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[54] **FUEL INJECTION DEVICE FOR INTERNAL COMBUSTION ENGINES**

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[58] **Field of Search** .....123/136, 32 EA, 32 AE, 123/139; 137/613

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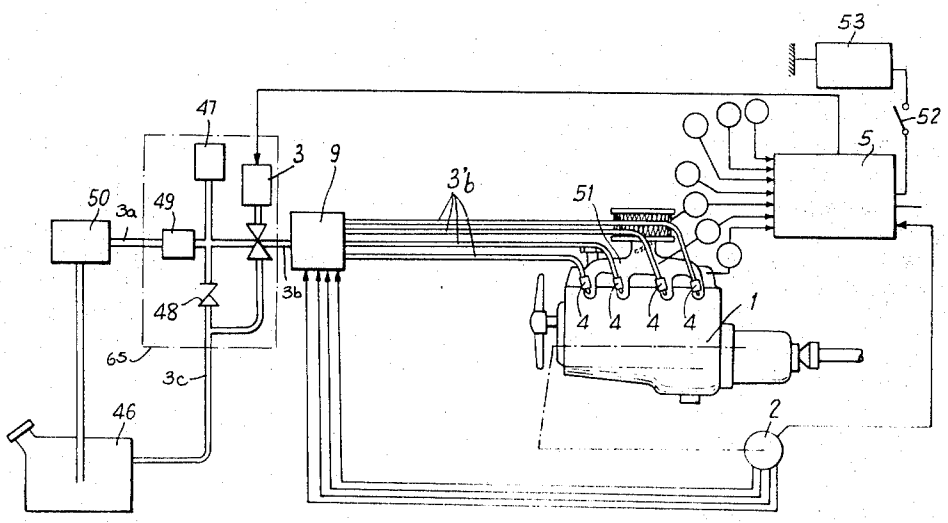
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[57] **ABSTRACT**

An improved device for controlling, either directly or indirectly, the injection of pressurized fuel into an internal combustion engine. The device comprises a body having a fuel inlet, a fuel outlet and a fuel return, as well as a valve mounted therein. The valve is actuated by an electromagnet and is adapted to establish communication between the fuel inlet and the fuel outlet when the valve is actuated. The device has a fuel accumulator comprising an opening in one side of the body and a diaphragm mounted across the opening to form an enclosed volume within the body. The enclosed volume communicates with the fuel input so that the diaphragm deflects outwardly with respect to the interior of the body in response to increases in the pressure of the pressurized fuel provided to the fuel input. The improvement comprises a pressure regulator having a regulatory valve disposed within the body and actuated by the diaphragm. The regulatory valve has an input in communication with the enclosed volume and an output in communication with the fuel return. The regulatory valve is adapted to establish communication between the enclosed volume and the fuel return when the pressure of the pressurized fuel in the enclosed volume reaches a predetermined value.

7 Claims, 2 Drawing Figures



2 Sheets-Sheet 1

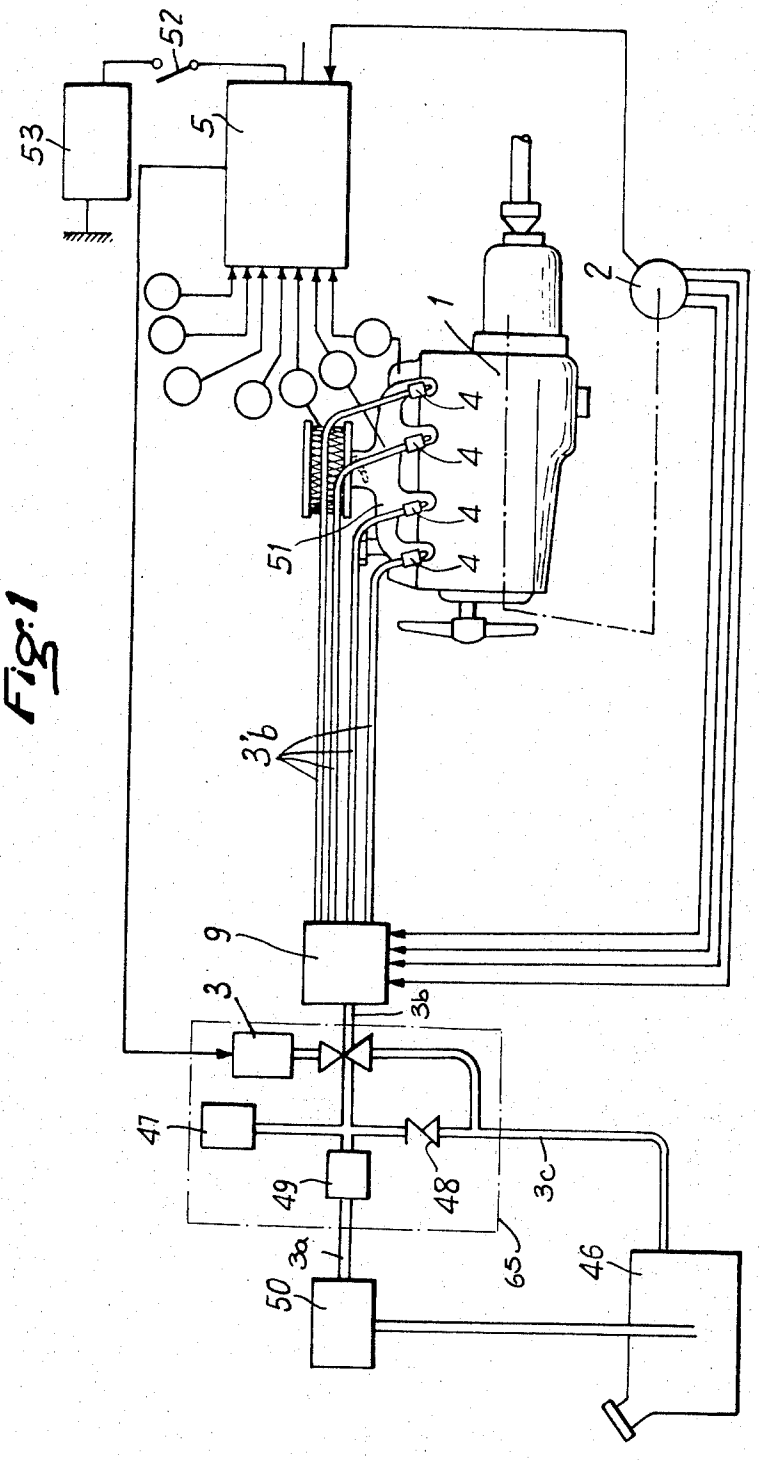
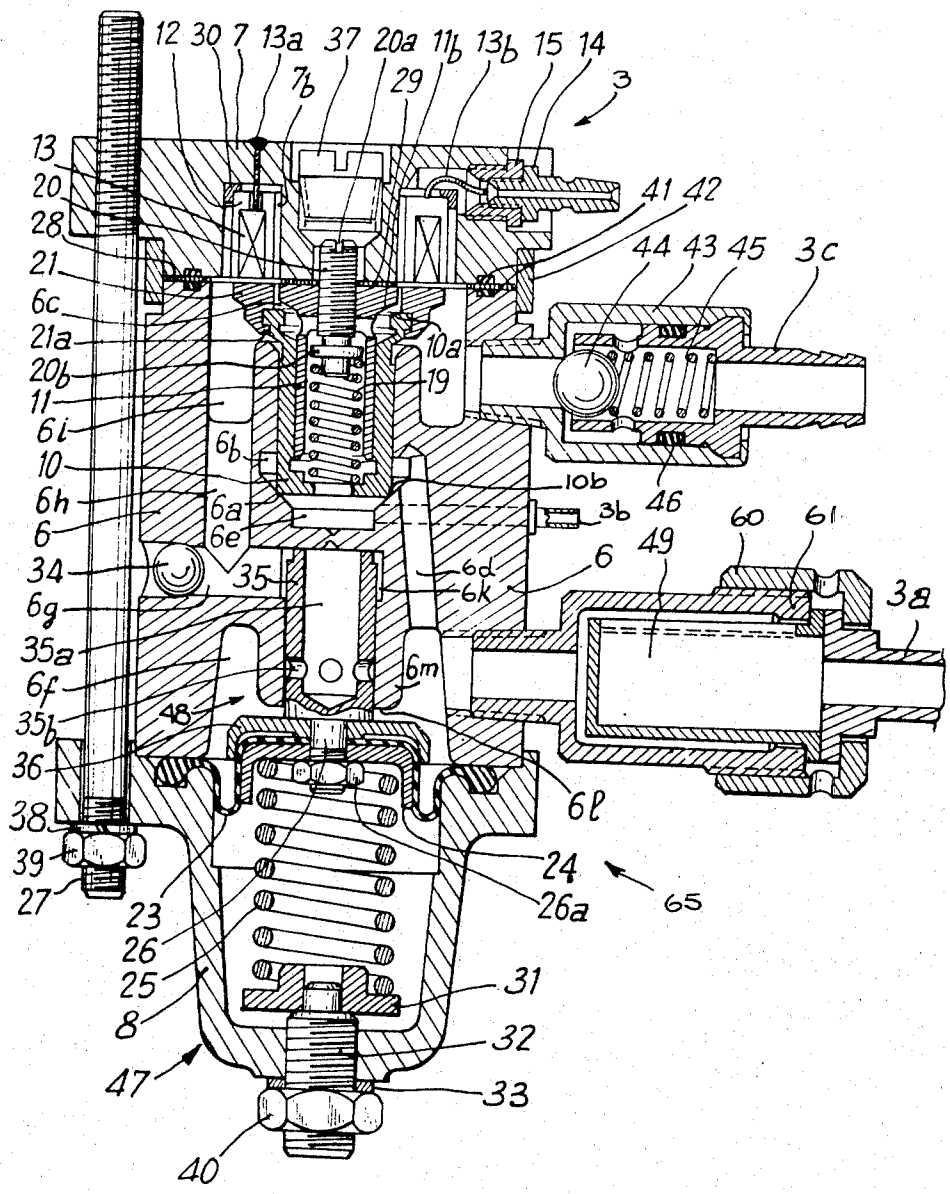


Fig. 1

Fig. 2


12
30
7
13a
37
20a
11b
13b
15
14
3
7b
29
13
20
28
21
6c
21a
20b
11
6i
10
6h
6
34
6g
35a
6f
35b
36
38
39
27
23
26
25
8
47
40
41
42
44
43
45
3c
10a
19
6b
6a
6e
35
10b
3b
46
60
61
49
6
6d
6k
3a
6m
48
6l
24
26a
65
31
32
33

FUEL INJECTION DEVICE FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The present invention concerns improvements to a device for directly or indirectly controlling the fuel for an internal combustion engine.

One such device is described in U.S. Pat. application Ser. No. 135,963 for "Control System for the Injection of Fuel Into Internal Combustion Engines", filed Apr. 21, 1971. The description of the device contained therein is incorporated by reference in this specification as though fully rewritten herein.

Briefly, the device comprises an electromagnetic metering valve which receives an electric signal having a duration which varies as a function of the operating conditions of the engine. The valve is disposed between a source of fuel under pressure and valve-type or needle-type mechanical injectors in a fashion that is of itself known. The metering valve has three flow paths. One of the paths is connected to the source of fuel under pressure while the second path is connected to the mechanical injectors either directly or through the intermediary of a sequential distributor. The third path is connected to a fuel-return conduit kept at a pressure lower than the calibrated pressure of the injectors. The metering valve is moreover arranged in such a way that, at the beginning or at the end of the electric signal, a connection is established between these three paths.

In accordance with another characteristic of the device, the metering valve comprises an annular hollow sliding piston having two positions. The piston is guided in sealed fashion in the body of the valve and is provided with a first face that in one position of the piston cooperates with a conical seat in the body. The inlet for the fuel under pressure is situated in an annular space between the conical seat and the guiding of the piston in the body, while the outlet to the injectors runs from a bore in the axis of the conical seat. The piston, which is integral with the mobile armature of the control electromagnet, comprises a second face that in another position of the piston cooperates with a second conical seat. The interior of the piston is in communication with the outlet to the injectors, while the annular space between the second conical seat and the body of the metering valve is connected to the return-flow conduit. Finally, in the device there is a provision for making the support for the valve body in the form of a flange having a central opening in communication with the fuel under pressure. The opening is closed by a diaphragm being held in position by the edge of a cover screwed on the flange. A spring is disposed between the diaphragm and the cover in such a way that the space defined by the opening and the diaphragm constitutes a hydraulic pressure accumulator.

These arrangements, and others that are described in the co-pending application provide an injection control device of very small bulk and of reliable and precise operation. However, the injection control device still necessitate the provision of a separate pressure regulator, and also the provision of a means disposed in the fuel-return conduit going to the tank for maintaining a certain back-pressure in this return flow conduit, for example, a means comprising a calibrated valve. Thus, the complete installation is relatively expensive to make, and it does not always provide the reliable functioning that should be achieved.

SUMMARY OF THE INVENTION

The present invention has the purpose of avoiding these deficiencies, and it has for its object improvements to the injection control device which controls the injection of fuel into internal combustion engines directly or indirectly. The invention is characterized by the fact that the diaphragm is connected to the regulatory valve of a pressure regulator disposed in the base of the body. When the pressure of the fuel reaches a certain value, the regulatory valve establishes communication between the opening, and thus the fuel input, and the fuel return, thereby providing a pressure regulated by-pass for the pressurized fuel.

In accordance with the present invention, the regulatory valve of the pressure regulator comprises a piston which slides in sealed fashion in an appropriate bore in the body of the device. At a certain distance from the end thereof, which is integral with the diaphragm, the piston has transverse parts. These parts cooperate with the bore within which the piston slides to place the hollow interior of the piston in communication with the opening in the base of the body through the transverse parts when the diaphragm is displaced a predetermined amount. The displacement of the diaphragm is a function of the fuel pressure. The interior of the piston is also placed in communication with the fuel-return conduit.

Further, a valve is provided in the fuel-return conduit at the outlet from the body of the device. The valve is calibrated at a certain pressure in such a way as to maintain, in the interior of the body of the device upstream of the said valve, a predetermined counter-pressure.

BRIEF DESCRIPTION OF THE FIGURES

By way of an example and to facilitate understanding of the following description of one embodiment of the invention, reference is made to the accompanying drawings wherein:

FIG. **1** is a schematic representation of one injection system in accordance with the invention.

FIG. **2** is a schematic section of a device for controlling the injection of fuel in accordance with the invention.

DESCRIPTION OF ONE EMBODIMENT

Referring to FIG. **1**, the engine includes an intake manifold **51** associated with the individual pipes opening into the different engine cylinders through conventional mechanical injectors, return flap valves or needle valves. The fuel is delivered out of the container **46** by the pump **50** and delivered into the electromagnetic measuring valve **3** through the filter **49**. The excess fuel returns into the container **46** under control of a pressure regulator **48**. A pressure accumulator **47** which may, if required, form a unit with the measuring valve **3** is also provided. The measuring valve **3** is connected with an input conduit **3***a* and with a liquid output conduit **3***b* wherein the liquid is subjected to a modulated pressure leading to the injectors **4** either directly or else through a sequential distributor **9**.

A pulse transmitter **2** controlled by the rotation of the engine is adapted to actuate the electronic system **5** producing the signal controlling the measuring valve **3** and to actuate the distributor **9** to define sequentially

the operation of the injectors. The electronic system **5** produces, as well-known in the art, an electric signal under control of the operative conditions of the engine. The signal controls the amount of fuel to be injected by adjusting the duration of opening periods of the conduits **3***a* and **3***b* controlled by the measuring valve **3**. Obviously, the injectors may be designed in a manner such that they provide direct injection into the combustion chamber of the engine instead of resorting to indirect injection as in the case illustrated, this modification remaining within the scope of the invention. Electric energy is fed to the electronic system **5** by the supply **53** under control of the switch **52**. The device **65** includes parts **3** and **47–49**.

Referring to FIG. **2** it is seen that the metering valve **3** of the device **65** of the present invention is combined with a hydraulic accumulator **47** integral with it. The body **6** of the metering valve **3** comprises the connection for the conduit **3***a* supplying the liquid fuel under pressure, and having its outlet, connected through the intermediary of the filter **49**, mounted in the filter body **61** and fastened in it by the nut **60**, into an opening **6***f* in the support of the said body. The connections for the outlet conduit **3***b* of the liquid fuel runs to injectors **4**, and the return flow connection **3***c* for the liquid fuel runs to the tank **46**.

The upper element **7** comprises the electromagnet which controls the movement of the annular piston **10**. The electromagnet is of annular form with a fixed armature **12** having an inverted U-cross-section. The winding **13** of the electromagnet is housed in the interior of the U-shaped armature **12** and is connected to a terminal **14** fastened in the upper element **7** through the intermediary of an insulating ring **15**. The wire **13***b* of the winding **13** is soldered to the element **7** for grounding. It should be noted that with this arrangement the Foucault or eddy currents that might be produced in the fixed armature **12** are not able to assume a circular path because they are cut by one or more radial slots (not shown) made in the fixed armature **12**. However, in order to avoid eddy currents in the fixed armature **12**, it is in addition carefully insulated from the upper element **7** of amagnetic material by a sheet **30** of insulating material and by the slot **7***b* filled with fuel. After the electromagnet has been put in place in the upper element **7**, the surface of armature **12** facing the body **6** is substantially coplanar with the surface of upper element **7** facing the body **6**.

The electromagnet **12** and **13** activates the annular piston **10**. To accomplish this effect, the mobile armature **21** is made integral with the piston by the forming of the edge **21***a* over a corresponding shoulder of the piston. The annular piston **10** slides in a sealed manner between two positions in the body **6**. This sealing is secured by a matched assembly with very slight radial clearance. The travel of piston **10** between its two positions is limited by the conical sealing surfaces **6***a* and **11***b* in the body **6** and the guide element **11**, respectively. However, the maximum air-gap corresponding to contact of the sealing edge **10***b* with the conical surface **6***a* is regulated by a shim or spacer **28** disposed between the upper element **7** and the body **6**. The minimum air-gap or residual air-gap, corresponding to contact of the sealing edge **10***a* with the conical surface **11***b*, is regulated by another shim or spacer **29** disposed between the upper element **7** and the guiding element **11**. For this purpose the upper face of the body **6**, as well as that of the mobile armature **21** and the cylindrical element **11**, are also trued up so as to be disposed in a common plane with all the elements being assembled in their places. By this simple means of machining and assembling there are avoided the difficulties of manufacturing tolerances in making the elements. By way of example only, it may be noted that the maximum air-gap is of the order of 0.15 mm, while the residual air-gap is of the order of 0.05 mm. The travel of the annular piston **10** is therefore about 0.10 mm.

As can be seen, the cylindrical element **11** is installed slidingly in the annular piston **10** and bears against that piston through the intermediary of a return motion spring **19** which bears by one of its ends in the annular piston **10** and by its other end against a shoulder **20***b* of the regulating screw **20**.

After the assembly of the metering valve **3** and after removing the plug **37**, the tension of the return motion spring **19** can be regulated by a screwdriver inserted into the slot **20***a* of the regulating screw **20**.

In the position of the annular piston **10** that is shown, i.e., the electromagnet not being energized, the outlet connection **3**b is in communication with the returned liquid conduit **3***c*. This is accomplished by way of the central bore **6***e*, the interior of the annular piston **10**, the cylindrical guiding element **11**, the annular space **6***c* and the annular space **6**i, in such a manner that the injectors **4** are subjected to a low pressure that is equal to a pressure of the order of 2 to 3 bars, in order to avoid a formation of vapor bubbles in the circuit at high operating temperatures. Nevertheless the counter-pressure must be less than the calibrated pressure of the injectors.

The aforesaid counter-pressure is obtained by means of a check valve mounted in the outlet conduit **3***c* and comprises a valve body **43** and a ball **44** pressed against its seat by the coil spring **45**. A toroidal seal **46** is provided to insure a leakproof seal.

When the electromagnet **12** and **13** is excited, its mobile armature **21** is attracted upward and the sealing edge **10***a* of the annular piston **10** comes into contact with the conical surface **11***b*. This terminates communication of the central bore **6***e* with the connector **3***c*, while establishing communication of the pressured liquid supplying connector **3***a* to the outlet connector **3***b* for the injectors. This is accomplished through the opening **6***f* in the base of the body **6**, the passage **6***d*, the annular space **6***b*, the passage between the sealing edge **10***b* and the conical surface **6***a*, and the central bore **6***e*. The outlet connector is communicatively connected to the central bore **6***e*.

The pressure accumulator **47** comprises a diaphragm **23** clamped by the cover **8** against the body **6**. The diaphragm **23** is guided by the piston **24** and the dome **36**, which are clamped against one another by the screw **26**, which is integral with the piston **35** and the nut **26***a*. The diaphragm **23** is pressed against by the spring **25**, which bears on the one hand against the interior of the piston **24**, and on the other hand against the abutment **31**. The position of the abutment **31** can be regulated by the regulating screw **32**, which is locked in position by the nut **40** through the intermediary of the washer **33**.

The piston 35 constitutes the regulatory valve for the pressure regulator 48. For this purpose it comprises transverse parts 35*b* which place the hollow interior 35*a* of the piston into communication with the opening 6*f* when the parts 35*b* pass beyond the edge 6*l* of the cylindrical casing 6*m* for the piston 35. In this position communication is established between the opening 6*f*, the annular space 6*k* at the base of the cylindrical casing 6*m*, the passages 6*g* and 6*h*, the annular space 6*i* and the outlet connector 3*c*. The passage 6g is moreover closed off from the outside by a press-fit ball 34.

It may therefore be considered that the construction of the regulatory valve of the pressure regulator in the form of a piston permits combining the function of a pressure accumulator 47 with the function of a pressure regulator 48. In fact, as long as the transverse ports 35*b* do not reach the edge 6*l* of the cylindrical casing 6*m*, the pressure in the opening 6*f* is solely a function of the force exerted by the spring 25, which varies linearly with the displacement of the piston 35, on the diaphragm 23 which is integral with it through the intermediary of the piston 24 and the dome 36.

The characteristic of the spring 25 is of course chosen so that the force varies linearly with a very small slope so that the variation of the pressure between the position of rest, as illustrated in FIG. 2, and the position in which the transverse ports 35*b* are uncovered may be as small as possible. When the transverse ports 35*b* are uncovered, the piston 35 operates like the valve of a pressure regulator; that is to say, the displacements of the piston as a function of the supply that should pass through it are of very small amplitude because the passageway section of the ports 35*b* increases very rapidly with the displacement of the piston 35. Therefore, the pressure remains practically constant from the time when the transverse ports 35*b* reach the edge 6*l* of the cylindrical casing 6*m*. The three elements 7, 6 and 8, are clamped together by gudgeons 27, which are on the one hand screwed directly into a threaded hole in the element 7, and are on the other hand tightened up by a nut 39 through the intermediary of a washer 38. Centering of the element 7 relatively to the body 6 is obtained by a cylindrical ring 42. Sealing between the body and the upper element 7 is secured by the toroidal seals 41.

It should be noted that the arrangement according to the invention not only permits a compact construction of small bulk, but also the functioning of the device is improved because of the fact that the pressure regulator is disposed in the interior of the injection control device. This latter improvement permits a constant flow of the fuel through the device to be obtained, thus ensuring cooling of the entire device and the avoidance of the possibility of the formation of vapor bubbles therein.

What is claimed is:

1. An improved device for controlling the injection of pressurized fuel from a source of fuel on an internal combustion engine, the device having a body having a fuel input adapted to receive the pressurized fuel, a fuel output adapted to provide fuel to injectors, and a fuel return adapted to return fuel to the fuel source, a valve mounted within the body, the valve having a first path therein communicatively connected to the fuel input, a second path therein connected to the fuel output and a third path therein connected to the fuel return, an electromagnet mounted within the body for actuating the valve, the valve being adapted to place the fuel input into communication with the fuel output when it is actuated, the body having an opening in one surface thereof, a diaphragm mounted across the opening in the body to form an enclosed volume within the body, the enclosed volume being communicatively connected to the fuel input, the diaphragm being adapted to deflect outwardly away from the enclosed volume in response to increases in the pressure of the fuel to be provided to the fuel input, the improvement comprising a pressure regulator disposed within the body and having a regulatory valve, the regulatory valve having an input in communication with the enclosed volume and an output in communication with the fuel return, the regulatory valve being adapted to establish communication between the enclosed volume and the fuel return when the pressure of the pressurized fuel to be provided to the fuel input reaches a predetermined value.

2. A device in accordance with claim 1 and further defined wherein the regulatory valve of the pressure regulator is adapted to establish the communication between the enclosed volume and the fuel return in response to a predetermined deflection of the diaphragm caused by a predetermined pressure of the pressurized fuel to be provided to the fuel input.

3. A device in accordance with claim 2 and further defined wherein the regulatory valve of the pressure regulator comprises a bore in the body of the device and a piston mounted in the bore for movement in a first and a second direction, the piston having a hollow interior and having transverse ports disposed at a predetermined distance from one end of the piston, the transverse ports extending from the exterior of the piston to the hollow interior thereof, the hollow interior of the piston being in communication with the bore adjacent the other end of the piston, the bore being in communication with the fuel return, the piston being adapted for movement in the first direction in response to an outward deflection of the diaphragm and for movement in the second direction in response to an inward deflection of the diaphragm, the piston and the bore being adapted to place the enclosed volume, and thus the fuel input, in communication with the fuel return through the transverse ports and the hollow interior of the piston when the piston moves at least a predetermined distance in the first direction in response to a predetermined deflection of the diaphragm.

4. A device in accordance with claim 3 and further defined wherein the one end of the piston is coupled to the diaphragm for movement therewith.

5. A device in accordance with claim 2 and further defined wherein the diaphragm deflects outwardly in two stages, the first stage of outward deflections encompasses from zero deflection to the predetermined deflection and the second stage of deflections encompasses further outward deflections of the diaphragm, during the first stage of deflections the enclosed volume being adapted to function as an accumulator for the pressurized fuel to be provided, further outward deflection of the diaphragm causing the regulatory valve of the pressure regulator to open whereby the

pressurized fuel to be provided to the fuel input passes from the enclosed volume to the fuel return.

6. A device in accordance with claim 2 and further defined wherein a passage is formed in the body of the device adjacent to and about the valve, the passage being in communication with the fuel return, the second path of the valve and the output of the regulatory valve, whereby pressurized fuel passing from the enclosed volume through the regulatory valve to the fuel return in response to the opening of the regulator valve circulates about the valve.

7. A device in accordance with claim 2 and further comprising a valve in the fuel return of the body of the device, the valve being adapted to remain closed until the hydraulic pressure of the pressurized fuel to be provided in the interior of the body reaches a predetermined pressure upstream of the valve, thus establishing a predetermined counter-pressure for the fuel within the device.

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