It will be appreciated that, by employing such an integral construction of the fuel pressure regulator, the number of connecting sections of the piping of the fuel injection system is considerably decreased compared with conventional piping of the fuel injection system, which decreases the number of connectors in the piping and simplifies the assembly of the fuel injection system.

Fig. 3 illustrates another embodiment of the fuel pressure regulator 30' in accordance with the present invention, which is similar to the embodiment of Fig. 2 with the exception that the fuel disributor pipe 22 is provided at its both ends with two dampers 54A and 54B to absorb the fuel pressure pulsation due to the intermittent opening and closing action of the valves of the fuel injectors. The two dampers 54A and 54B are the same in construction and accordingly only the damper 54A will be described, assigning the same reference numerals to similar parts.

The fuel distributor pipe 22 is formed at both its ends with flange portions 56 defining openings (no numerals). As shown, the flange portion 58a of a diaphragm casing 58 is secured to the flange portion 56 of the distributor pipe 22, positioning a diaphragm member 60 between both flange portions 56 and 58b. The diaphragm casing 58 defines therein a damping chamber 62 which is communicated through an orifice 64 with atmosphere. A spring 64 is disposed in the chamber 62 to bias the diaphragm member 60. The biasing force of the spring 66 is adjustable by a screw 68 under cooperation with a spring retainer (no numeral) for the spring 66.

Now, the fuel pressure change due to the opening and closing actions of the fuel injectors are transmitted as fuel pressure pulsations to the fuel chamber 24 of the fuel distributor pipe 22

through the fuel supply lines 32a to 32d. Under such a condition, it is required to suppress the rapid change in fuel pressure or the fuel pressure pulsation as much as possible in order to achieve an accurate control of the fuel amount injected from the fuel injector.

In this regard, with the fuel pressure regulator 22' shown in Fig. 3, the diaphragm members 60 of the dampers 54A and 54B are moved in response to the fuel pressure pulsation applied to the fuel in the fuel chamber 24 to absorb the fuel pressure pulsation. As a result, the fuel supplied through the fuel supply lines 32a to 32d cannot be affected by the fuel pressure pulsation applied to the fuel in the fuel chamber 22 of the fuel distributor pipe 22.

While the fuel discharge nozzle 50 has been shown and described to be formed as a separate member relative to the fuel distributor pipe 22, it will be appreciated that the nozzle 50 may be formed integrally with the pipe 22.

CLAIMS

1. A fuel pressure regulator for use in a fuel injection system of a petrol fuelled internal combustion engine, said fuel pressure regulator comprising:

a fuel distributor pipe defining therein a fuel chamber, having a fuel inlet through which the fuel chamber communicates with a fuel source, and a plurality of fuel outlets through which the fuel chamber communicates with fuel injectors;

a casing securely connected to said fuel distributor pipe to define therein a vacuum chamber which is communicated with an intake passageway of the engine;

a diaphram member secured at a section where said distributor pipe and said casing is connected, to separate said fuel chamber and said vacuum chamber, said diaphragm member being provided with a valve member; and

a fuel discharge nozzle through which the fuel in said fuel chamber is dischargeable, said nozzle being disposed in said fuel chamber and closable with said valve member to prevent the fuel in said fuel chamber from being discharged out of said fuel chamber.

2. A fuel pressure regulator as claimed in claim 1, further comprising a spring member disposed in said vacuum chamber to bias said diaphragm member so that said valve member closes said fuel discharge nozzle.

3. A fuel pressure regulator as claimed in claim 2, in which said fuel distributor pipe is straight elongate and formed at its central portion with a first flange portion defining an opening, wherein said casing is formed with a second flange portion which is secured to said first flange portion, positioning said diaphragn member between said first and second flange portions so that said diaphragm member closes the opening defined by said first flange portion.

4. A fuel pressure regulator as claimed in claim 3, in which said fuel discharge nozzle is secured through the wall of said fuel distributor pipe and such located so that the tip thereof is contactable with said valve member so as to be closable.

5. A fuel pressure regulator as claimed in claim 2, further comprising damper means for absorbing the fuel pressure pulsation applied to the fuel in said fuel chamber of said fuel distributor pipe.

6. A fuel pressure regulator as claimed in claim 5, in which said damper means includes first and second dampers which are provided at both open end portions of said straight elongate fuel distributor pipe, each of said damper means including a diaphragm member secured to close the open end portion of said fuel distributor pipe.

7. A fuel pressure regulator as claimed in claim 6, in which each damper includes a casing secured to the end portion of said fuel distributor pipe to form therein a chamber defined by said diaphragm member of said damper, said casing being formed with an orifice through which said chamber communicates with atmosphere, and a spring disposed in said chamber of said damper to bias said diaphragm member of said damper.

8. A fuel pressure regulator constructed and arranged substantially as described herein with reference to Fig. 2, or Fig. 3 of the accompanying drawings.

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