April 1, 1952 H. G. CAMNER 2,591,401

FUEL INJECTION DEVICE

Filed May 27, 1947 3 Sheets-Sheet 1

Fig. 1

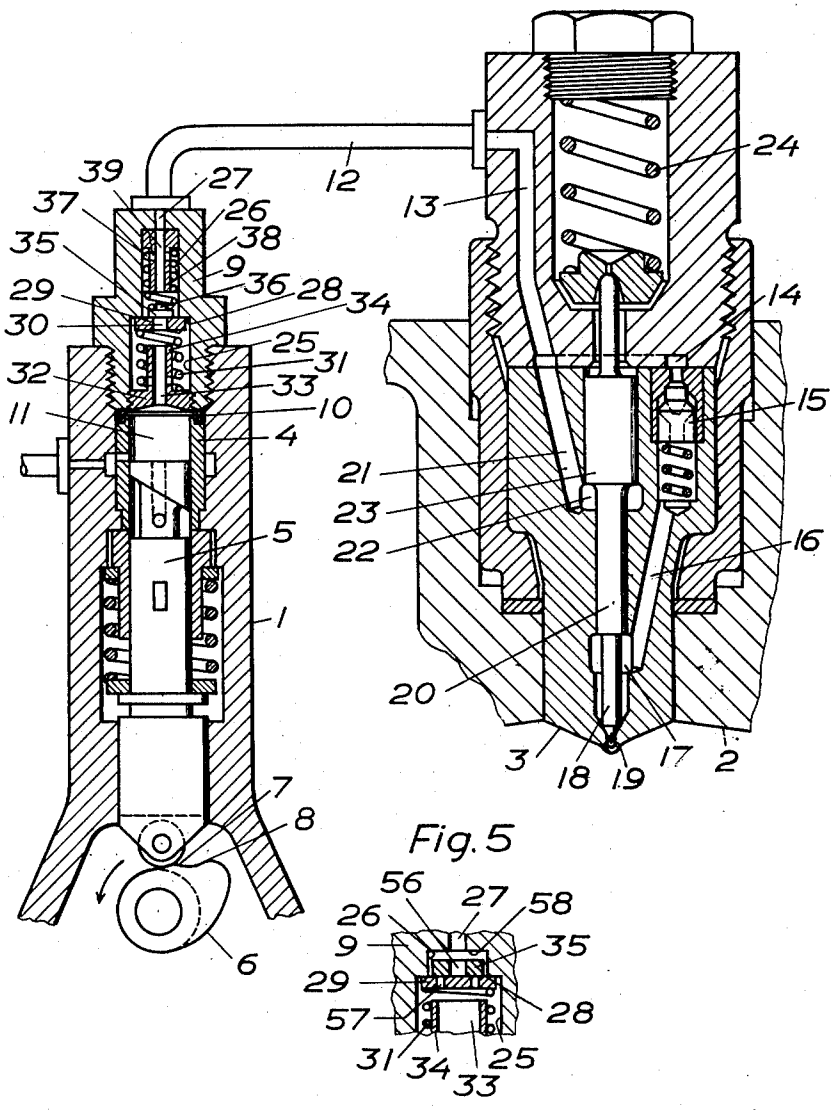

Fig. 5

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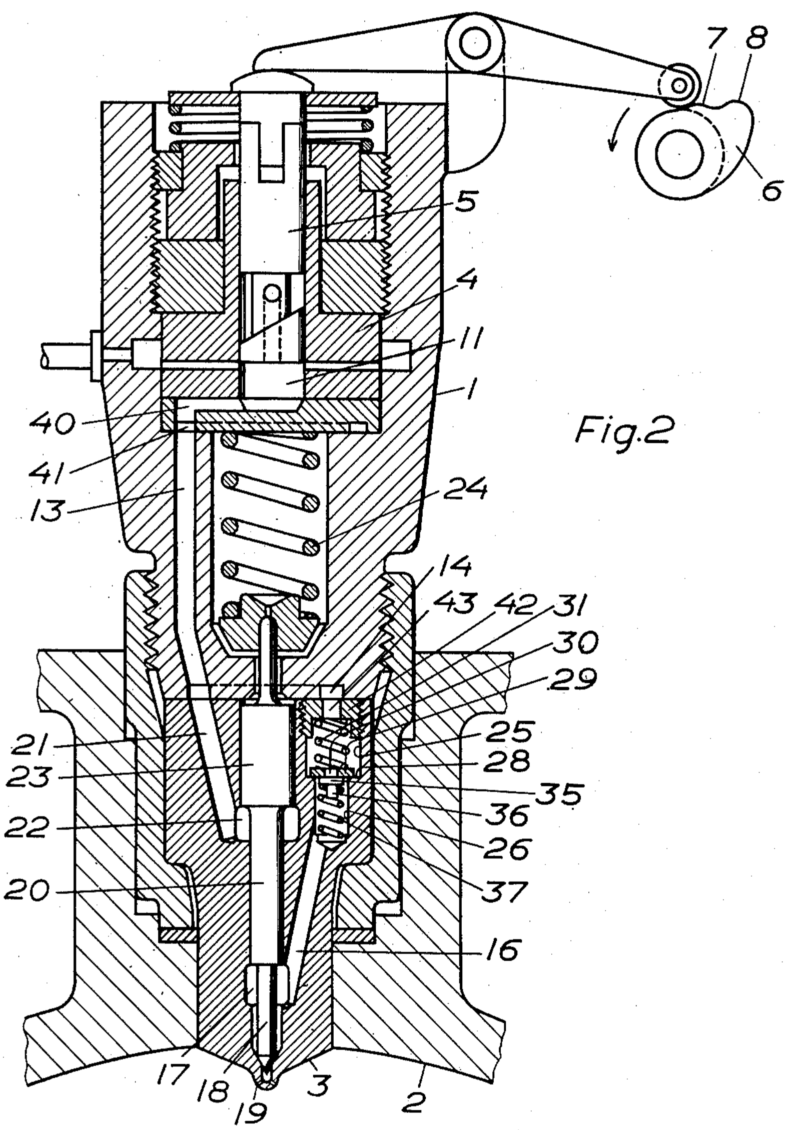

Fig.2

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FUEL INJECTION DEVICE

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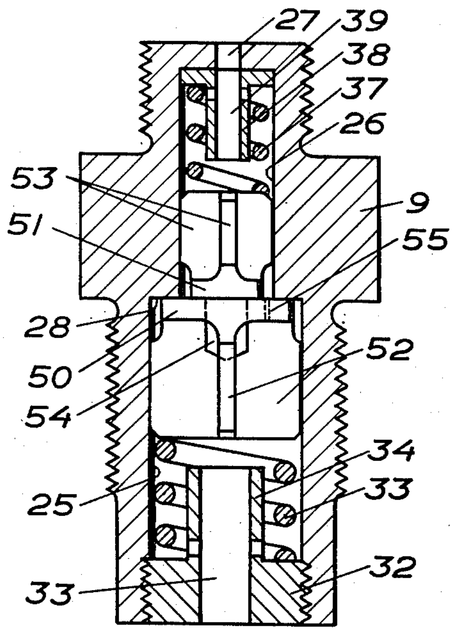

Fig. 4

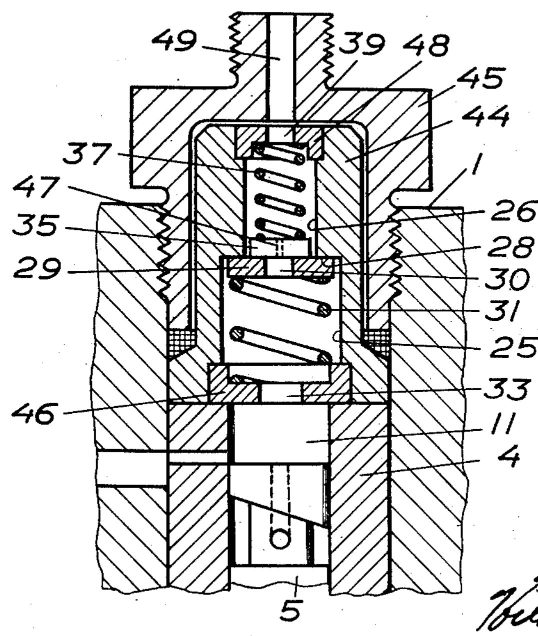

Fig. 3

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UNITED STATES PATENT OFFICE

2,591,401

FUEL INJECTION DEVICE

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23 Claims. (Cl. 103—41)

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This invention relates to improvements in fuel injection devices provided with a pressure reduction valve permitting flow of fuel in two directions in a fuel conduit. One object of the invention is to provide a device of this type which is simple and cheap in manufacture and produces little flow resistance. A further object of the invention is to provide a device in which it is possible to use a low feed pressure at a fuel injection pump forming a part of the device. According to the invention a fuel injection device including a fuel conduit and a pressure reduction valve permitting flow of fuel in both directions in said conduit comprises a valve housing, a passage in said valve housing forming a portion of the fuel conduit, a seat in said passage in the housing, a spring loaded member movable in the longitudinal direction of the passage and forced towards said seat by the spring load and having a plane surface substantially perpendicular to the longitudinal direction of the passage, a passage in said spring-loaded member opening in said plane surface, and a valve member movable in the longitudinal direction of the passage in the housing having a plane surface perpendicular to said direction and cooperating with the plane surface of the spring-loaded member when the fuel pressure acts on the valve member against the action of the spring load. Since the spring-loaded member and the valve member are combined and cooperate in the manner set forth with plane surfaces substantially perpendicular to the longitudinal direction of the passage a very simple device is obtained which is easily manufactured and assembled and requires little accuracy in manufacture.

In the accompanying drawings some embodiments of fuel injection devices according to the invention are illustrated by way of example. Fig. 1 is a section of a fuel injection pump and a fuel injection valve device connected therewith according to the invention. Fig. 2 is a section of a fuel injection pump built together with a fuel injection valve device according to the invention. Fig. 3 illustrates in section on a larger scale a further embodiment of a pressure reduction valve incorporated in a device according to the invention. Fig. 4 illustrates also in section a still further embodiment of a pressure reduction valve according to the invention. Fig. 5 is a detail view showing a modification of the pressure reduction valves illustrated in Figs. 1–3.

The fuel injection device illustrated in Fig. 1 includes a fuel injection pump and a fuel injection valve device with low opening pressure and

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high closing pressure provided in a wall of a combustion chamber. 1 designates the pump housing of the fuel injection pump, 2 a portion of the wall of a combustion chamber, and 3 a fuel injection valve device disposed in said wall. 4 is the cylinder of the pump in which a piston 5 is reciprocable said piston being driven by a cam 6. The pump may naturally have any number of cylinders one of which only is illustrated in the drawing. The cam 6 is provided with a cam portion 7 having a moderate rise for producing a preliminary injection of a small fuel quantity and a further cam portion 8 with steeper rise for producing the main injection. The latter cam portion may preferably be combined with the first-mentioned cam portion in such a manner that the fuel injection valve device does not close between the preliminary injection and the main injection. The cam 6 and the fuel injection pump as well as the fuel injection valve device may naturally be carried out in other ways common to the art without departing from the scope of the present invention.

At the upper end of the pump housing 1 a valve housing 9 is screwed into the pump housing a packing 10 being provided between the pump cylinder 4 and the valve housing 9. The valve housing forms a passage from the pressure chamber 11 of the fuel injection pump to a conduit 12 leading to the fuel injection valve device in which it is connected to a duct 13 leading through an annular groove 14 over a spring-loaded check valve 15 provided with a pressure reducing piston portion to a duct 16 and a space 17. A needle valve 18 extends through said space and in closed position of said valve the space 17 is separated by the valve from nozzle openings 19 and the combustion chamber. The space 17 is partly confined by an end surface of a small piston portion 20 formed on the needle valve and subjected to the fuel pressure in the space 17. A duct 21 leads from the annular groove 14 to a space 22 in the fuel injection valve said space being partially confined by an end surface of a large piston portion 23 formed on the needle valve. The piston portions 20 and 23 are lapped in the body of the fuel injection valve device and the needle valve 18 is pressed towards its seat in a direction towards the combustion chamber by a spring 24.

The passage through the valve housing 9 comprises a large axial cylindrical bore 25 and a smaller coaxial bore 26 from which a duct 27 leads to the conduit 12. At the juncture of the bore 25 and the bore 26 an annular seat 28 for

a valve disc 29 carried out with parallel surfaces is formed in the housing 9 by a surface perpendicular to the passage through the valve housing. The disc 29 is provided with a central passage 30 opening into the plane ground upper side of the disc. The disc 29 may be circular, square with rounded corners or of any other shape or size so that fuel may flow, for instance, past the periphery of the disc when the disc lifts from the seat 28. A spring 31 normally forces the valve disc 29 towards the seat 28. The spring 31 is inserted between the valve disc and a spring retainer 32 screwed into the lower portion of the valve housing 9. The retainer 32 has a central passage 33 and forms a stopper 34 for limiting the movement of the valve disc. The tension of the spring 31 may be considerable and determines the value of the residual pressure remaining in the fuel conduit between the valve disc 29 and the fuel injection valve device. A plane valve 35 rests on the plane upper side of the valve disc 29 with its plane ground under side and covers the openings of the passage 30 and forms a seal together with the plane upper side of the valve disc 29. The valve 35 is provided with a guide pin 36 on which the small lower windings of a soft helical spring 37 are wound. The upper portion of the spring 37 is cylindrical and guided by the bore 26. The valve disc 29 may naturally be guided in similar manner. A stopper 38 for limiting the motion of the valve 35 is provided at the bottom of the bore 26 said stopper being provided with ducts 39 through which fuel may pass to and from the duct 27. The spring 37 as well as the guide pin 36 may sometimes be dispensed with. In certain cases one or both stoppers 34 and 38 may also be dispensed with.

During the pressure stroke of the pump piston 5 fuel flows from the pressure chamber 11 through the passage 33 and the passage 30 lifting the valve 35 against the action of the spring 37 and flowing on through the ducts 39, 27, 12 and 13 to the groove 14 in the fuel injection valve device. From the groove 14 a portion of the fuel is conducted through the duct 21 to the space 22 in which it acts on the large piston portion 23 of the needle valve in the opening direction. From the groove 14 fuel also flows past the valve 15 through the duct 16 to the space 17 in which it acts upon the small piston portion 20. When the fuel pressure on the piston portions 23 and 20 is sufficient for overcoming the force of the spring 24 the needle valve 18 opens and fuel is injected into the combustion chamber through the nozzle openings 19. When the pressure in the pressure chamber 11 is unloaded the needle valve quickly closes and a certain fuel quantity then moves back from the fuel injection valve device in the duct 13 and the conduit 12 towards the valve housing 9 in which the valve 35 due to the pressure release in the chamber 11 has just returned to the position in which it covers the opening of the passage 30 in the valve disc 29. The return flow of fuel then lifts the valve disc 29 from its seat 28 against the action of the spring 31 so that fuel may pass at the periphery of the disc 29. Pressure waves from the fuel injection valve device are caught in the same way, and, consequently, cannot be reflected back to the fuel injection valve device where they might produce a momentary opening of the needle valve at not desired times.

In the embodiment according to Fig. 2 parts corresponding to equivalent parts in Fig. 1 have been designated by the same reference numerals

and are not described again. The main differences with respect to the device according to Fig. 1 are due to the fact that the device according to Fig. 2 consists of a pump housing 1 built together with the fuel injection valve device 3. The spring 24 loading the needle valve 18 is disposed in said pump housing and the pressure reduction valve is disposed in the body of the fuel injection valve device in which it replaces the valve 15 according to Fig. 1. Thus, the pump in this case is not provided with a pressure valve in direct connection with the pump cylinder 4, but the pressure chamber 11 is connected through a duct 40 and an annular groove 41 directly to the duct 13 in the portion of the device common for the pump housing and the fuel injection valve device. A pressure reduction valve is built into the body of the fuel injection valve device 3, which consequently replaces the valve housing 9 of Fig. 1. In order to accommodate the pressure reduction valve the fuel injection valve device 3 is provided with a large bore 25 from the bottom of which a small bore 26 extends towards the duct 16. The portion at the juncture between said bores forms an annular seat 28 as in Fig. 1 for a valve disc 29 having a central passage 30 and normally held towards the seat 28 by a spring 31. The spring 31 is inserted between the valve disc 29 and a spring seat 42 screwed into the upper end of the bore 25 and provided with a duct 43 communicating with an annular groove 14. A spring 37 is inserted in the bore 26 between the bottom of the bore and the valve 35 which with its plane upper side rests on the plane under side of the valve disc 29 and is guided with its pin 36 in the spring 37.

In the embodiment of the invention illustrated in Fig. 3, which shows a pressure reduction valve assembly and the upper portion of a fuel injection pump only, the pressure reduction valve is provided in a valve housing 44 which is pressed towards the upper end of the pump cylinder 4 by a nut 45. In this case the valve disc 29 is inserted between the annular seat 28 and the helical spring 31 which rests in a spring seat 46 press-fitted into the valve housing 44. The valve member 35 is carried out as a plane disc provided with a small leak passage 47 disposed opposite the opening of the passage 30 in the valve disc 29 so that a certain fuel quantity determined by the size of the leak opening 47 can always leak past the valves. By this means the pressure drop or pressure reduction in the fuel conduit between the valve 35 and a fuel injection valve device connected to the pressure reduction valve assembly may be varied, for instance according to the number of revolutions of an engine driving the pump in such a manner that at a high number of revolutions a small pressure reduction only gets time to occur in the fuel conduit additional to the pressure reduction determined by the valve disc 29 and the spring 31. The valve 35 is pressed towards the valve disc 29 by a helical spring 37 inserted between the valve 35 and a spring seat 48 press-fitted into the upper end of the valve housing 44. The bore 26 is connected with the fuel conduit to the fuel injection valve device by a duct 39 in the spring seat 48 and a duct 49 in the nut 45.

In the embodiment illustrated in Fig. 4, which shows a reduction valve assembly only, the valve housing 9 contains valve members 50 and 51 provided with guide ribs 52 and 53, respectively, so that said valve members are guided axially in the bores 25 and 26, respectively. The valve 50 has

an annular plane upper side provided with a central recess **54** through which fuel may pass when the valve **51** is open. In closed position the valve **51** rests on the plane upper side of the valve **50** with its plane under side thereby covering the opening of the recess **54**. The valve **50** is provided with a small leak opening **55** which is never covered by the valve **51** and through which fuel can always leak said passage serving the same purpose as the leak passage **47** according to Fig. 3.

Fig. 5 illustrates a modification of the pressure reduction valves of the devices according to Figs. 1–3. The valve **35** according to Fig. 5 is a plane disc valve having a central opening **56** and cooperating with the plane underside with a valve disc **29** provided with passages **57** normally covered by the valve **35**. The valve disc **29** is movable between the seat **28** and a stopper **34** and is normally held against the seat **28** by the spring **31**. The valve **35** is movable between the bottom **58** of the bore **26** and the valve disc **29** but has no spring load. Free spaces are provided at the periphery of the valve **35** and the valve disc **29** for passage of fuel when the valve disc **29** moves from its seat **28**.

The devices according to the invention described hereinabove and illustrated in the drawings should only be considered as examples and the details of the invention may be modified or combined in several different ways within the scope of the claims.

What I claim is:

1. A fuel injection device including a fuel conduit and a pressure reduction valve permitting flow of fuel in both directions in said conduit and comprising a valve housing, a passage in said valve housing forming a portion of the fuel conduit, a seat in said passage in the housing, a spring loaded member movable in the longitudinal direction of the passage and forced towards said seat by the spring load and having a plane surface substantially perpendicular to the longitudinal direction of the passage, a passage in said spring loaded member opening in said plane surface, and a valve member movable in the longitudinal direction of the passage in the housing having a plane surface substantially perpendicular to said direction and cooperating with the plane surface of the spring loaded member when the fuel pressure acts on the valve member against the action of the spring load.

2. A fuel injection device including a fuel conduit and a pressure reduction valve permitting flow of fuel in both directions in said conduit and comprising a valve housing, a passage in said valve housing forming a portion of the fuel conduit, a seat in said passage in the housing, a spring loaded member movable in the longitudinal direction of the passage and forced towards said seat by the spring load and having a plane surface substantially perpendicular to the longitudinal direction of the passage, a passage in said spring loaded member opening in said plane surface, and a valve member movable in the longitudinal direction of the passage in the housing having a plane surface substantially perpendicular to said direction and cooperating with the plane surface of the spring loaded member so as to seal the passage in the spring loaded member when the fuel pressure acts on the valve member and the spring loaded member against the action of the spring load.

3. A fuel injection device according to claim 1 in which the passage in the valve housing comprises a bore with large cross section and a co-axial bore with small cross section the seat in the passage being formed on an annular surface at the juncture between said bores.

4. A fuel injection device according to claim 2 in which the passage in the valve housing comprises a bore with large cross section and a co-axial bore with small cross section the seat in the passage being formed on an annular surface at the juncture between said bores and forming a seal with the plane surface of the spring loaded member when in seated position.

5. A fuel injection device including a fuel conduit and a pressure reduction valve permitting flow of fuel in both directions in said conduit and comprising a valve housing, a passage in said valve housing forming a portion of the fuel conduit and comprising a bore with large cross section and a co-axial bore with small cross section forming a continuation of said large bore, a duct in the housing leading from said small bore and forming a portion of the conduit, a seat in the housing formed on an annular surface at the juncture between the large bore and the small bore, a spring loaded member moveable in the longitudinal direction of said bores and forced towards said seat by the spring load and having a plane surface substantially perpendicular to the bores and cooperating with the seat to form a seal, a passage in said spring loaded member opening in said plane surface, a valve member movable in the longitudinal direction of the bores having a plane surface substantially perpendicular to said direction and cooperating with the plane surface of the spring loaded member so as to seal said passage in the spring loaded member when the fuel pressure acts on the valve member and the spring loaded member against the action of the spring load, a plug in the large bore serving to retain the valve member and the spring loaded member and the spring in the bores in the housing as a self contained unit, and a passage in said plug forming a portion of the conduit.

6. A fuel injection device according to claim 2 in which the spring loaded member consists of a plane disc confined by two parallel surfaces and provided with a passage extending from one of said surfaces to the other.

7. A fuel injection device according to claim 2 in which the valve member consists of a plane disc confined by two parallel surfaces.

8. A fuel injection device according to claim 1 in which a stopper is provided for limiting the movement of the spring loaded member.

9. A fuel injection device according to claim 1 in which a stopper is provided for limiting the movement of the valve member.

10. A fuel injection device according to claim 2 in which a stopper is provided for limiting the movement of the spring loaded member.

11. A fuel injection device according to claim 2 in which a stopper is provided for limiting the movement of the valve member.

12. A fuel injection device according to claim 2 in which the valve member is loaded by a soft spring and the spring loaded member by a spring of larger force.

13. A fuel injection device according to claim 2 in which the valve member is provided with a leak passage through which fuel may leak in all positions of the valve member.

14. A fuel injection device according to claim 2 in which the spring loaded member is provided

with a leak passage forming a by-pass of the valve member.

15. A fuel injection device according to claim 1 in combination with a fuel injection valve device having a needle valve provided with a large piston portion and a small piston portion actuated by the fuel pressure in the fuel conduit in opening direction of said needle valve, at least one of said piston portions producing a certain movement of fuel away from the fuel injection valve device upon closure of the needle valve.

16. A two way flow valve assembly for fuel injection devices comprising a valve housing, a fuel passage in said housing, a seat in the housing through which said passage extends, a spring loaded member movable in the passage and forced towards said seat by the spring load and having a surface formed for cooperation with the seat, a communication between portions of the passage which in seated position of said spring loaded member by-passes the surface cooperating with the seat, and a spring load free valve member movable in the passage for restricting fuel flow through said communication in one direction in one seated position of said valve member and for permitting fuel flow through the communication in the opposite direction in another seated position of the valve member.

17. A two way flow valve assembly for fuel injection devices comprising a valve housing, a fuel passage in said housing, a seat in the housing through which said passage extends, a spring loaded member movable in the passage and forced towards said seat by the spring load and having a surface formed for cooperation with the seat to form a seal, a communication between portions of the passage which in seated position of said spring loaded member by-passes said surface cooperating with the seat, and a spring load free valve member movable in the passage for interrupting fuel flow through said communication in one direction in one seated position of said valve member and for permitting flow through the communication in the opposite direction in another seated position of the valve member.

18. A two way flow valve assembly for fuel injection devices comprising a valve housing, a fuel passage in said housing, a seat in the housing through which said passage extends, a spring loaded member movable in the passage and forced towards said seat by the spring load and having a surface formed for cooperation with the seat, a communication in said spring loaded member between portions of the passage which in seated position of the spring loaded member by-passes said surface cooperating with the seat, a seat on the spring loaded member through which said communication extends, a further seat in the housing, and a spring load free valve member movable in the passage between said seat on the spring loaded member and said further seat for restricting fuel flow through the communication in one direction in seated position of said valve member on the seat on the spring loaded member and for permitting fuel flow through the communication in the opposite direction in seated position of the valve member on the further seat.

19. A two way flow valve assembly for fuel injection devices comprising a valve housing, a fuel passage in said housing, a seat in the housing through which said passage extends, a spring loaded member movable in the passage and forced towards said seat by the spring load and having a surface formed for cooperation with the seat to form a seal, a communication in said spring loaded member between portions of the passage which in seated position of the spring loaded member by-passes said surface cooperating with the seat, a seat on the spring loaded member through which said communication extends, a further seat in the housing, and a spring load free valve member movable in the passage between said seat on the spring loaded member and said further seat and having a surface cooperating with the seat on the spring loaded member to form a seal for interrupting fuel flow through the communication in one direction in seated position of said valve member on the seat on the spring loaded member and movable towards the further seat for permitting fuel flow through the communication in the opposite direction in seated position of the valve member on the further seat.

20. A two way flow valve assembly for fuel injection devices comprising a valve housing, a fuel passage in said housing, a plane seat in the housing through which said passage extends, a spring loaded member movable in the passage and forced towards said seat by the spring load and having a plane surface formed for cooperation with the seat to form a seal, a communication in said spring loaded member between portions of the passage which in seated position of the spring loaded member by-passes said surface cooperating with the seat, a plane seat on the spring loaded member forming a continuation of the surface cooperating with the seat in the housing through which said communication extends, a further seat in the housing, and a spring load free valve member movable in the passage between said seat on the spring loaded member and said further seat and having a plane surface cooperating with the seat on the spring loaded member to form a seal for interrupting fuel flow through the communication in one direction in seated position of said valve member on the seat on the spring loaded member and movable towards the further seat for permitting fuel flow through the communication in the opposite direction in seated position of the valve member on the further seat.

21. A two way flow valve assembly for fuel injection devices comprising a valve housing, a fuel passage in said housing, a seat in the housing through which said passage extends, a member movable in the passage and having a surface formed for cooperation with the seat, a communication between portions of the passage which in seated position of said member by-passes the surface cooperating with the seat, and a valve member movable in the passage for restricting fuel flow through said communication in one direction in one seated position of said valve member and for permitting fuel flow through the communication in the opposite direction in another position of the valve member.

22. A fuel injection device including a fuel conduit and a pressure reduction valve permitting flow of fuel in both directions in said conduit and comprising a valve housing, a passage in said valve housing forming a portion of the fuel conduit, a seat in said passage in the housing, a first member movable in the passage and forced towards said seat and having a plane surface, a passage in said member opening in said plane surface, and a valve member movable in the passage in the housing having a plane surface and cooperating with the plane surface of

said first member when the fuel pressure acts on the valve member to move it towards said first member to close said opening in the plane surface of said first member.

23. A two way flow valve assembly for fuel injection devices comprising a valve housing, a fuel passage in said housing, a plane seat in the housing through which said passage extends, a disc shaped valve member movable in the passage and having a plane surface formed and disposed for cooperation with said seat to form a seal, a leak passage in said valve member, and a further seat in the passage, said valve member being movable between said seats and, when seated on said first mentioned seat, providing a restricted passage for fuel through said leak passage, and when unseated from said first mentioned seat, providing an unrestricted passage for the fuel through the valve assembly.

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