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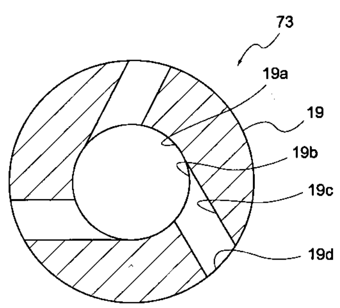
(54) HIGH FLOW RATE FUEL VALVE AND FUEL SUPPLY PUMP WITH THE VALVE

(57) A high flow rate fuel valve suitable for an accumulator fuel injection device by which a large amount of fuel is amplified using a piston and used and a fuel supply pump using the high flow rate fuel valve are provided.

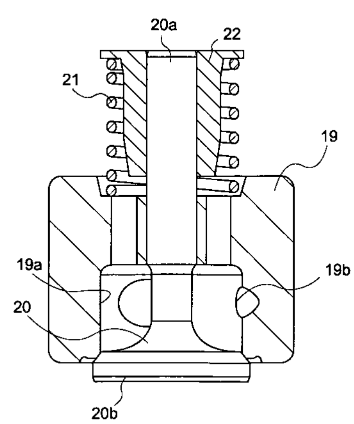
For this purpose, in a fuel supply pump with a fuel inlet valve and fuel outlet valve, the fuel inlet valve has a valve main body, a valve body received in the valve main body, an inlet chamber provided inside the valve main body, inlet holes, a seat portion where the valve body and part of valve main body are in contact with each other. The inlet holes are arranged in a non-radial pattern relative to the inlet chamber.

Fig.1

(a)



(b)



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Description

Technical Field

[0001] The present invention relates to a high flow rate fuel valve and a fuel supply pump with the valve. Particularly, the present invention relates to a high flow rate fuel valve suitable for a fuel supply pump used in an accumulator fuel injection device (APCRS: Amplified Piston Common Rail System) that amplifies the pressure of a large flow rate of fuel through the use of a pressure piston, and a fuel supply pump with the valve.

Backgrounds

[0002] Conventionally, various accumulator fuel injection devices (CRSs: Common Rail Systems) using pressure accumulators (common rails) have been proposed in order to inject high-pressure fuels efficiently in diesel engines and so on.

[0003] For instance, as shown in Fig. 20, for switching the pressures of a pressure accumulator depending on the driving conditions of an engine, JP 06-93936 A has proposed an accumulator fuel injection device having a first pressure accumulator 236 responsible for a main injection and a second pressure accumulator 278 responsible for a pilot injection. These pressure accumulators 236, 278 are switched by a switching device 286 to carry out a fuel injection.

[0004] For obtaining the injection pressure, which is perfect for engine performance, JP 2885076 B has proposed an accumulator fuel injection device having a pressure-amplifying piston for amplifying the pressure of a fuel and a cylinder chamber, located between a pressure accumulator and a fuel injection valve. More specifically, as shown in Fig. 21, there is disclosed an accumulator fuel injection device 380 that comprises a pressure accumulator 395; an oil supply channel 360 for a fuel; an oil control channel 361; a switching valve 362 for fuel injection control; a pressure amplifying piston 378 for elevating the fuel pressure to 70 to 120 MPa (approximately 700 to 1,200 kgf/cm^2); a cylinder chamber 383 for housing the pressure amplifying piston 378; a hydraulic circuit 363; a piston-work switching valve (three-way solid valve for amplifier) 364; and a controller (not shown).

[0005] On the other hand, in JP 06-101597 A, as shown in Fig. 22, there is proposed a fuel injection valve having a fuel spiral member and the angle formed between a fuel spiral flow channel and a circular flow channel is restricted. More specifically, the fuel provided with a revolving force by the fuel spiral member on the upstream side of a valve sheet flows between the tip portion of a valve body and the valve sheet toward a fuel injection hole and the spiral movement of the fuel flow forms a hollow portion in a flow channel between the tip of the valve body and the fuel injection hole.

[0006] Similarly, in JP 10-47208 A, as shown in Fig. 23, there is proposed a fuel injection valve that performs fuel injection by setting revolving energy to the flow of fuel. More specifically, there is disclosed a fuel injection valve where the numbers of periphery portions, flow channel portions, and revolving grooves are defined as 4 to 8, respectively. Each of the revolving grooves is eccentric with a predetermined distance from a valve axis. In addition, the side of the revolving groove far from the valve axis is tangentially connected to the periphery of a circular groove. The side surfaces of the respective grooves facing to the revolving groove are arranged in parallel with each other.

[0007] However, the accumulator fuel injection device disclosed in JP 06-93936 A needs to be provided with two kinds of the pressure accumulator, their switching device, and so on. Therefore, there is a problem in that the accumulator fuel injection device is complicated and grown in size. In the accumulator fuel injection device, furthermore, there is an another problem in that a large amount of fuel cannot be pressurized sufficiently because the fuel is difficult to flow quickly to the fuel injection valve when the cam and plunger of the fuel supply pump are driven at high speed. As the flow rate of fuel is restricted, a large amount of fuel cannot be pressurized sufficiently.

[0008] For the accumulator fuel injection device disclosed in JP 2885076B, a pressure amplifying piston is placed between the pressure accumulator and the fuel injection valve to intend to provide a multi-stage pressure injection. In thiscase,there is also proposed a pressure pump for supplying the high-pressure fuel to the pressure accumulator. However, such a pressure pump is one of the conventional pressure pumps used for the conventional accumulator fuel injection devices. Any fuel injection valve adapted for the pressure pump, which intends to supply a large amount of high-pressure fuel, is not designed.

[0009] Furthermore, the fuel injection valves disclosed in JP 06-101597 A and JP 10-47208 A are difficult to be used as high flow fuel valves because their structures differ fundamentally from the high flow fuel valves in that the proportion of the length of an injection hole to the diameter of the injection hole is restricted within a predetermined range, a revolving body is installed, and so on.

[0010] Therefore, as a result of concentrated study, the present inventors have found out that, by providing a plurality of inlet holes and arranging the inlet holes in a non-radical pattern relative to an inlet chamber, fuel can be allowed to pass through the inlet holes quickly in a quantitative manner to pressurize a large amount of fuel sufficiently even in the case of driving a cum and a plunger at high speed.

[0011] Specifically, for addressing APCRS, an object of the present invention is to provide a fuel supply pump and a high flow value suitable for the fuel supply pump, wherein the fuel supply pump allows fuel to quickly pass through a pressure chamber of a high pressure pump to pressurize the fuel sufficiently when the cam and plunger in a fuel supply pump are driven at high speed to discharge a large amount of the fuel.

Disclosure of the Invention

[0012]

[1] According to the present invention, the above problems can be solved by providing a high flow fuel valve that comprises a valve main body, a valve body movably installed in the inside of the valve main body, an inlet chamber installed in the inside of the valve main body, inlet holes, and a seat portion where the valve body and part of the valve main body are in contact with each other, wherein a plurality of inlet holes is formed and the inlet holes are arranged in a non-radical pattern relative to the inlet chamber.

That is, as constituted above, the fuel can be introduced into the inlet chamber through a plurality of the inlet holes arranged in a non-radical pattern without substantially altering the direction of fuel flow. Even though the streams of fuel are introduced from plural directions, their mutual collisions in the inlet chamber can be lessened. Therefore, fuel, even in an extremely large amount, can be passed quickly and quantitatively through the high flow fuel valve.

[2] In addition, for constituting the high flow fuel valve of the present invention, it is preferable that the horizontal cross sectional shape of the inlet chamber is substantially a circle and the inlet holes are arranged in the tangential direction of the inlet chamber.

As constituted above, the fuel can be introduced as a rotational flow in one direction. In addition, even though the fuel is introduced from plural directions, the mutual collisions in the inlet chamber are lessened and the streams of fuel can be easily combined together as rotational flow in one direction, resulting in smooth flow.

[3] In addition, for constituting the high flow fuel valve of the present invention, it is preferable that the inlet holes are inclined in the vertical direction with respect to the inlet chamber.

As constituted above, utilizing the gravity, the fuel can be introduced as a further controlled rotational flow in one direction. In addition, the mutual collisions of streams of fuel flow tangentially from plural directions can be lessened and the streams of fuel can be easily combined together as rotational flow in one direction.

[4] In addition, for constituting the high flow fuel valve of the present invention, the diameter of the inlet hole is preferably in the range of 2 to 12 mm.

As constituted above, for example, fuel at a flow rate of approximately 500 to 1,500 liters per hour can be easily ensured, allowing the fuel supply pump to process a large amount of fuel under high pressure. In addition, it is easy to attain ultra-high pressure conditions of 180 MPa or more even in an accumulator fuel injection device used together with a pressure amplifying piston coupled with the fuel supply pump.

[5] Furthermore, for constituting the high flow fuel valve of the present invention, the seat diameter of the valve body is preferably 8 mm or more.

As constituted above, for example, fuel at a flow rate of approximately 500 to 1, 500 liters per hours can be easily ensured, allowing the fuel supply pump to process a large amount of fuel under high pressure. In addition, it is easy to attain ultra-high pressure conditions of 180 MPa or more even in an accumulator fuel injection device used together with a pressure amplifying piston coupled with the fuel supply pump.

[6] Furthermore, for constituting the high flow fuel valve of the present invention, a fuel-passing area of the inlet hole is larger than a fuel-passing area of the seat portion.

As constituted above, in the inlet chamber, fuel can be introduced into an inlet chamber without substantially changing the direction of fuel flow and the residence time in the inlet chamber can be shortened. Therefore, the fuel, even in a large amount, can be allowed to pass quickly through the high flow fuel valve in a quantitative manner.

[7] Furthermore, another aspect of the present invention is a fuel supply pump comprising a fuel inlet valve and a fuel out let valve, wherein the fuel inlet valve is constructed of: a valve main body, a valve body movably installed in the inside of the valve main body, an inlet chamber installed in the inside of the valve main body, inlet holes, and a seat portion where the valve body and part of the valve main body are in contact with each other, where a plurality of the inlet holes is formed and arranged in a radial pattern relative to the inlet chamber.

That is, as constituted above, the fuel, even in a large amount, can be allowed to pass quickly through the high flow fuel valve in a quantitative manner, allowing the fuel supply pump to process a large amount of fuel under high pressure. In addition, as constituted above, it is easy to attain ultra-high pressure conditions of 180 MPa or more even in an accumulator fuel injection device used together with a pressure amplifying piston coupled with the fuel supply pump.

[8] Furthermore, for constituting the fuel supply pump of the present invention, the fuel supply pump is used in an accumulator fuel injection device for pressurizing fuel at a flow rate of 500 to 1,500 litters per hour to a value of 50 MPa or more.

Using such an accumulator fuel injection device, a large amount of fuel can be easily pressurized. Therefore, the combustion efficiency in the fuel injection system can be raised. Also, the generation of erosion can be easily prevented, while the durability can be increased.

Brief Description of the Drawings

[0013]

Fig. 1 is a diagram that illustrates a high flow valve of the present invention, where (a) and (b) are cross-sectional views thereof, respectively.
Fig. 2 is a cross-sectional view of the high flow fuel valve of the present invention in an installed state.
Fig. 3 is a cross-sectional view of another high flow fuel valve.
Fig. 4 is a diagram for illustrating a high flow flue valve equipped with a second valve spring (coil spring).
Fig. 5 is a diagram for illustrating a high flow valve equipped with a second valve spring (flat spring).
Fig. 6 is a diagram for illustrating a high flow valve using a non-linear spring.
Fig. 7 is a characteristic diagram that illustrates the relationship between the lift of the high flow fuel valve and the flow rate per unit time.
Fig. 8 is a diagram that illustrates the conventional fuel valve, where (a) and (b) are cross-sectional views thereof, respectively.
Fig. 9 is a diagram that illustrates another conventional fuel valve, where (a) and (b) are cross-sectional views thereof, respectively.
Fig. 10 is a diagram that illustrates the conventional fuel valve, where (a) and (b) are cross sectional views for illustrating throttle positions in the fuel valve, respectively.
Fig. 11 is a diagram that illustrates another conventional fuel valve, where (a) and (b) are cross sectional views for illustrating throttle positions in the fuel valve, respectively.
Fig. 12 is a diagram that illustrates the fuel valve of the present invention, where (a) and (b) are cross sectional views for illustrating throttle positions in the conventional fuel valve, respectively.
Fig. 13 is a cross sectional view of a fuel supply pump equipped with a high flow valve as a fuel inlet valve or a fuel outlet valve.
Fig. 14 is a cross sectional view of an 10 valve constructed of a fuel inlet valve and a fuel outlet valve.
Fig. 15 is a diagram for illustrating the system of an accumulator fuel injection device (APCRS: Amplified Piston Common Rail System) in the form of a pressure amplifying piston system.
Fig. 16 is a diagram for illustrating the action of a proportional control valve (FMU) installed in a fuel supply pump.
Fig. 17 is a diagram for illustrating the configuration of an accumulator fuel injection device (APCRS: Amplified Piston Common Rail System) in the form of a pressure amplifying piston system.
Fig. 18 is a schematic diagram for illustrating a method for raising the pressure of fuel in the accumulator fuel injection device (APCRS: Amplified Piston Common Rail System) in the form of a pressure amplifying piston system.
Fig. 19 is a diagram for illustrating a timing chart of high-pressure fuel injection.
Fig. 20 is a diagram for illustrating the configuration of the conventional accumulator fuel injection device.
Fig. 21 is a diagram for illustrating the configuration of another conventional accumulator fuel injection device.
Fig. 22 is a diagram for illustrating the configuration of the conventional fuel injection system.
Fig. 23 is a diagram for illustrating the configuration of another conventional fuel injection system.

Best Mode for Carrying Out the Invention

[0014] Hereinafter, the high flow fuel valve and the fuel supply pump provided therewith will be described concretely with proper references to the drawings.

[First Embodiment]

[0015] As illustrated in (a) and (b) of Fig. 1, a first embodiment of the present invention is a high flow fuel valve 73 that comprises a valve main body 19, a valve body 20 movably installed in the inside of the valve main body 19, an inlet chamber 19a formed in the inside of the valve main body 19, inlet holes 19c, and a seat portion 23 where part of the valve body 20 and part of the valve main body 19 are contact with each other. The high flow fuel valve 73 is characterized in that a plurality of inlet holes 19c is formed and these inlet holes 19c are arranged in a non-radical pattern relative to the inlet chamber 19a.

[0016] Hereinafter, the high flow fuel valve 73 will be described more concretely by way of individually describing its structural components.

1. Valve Main Body

[0017] A valve main body is not specifically limited to a certain configuration as far as it retains a valve body and performs a predetermined movement. Preferably, however, the valve main body may be in the shape of a cap opened downwardly as shown in Fig. 1(b).

[0018] In addition, as shown in Fig. 1(b), the external shape of the valve main body 19 is substantially in the form of a cylinder, while no protrusion, rib, or the like is formed thereon so as to be substantially flat. In other words, conventionally, for centering, a rib portion 33 is formed on the upper portion of the valve main body 19 as shown in Fig. 8(b) and then the rib portion 33 is used for fixing the valve main body in position with respect to a barrel or the like. Therefore, there are problems in that the valve main body is hardly produced and the cost thereof increases. Therefore, as shown in Fig. 2, The problems in producing the valve main body can be solved by carrying out the centering by adjusting the inner diameter of a valve retaining portion 71 and the external diameter of a valve 73, while no rib portion or the like is formed on the valve main body.

[0019] Furthermore, as described latter, a valve body is installed in the valve main body. Preferably, the valve body is movable in the inside of the valve main body. That is, it is preferable to constitute a poppet valve structure.

[0020] Here, a method for driving the valve body installed in the valve main body is, but not specifically limited to, preferably a mechanical driving method using a valve spring 21 provided above the valve main body 19. Alternatively, an electro-magnetic driving method may be preferably applied.

2. Valve Body

[0021] Furthermore, it is preferable that the valve body has a sheet diameter of 8 mm or more. This is because such a configuration of the valve body leads to secure fuel at a flow rate of approximately 500 to 1,500 litters per hour and to supply the fuel to a fuel supply pump to pressurize a large amount of fuel. In addition, this is also because an ultra-high pressure injection of 180 MPa or more can be easily attained even if the fuel supply pump is coupled with an accumulator fuel injection device used together with a pressure amplifying piston.

[0022] However, the high flow fuel valve itself grows in size as the sheet diameter of the valve body increases too much. Therefore, it may lead to be difficult in installation of the high flow valve and high-precision movement of the valve body, or decrease in durability or mechanical strength of the valve body.

[0023] Therefore, the sheet diameter of the valve body is preferably in the range of 8 to 15 mm, more preferably in the range of 8 to 12 mm.

3. Inlet Holes

[0024]

(1) Number of Inlet holes

Furthermore, as shown in Fig. 1(a), the first embodiment is characterized in that plural of inlet holes 19c are formed. That is, an extremely large amount fuel can be introduced into an inlet chamber through a plurality of the inlet holes. Thus, the number of the inlet holes may be two or more, preferably in the range of three to five, more preferably three or four.

(2) Arrangement 1

Furthermore, s shown in Fig. 1(a), the arrangement of plural inlet holes is characterized in that the plural inlet holes 19c are arranged so as to be in a non-radical direction with respect to an inlet chamber 19a. Specifically, the plural inlet holes 19c are arranged such that the directions of fuel flow from the respective inlet holes 19c are staggered from the corresponding phantom lines extending toward the center of an inlet chamber 19a.

This is because the fuel can be introduced into the inlet chamber through a plurality of the inlet holes arranged in a non-radical pattern without substantially altering the direction of fuel flow. In addition, even though the streams of fuel are introduced from plural directions, their mutual collisions in the inlet chamber can be lessened because of their introduction from the directions in a non-radial pattern.

Therefore, a high flow fuel valve in which a plurality of inlet holes is arranged in a non-radial pattern allows fuel to pass through the inlet holes quickly in a quantitative manner while keeping the lift of the valve comparatively low even though the fuel is of an extremely large amount as much as approximately 500 to 1,500 liters per hour.

Furthermore, as shown in Fig. 1(a), it is preferable that the inlet chamber 19a substantially have a circular horizontal cross sectional shape and also the inlet holes 19c are arranged along the tangential directions of the inlet chamber 19a, respectively.

This is because, as the inlet holes are arranged in such a configuration, the fuel can be introduced as rotational flow in one direction into the inlet chamber. In addition, this is also because, the flue is introduced in tangentially directions. Even though the fuel is introduced from plural directions, the mutual collisions in the inlet chamber are lessened and the streams of fuel can be easily combined together as rotational flow in one direction.

However, the inlet hole does not necessarily need to be arranged in the tangential direction. For example, if it is within the limits of ±20 degrees to the tangential direction, it is tolerance level.

(3) Arrangement 2

Furthermore, according the high flow fuel valve of the present invention, as shown in Fig. 3, it is preferable to arrange an inlet hole 19c in an oblique direction with respect to an inlet chamber 19a. That is, the inlet hole is preferably arranged so as to incline the direction along which fuel is introduced from the inlet hole at a given angle (θ) with respect to a horizontal plane on which the inlet chamber that receives the fuel is present.

This is because further accelerated fuel can be introduced into the inlet chamber by arranging the inclined inlet holes and thus a much more amount of fuel can be introduced easily. In addition, the above arrangement of inclined inlet holes reduces mutual collisions between the streams of fuel flow from plural tangential directions to easily bring them together as rotational flow in one direction.

Furthermore, when each of the inlet holes 19c is perpendicularly inclined to the inlet chamber 19a, as shown in Fig. 3, the inlet hole 19c has preferably an inclined angle (θ) of 1 to 45 degrees with respect to the horizontal direction.

This is because the effect of inclined inlet holes may not be exerted when the inclined angle of inlet hole is less than 1 degree. On the other hand, the inlet flow-ability of fuel into the inlet chamber may decrease when the inlet hole has an inclined angle of more than 45 degrees. Therefore, the inclined angle of the inlet hole is preferably in the range of 5 to 30 degrees, more preferably in the range of 10 to 25 degrees.

(4) Diameter

Furthermore, each of the inlet holes has a diameter of preferably 2 to 12 mm because of the following reasons. The inlet holes of less than 2mm lead to, for example, the difficulty of ensuring fuel with a flow rate of 500 to 1,500 liters per hour and thus a large amount of fuel is hardly pressurized in a fuel supply pump. Therefore, in an accumulator fuel injection device used together with a pressure amplifying piston coupled with the fuel supply pump, for example, it is difficult to attain the ultra-high pressure conditions of 180 MPa or more.

On the other hand, when the diameter of the inlet hole exceeds 12 mm, the mechanical strength or durability of the inlet hole may decrease.

Therefore, the diameter of the inlet hole is more preferably in the range of 2.5 to 11.5 mm, further preferably in the range of 3 to 11 mm.

(5) Area of Inlet Holes

The area of inlet holes (total area of openings), the fuel-passing area of plural inlet holes is preferably larger than the fuel-passing area of a seat portion.

[0025] This is because, as the fuel-passing area of plural inlet holes is considered as described above, fuel can be introduced into an inlet chamber without substantially changing the direction of fuel flow and the residence time in the inlet chamber can be shortened. Therefore, the fuel, even in a large amount, can be allowed to pass quickly through the high flow fuel valve in a quantitative manner.

[0026] More specifically, furthermore, the area (opening area) of one inlet hole is preferably in the range of 15 to 250 mm^2.

[0027] This is because, if the area of the inlet hole is less than 15 mm^2, for example, the fuel at a flow rate of approximately 500 to 1,500 litters per hour cannot be ensured and thus a large amount of the fuel is difficult to be pressurized in a fuel supply pump. Therefore, in an accumulator fuel injection device used together with a pressure amplifying piston coupled with the fuel supply pump, for example, it is difficult to attain the ultra-high pressure conditions of 180 MPa or more.

[0028] On the other hand, the area of the inlet hole exceeds 250 mm^2, the mechanical strength or durability of the inlet hole may decrease.

[0029] Therefore, the area of the inlet hole is more preferably in the range of 20 to 200 mm^2, further preferably in the range of 25 to 150 mm^2.

[0030] Here, for plural inlet holes 19c shown in Fig. 1 (a), the term "area of one inlet hole" means the area of one opening portion 19b opened toward the inlet chamber 19a.

4. Seat Portion

[0031] As shown in Fig. 1(b), the first embodiment is characterized in that part of a valve body 20 and part of a valve main body 19 are contact with each other to provide a seat portion 23 as a fuel-passing portion for correctly controlling the mount of fuel passed. Specifically, the valve body moves up and down by means of a valve spring or the like, so that the valve body and valve main body can be partially contact with each other to form such a seat portion. Therefore, the fuel, even in a large amount, can be allowed to pass quickly through the high flow fuel valve in a quantitative manner.

[0032] In addition, as mentioned above, the seat portion is more preferably constructed such that the fuel-passing area of the seat portion is smaller than the area of the inlet hole.

5. Valve Spring

[0033]

(1) First Valve Spring

[0034] Furthermore, as shown in Fig. 1(b), it is preferable to provide a valve spring (first spring) for driving a valve body 20 above a valve main body 19.

[0035] As constituted above, the valve body can be moved up and down by the valve spring to allow the valve main body and valve body to be easily contact with each other, while absorbing a seat impact at the time of lifting the valve body.

(2) Second Valve Spring

[0036] Furthermore, as shown in Fig. 4, a second valve spring 24 is preferably installed together with the first valve spring (first spring) 21. That is, the second valve spring 24 is provided such that it is brought into contact with a valve body 20 from an initial stage of lifting the valve body 20. It is preferable to install the second valve spring 24 having a comparatively high spring constant together with the first spring 21 having a comparatively low spring constant from the middle stage of the lifting so as to be brought into contact with the valve body 20.

[0037] As constituted above, the valve body can be easily lifted at initial valve opening, so that the fuel inlet efficiency to a plunger can be increased. In addition, as the valve opening proceeds, an increasing lifting speed is lowered by the second valve spring to reduce impact force at full lift. Therefore, even in the case of the high flow fuel valve, reduction in durability and strength can be prevented and also impact noises at the time of seating the valve body can be reduced.

[0038] In addition, the second valve spring may be alternatively a spring 24 as shown in Fig. 4 or a flat spring 25 as shown in Fig. 5(a) to Fig. 5(c).

(3) Non-Linear Spring

[0039] Furthermore, as an alternative to the use of the first and second valve springs together, a non-linear spring 26 as shown in Fig. 6 is preferably used. That is, for example, the spring is constructed such that the spring has a conical shape gradually increasing in diameter toward the bottom. Therefore, the spring constant can be variable and the same effects as those obtained by installing the first and second valve springs can be obtained without increasing the number of the valve spring.

6. Performance

(1) Fuel-Passing Amount (Flow velocity)

[0040] Furthermore, for the fuel-passing amount (flow velocity) in the high flow fuel valve of the first embodiment, the flow rate of fuel per unit time when the lift of a valve body is almost 1 mm is preferably in the range of 500 to 1,500 liters per hour, more preferably in the range of 800 to 1,300 liters per hour.

[0041] This is because, as constituted above, a small-sized and low-height high flow fuel valve, which is capable of ensuring a large flow rate of fuel with a comparatively small lift of the valve body, can be provided.

[0042] Here, preferably, the high flow fuel valve of the first embodiment has a performance curve shown in Fig. 7. That is, in Fig. 7, the lift (relative value) of the valve body is plotted on the abscissa and the flow rate of fuel per unit of time, i.e., flow velocity (relative value) is plotted on the ordinate.

[0043] In Fig. 7, the line A corresponds to the conventional fuel valve. As shown in Fig. 8, this is a fuel valve 32 having a sheet diameter of 7.6 mm, in which three inlet holes 19c are arranged in a radial pattern along the periphery of a circular inlet chamber 18 (Type 1).

[0044] Likewise, the line B corresponds to a modified example of the conventional valve having an enlarged sheet diameter. As shown in Fig. 9, this is a fuel valve 34 having a sheet diameter of 10 mm, in which three inlet holes 19c are arranged in a radial pattern along the periphery of a circular inlet chamber 18 (Type 2).

[0045] Furthermore, the line C corresponds to one example of the high flow fuel valve of the present invention. As shown in Fig. 1, this is a high flow fuel valve 73 having a sheet diameter of 10 mm, in which three inlet holes 19c are arranged in a non-radial pattern along the tangent of a circular inlet chamber 18 (Type 3).

(2) Throttle and Characteristics

[0046] Furthermore, in Fig. 10 (a) and Fig. 10 (b) to Fig. 12 (a) and Fig. 12(b), throttle positions decided from the distribution of fuel velocities in the respective fuel valves (small lift and large lift) are shown, respectively.

[0047] That is, Fig. 10(a) and Fig. 10(b) illustrate throttle positions of the conventional fuel valve shown in Fig. 8, respectively. These figures correspond to the valve of Type 1 described above. In addition, Fig. 11(a) and Fig. 11(b) illustrate throttle positions of the modified example of the conventional fuel valve shown in Fig. 9, respectively. These figures correspond to the valve of Type 2 described above. Furthermore, Fig. 12(a) and Fig. 12(b) illustrate throttle positions of the high flow fuel valve shown in Fig. 1, respectively. These figures correspond to the valve of Type 3 described above.

[0048] As is evident from these figures, in the valve of Type 1, it is confirmed that the throttle position is located near the seat position irrespective of the lift. For the flow velocity characteristics of the valve, it is confirmed that predetermined flow velocity cannot be attained because of an insufficient sheet diameter in spite of an increase in valve lift as indicated by the line A in Fig. 7.

[0049] Furthermore, in the case of the valve of Type 2 having an enlarged sheet diameter, it is confirmed that the throttle position moves toward the inlet chamber 18 from the seat portion as the lift increases. For the flow velocity characteristics of the valve, however, the flow velocity increases more than that of Type 1 as indicated by the line B in Fig. 7, but it does not reach to predetermined flow rate. That is, in the valve of Type 2, the flow velocity is restricted by the throttle of the inlet chamber even though the sheet diameter is enlarged.

[0050] On the other hand, in the valve of Type 3, it is confirmed that inlet holes are tangentially arranged and the sheet diameter is enlarged, so that the throttle position can be only found on the seat position irrespective of the lift of the valve and the throttle of the inlet chamber 18 is improved, even compared with the valve of Type 2.

[0051] Furthermore, in terms of the flow characteristics of the valve of Type 3, as indicated by the line C in Fig. 7, it is confirmed that the predetermined flow velocity can be obtained at a predetermined lift of the valve as the throttle of the inlet chamber is improved.

[Second Embodiment]

[0052] As shown in Fig. 13, a second embodiment of the present invention is a fuel supply pump 50 having a fuel inlet valve 73 and a fuel outlet valve 19 and is characterized by the following configuration. The fuel inlet valve 73 comprises a valve main body 19, a valve body 20 movably installed in the inside of the valve main body 19, an inlet chamber 19a formed in the inside of the valve main body 19, inlet holes 19c, a seat portion 23 where part of the valve body 20 and part of the valve main body 19 are contact with each other, wherein a plurality of inlet holes 19c is formed and these inlet holes 19c are arranged in a non-radical pattern.

[0053] Hereinafter, the fuel supply pump 50 will be described more concretely by way of individually describing its structural components.

1. Fuel Inlet Valve

[0054] The second embodiment is characterized in that a fuel inlet valve used is the high flow fuel valve described in the first embodiment. Thus, it is preferable to design an 10 valve 70 constructed of a fuel inlet valve 73 and a fuel outlet valve 60.

[0055] In addition, when the high flow fuel valve of the first embodiment is used as a fuel inlet valve, even if the flow of fuel per unit of time is approximately 500 to 1,500 liters per hour, the fuel can be quantitatively supplied to a fuel supply pump in a extremely precise manner.

2. Fuel Supply Pump

[0056] For example, the configuration of the fuel supply pump is, but not specifically limited to, preferably one having a fuel supply pump 50 shown in Fig. 13. That is, the fuel supply pump is preferably constructed of a pump housing 52, a barrel (cylinder) 53, a plunger 54, a fuel compression chamber 74, a tappet 58, and a cam 60.

[0057] Furthermore, the plunger 54 slides along the inside of the barrel 53 in the pump housing 52 to form a fuel compression chamber 74 for pressurizing fuel. The plunger 54 is preferably constructed so as to perform reciprocal motion in response to the rotary movement of the cam 60. Therefore, the fuel fed under pressure from a feed pump 64 is effectively pressurized by the plunger 54 in the fuel compression chamber 74, resulting in high pressure fuel.

[0058] In this example of the fuel supply pump 50, for example, two sets of the barrel (cylinder) 53 and the plunger 54 are installed in the pump housing 52. For pressurizing a much more amount of fuel, two or more sets are preferably used.

3. Amplified Piston Common Rail System (APCRS)

[0059] Furthermore, the fuel supply pump of the second embodiment is preferably a part of an amplified piston common rail system using a mechanical pressure amplifying system such as piston.

[0060] That is, as shown in Fig. 15, the fuel supply pump 103 is preferably constructed of a fuel tank 102, a feed pump (low pressure pump) 104 for supplying the fuel from the fuel tank 102, a fuel supply pump (high pressure pump) 103, a common rail 106 provided as a pressure accumulator for pressure-accumulation of the fuel fed under pressure from the fuel supply pump 103, a piston amplifier 108, and a fuel injection system 110.

(1) Fuel Tank

[0061] The capacity and form of a fuel tank 102 exemplified in Fig. 15 are preferably defined in consideration of, for example, the circulation of fuel at a flow rate of approximately 500 to 1,500 liters per hour.

(2) Feed Pump and Fuel Supply Pump

[0062] The feed pump 104 is, as shown in Fig. 15, provided for feeding fuel (diesel oil) in the fuel tank 102 to the fuel supply pump 103 under pressure. It is preferable that a filter 105 is placed between the feed pump 104 and the fuel supply pump 103. Preferably, for example, the feed pump 104 has a gear pump structure mounted on the end of the cam such that the feed pump 104 can be driven by directly connecting with the axis of the cam or through an appropriate gear ratio.

[0063] In addition, the fuel supply pump 103 is a device for pressurizing fuel supplied from the feed pump 104 at high pressure. The fuel supply pump 103 is constructed such that, after pressurizing the fuel, the fuel is fed to the common rail 106 under pressure through a high pressure channel 107.

[0064] Furthermore, the fuel fed under pressure from the feed pump 104 through the filter 105 is preferably supplied to the fuel supply pump 103 through a proportional control valve (FMU) 120 for adjusting the amount of fuel injected as shown in Fig. 16. Preferably, the proportional control valve 120 controls the amount of current passing through a coil 124 under the control of ECU to proportionally adjust the position of an anchor 125. That is, the position of a piston 127 at the tip portion of the anchor 125 is adjusted in response to the position of the anchor 125, so that the fuel-passing area between a slit 122 formed in the piston 127 and the fuel supply portion 129 can be varied to control the fuel supplied to an inlet valve (not shown) in the fuel supply pump 103.

[0065] Furthermore, as shown in Fig. 16, in addition to feed the fuel supplied from the feed pump 104 to the proportional control valve 120 and the fuel supply pump 103 under pressure, it is preferable to construct that the fuel is returned to the fuel tank 102 through a overflow valve (OFV) 134 installed in parallel with the proportional control valve 120. Moreover, it is preferable that part of the fuel is fed under pressure to a bearing (not shown) of the fuel supply pump 103 and then used as a fuel lubricating oil of the bearing.

[0066] By the way, the fuel supplypump 103 is a device for pressurizing the fuel supplied from the feed pump 104 at high pressure as described above. The fuel supply pump 103 is preferably constructed such that, after pressurizing the fuel, the fuel is fed to the common rail 106 under pressure through the high pressure channel 107.

(3) One way Valve

[0067] Furthermore, as shown in Fig. 15, it is preferable to install a one way valve (not shown) on the outlet of the fuel supply pump 103, or both of the common rail 106 described below and the fuel supply pump 103.

[0068] This is because, as constituted above, the fuel can be only fed from the fuel supply pump 103 to the common rail 106. Therefore, the adverse current at the time of opening an electromagnetic control valve can be effectively prevented to effectively prevent a decrease in pressure in the common rail 106.

(4) Common Rail

[0069] Furthermore, as shown in Fig. 15, the common rail 106 is connected to a plurality of injectors (injection valves) 110. Preferably, the accumulated pressure fuel at high pressure by the common rail 106 is injected into an internal combustion engine (not shown) from each of the injectors 110.

[0070] Furthermore, but not shown in the figure, the amount of discharge from each of these injectors 110 is preferably controlled through an injector driving unit (IDU). The IDU is connected to an electrical controlling unit (ECU) provided as a controller described letter. The IDU is driven by drive signals from the ECU.

[0071] Moreover, a pressure detector 117 is connected to the side end of the common rail 106 and a pressure-detection signal obtained by the pressure detector 117 is preferably sent to the ECU. That is, it is preferable to control an electromagnetic control valve (not shown) and also control the drive of IDU in response to the pressure detected when the ECU receives the pressure-detection signal from the pressure detector 117.

(5) Piston amplifier

[0072] Furthermore, as exemplified in Fig. 17, a piston amplifier (pressure amplifying piston) is constructed of a cylinder 155, a mechanical piston 154, a compression chamber 158, an electromagnetic valve 170, and a circulation pathway 157. It is preferable that the mechanical piston 154 is equipped with a pressure-receiving portion 152 having a comparatively large area and a pressure portion 156 having a comparatively small area.

[0073] That is, the mechanical piston 154 housed in the cylinder 155 is pushed and moved by the fuel having a common rail pressure at the pressure-receiving portion 152. The common rail pressure of the compression chamber 158 is preferably adjusted to one that allows fuel having a pressure of approximately 50 MPa to be pressurized by the pressure portion 156 having a comparatively small area to make the pressure of the fuel within the range of 150 to 300 MPa.

[0074] Furthermore, for pressurizing the mechanical piston 154, a large amount of fuel having the common rail pressure is used. After pressurization, it is preferable to flow the fuel back to the fuel tank or the like through an electromagnetic driven overflow valve 170. That is, a major part of the fuel having the common rail pressure is pressurized by the mechanical piston 154 and then flows back to the fuel tank or the like together with spilled fuel. Then, the fuel is preferably used for pressurizing the mechanical piston 154 again.

[0075] On the other hand, the fuel pressurized by the pressure portion 156 is fed to a fuel injection system (fuel injection nozzle) 163, effectively injected, and combusted.

[0076] Therefore, providing the piston amplifier as described above, the mechanical piston can be effectively pushed by the fuel having a common rail pressure without excessively increasing the size of the common rail.

[0077] That is, as illustrated in the schematic diagram of Fig. 18, according to the ARCRS system, a mechanical piston is equipped with a pressure-receiving portion having a comparatively large area and a pressure portion having a comparatively small area. While considering the stroke of the mechanical piston, it is possible to effectively pressurize e fuel having the common rail pressure to a desired level with a small pressure.

[0078] More concretely, the fuel from the common rail (pressure: p1, volume: V1, work load: W1) can be received by a pressure-receiving portion having a comparatively large area and then changed to higher-pressure fuel (pressure: p2, volume: V2, work load: W2) by a mechanical piston equipped with a pressure portion having a comparatively small area.

(6) Fuel Injection System

(i) Basic Configuration

[0079] Furthermore, the configuration of the fuel injection system (fuel injection nozzle) 110 is, but not specifically limited to, preferably constructed as follows: As shown in Fig. 17, for example, the fuel injection system 110 comprises a seat surface 164 on which a needle valve body 162 can be placed on a seat surface 164, an injection hole 165 formed on the downstream side from the valve body abutting portion of the seat surface 164. Preferably, it is constructed that the fuel supplied from the upstream side of the seat surface 164 at the time of lifting a needle valve body 162 is introduced into the injection hole 165.

[0080] Furthermore, such a fuel injection nozzle system 166 is preferably of an electromagnetic valve type, in which the needle valve body 162 is always energized toward the seat surface 164 by the spring 161 and opens and shuts the needle valve body 162 by switching energization / no energization of solenoide 180.

(ii) Injection Timing Sheet

[0081] Furthermore, as to a time chart of high-pressure fuel injection, it is preferable to indicate a fuel injection chart having two-staged injection conditions as indicated by the solid line as exemplified in Fig. 19.
[0082] This is because such a two-stage injection timing chart can be attained by a combination of the common rail pressure and amplification with a piston amplifier, and thus the combustion efficiency of fuel can be raised, while cleaning an exhaust gas.
[0083] Furthermore, according to the present invention, it is also preferable to indicate a fuel injection chart as indicated by the dashed line B in Fig. 19, a combination of the common rail pressure and amplification with a piston amplifier.
[0084] By the way, when the piston amplifier is not used, the conventional injection timing chart becomes a single-stage injection timing chart with a low injection amount as indicated by the dashed line C in Fig. 19.

(7) Movement

[0085] Next, the fuel supply pump 103, the actions of the piston amplifier 108, and the fuel injection valve 110 in the second embodiment will be described. That is, as shown in Fig. 15, at the time of operating the fuel injection system (fuel injection nozzle system) 110, the fuel in the fuel tank 102 is supplied from the feed pump 104 to the fuel supply pump 103. Then, the high-pressure fuel is supplied from the fuel supply pump 103 to the high pressure channel 107 under pressure.
[0086] Subsequently, as shown in Fig. 17, the fuel is subjected to pressure accumulation at approximately 50 MPa in the common rail 106 and then the fuel is preferably pressurized under ultra-high pressure conditions of 180 MPa or more as the piston amplifier 108 is provided between the common rail 106 and the fuel injection valve 110.
[0087] Furthermore, for actuating the piston amplifier 108, a large amount of fuel is used. Thus, in the case of the example shown in Fig. 17, the high flow fuel valve (not shown) installed in the fuel supply pump 103 is functioned effectively.
[0088] That is, the high flow fuel valve, in which a plurality of inlet holes are formed and arranged in a non-radial pattern relative to the inlet chamber, is used as a fuel inlet valve of the fuel supply pump 103. Therefore, for example, the fuel at a flow rate of approximately 500 to 1, 500 litters per hours can be passed quickly and quantitatively. In addition, a large amount of fuel can be processed by both the fuel supply pump 103 and the common rail 106.

Industrial Applicability

[0089] According to the high flow fuel valve of the present invention, a plurality of inlet holes is formed and these inlet holes are arranged in a non-radical pattern relative to the inlet chamber. Therefore, for example, even the fuel at a flow rate of approximately 500 to 1,500 liter per hour can be passed quickly and quantitatively.
[0090] In addition, according to the high flow fuel of the present invention, even if the lift of the valve body is comparatively low, a large amount of fuel at a flow rate of 1,000 liters per hour or more can be passed. Therefore, the positional change of the valve body decreases and the impact at the time of seating can be eased now.
[0091] Furthermore, according to the high flow fuel valve of the present invention, a large amount of fuel can be allowed to pass through the inlet holes quickly in a quantitative manner without excessively enlarging the diameter or cross-sectional area of the inlet hole. Therefore, the reduction of durability or strength of the high flow fuel valve itself can be prevented.
[0092] Consequently, the high flow fuel valve of the present invention can be suitably used as a high flow fuel valve of the fuel supply pump used in an amplified piston common rail system (APCRS) that pressurizes a large amount of fuel using a piston.
[0093] In addition, according to the fuel supply pump provided with the high flow fuel valve of the present invention is equipped with the high flow valve having a plurality of inlet holes arranged in a non-radial pattern relative to the inlet chamber. Therefore, for example, even the fuel at a flow rate of approximately 500 to 1,500 liter per hour can be passed quickly and quantitatively.

Claims

1. A high flow fuel valve, comprising a valve main body, a valve body movably installed in the inside of the valve main body, an inlet chamber installed in the inside of the valve main body, inlet holes, a seat portion where the valve body and part of the valve main body are in contact with each other, wherein a plurality of the inlet holes is formed and arranged in a radial pattern relative to the inlet chamber.

2. The high flow fuel valve as described in claim 1, wherein a horizontal cross sectional shape of the inlet chamber is substantially a circle and the inlet holes are arranged in a tangential direction of the inlet chamber.

3. The high flow fuel valve as described in claim 1 or 2, wherein the inlet holes are inclined in the vertical direction with respect to the inlet chamber.

4. The high flow fuel valve as described in one of

claims 1 to 3, wherein the inlet hole has a diameter of 2 to 12 mm.

5. The high flow fuel valve as described in one of claims 1 to 4, wherein a seat diameter of the valve body is 8 mm or more.

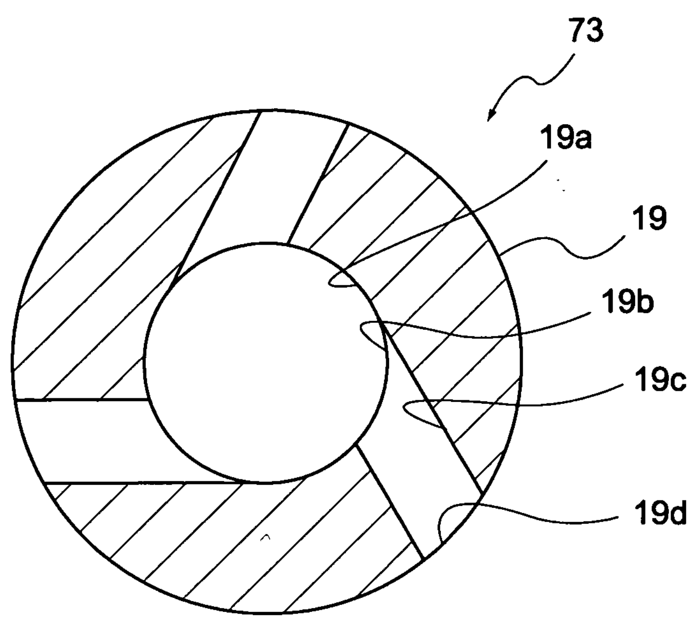
6. The high flow fuel valve as described in one of claims 1 to 5, wherein a fuel-passing area of the inlet hole is larger than a fuel-passing area of the seat portion.

7. A fuel supply pump comprising a fuel inlet valve and a fuel out let valve, wherein the fuel inlet valve is constructed of a valve main body, a valve body movably installed in the inside of the valve main body, an inlet chamber installed in the inside of the valve main body, inlet holes, and a seat portion where the valve body and part of the valve main body are in contact with each other, where a plurality of the inlet holes is formed and arranged in a radial pattern relative to the inlet chamber.

8. The fuel supply pump as described in claim 7, wherein the fuel supply pump is used in an accumulator fuel injection device for pressurizing fuel at a flow rate of 500 to 1,500 liters per hour to a value of 50 MPa or more.

Fig.1

(a)



(b)

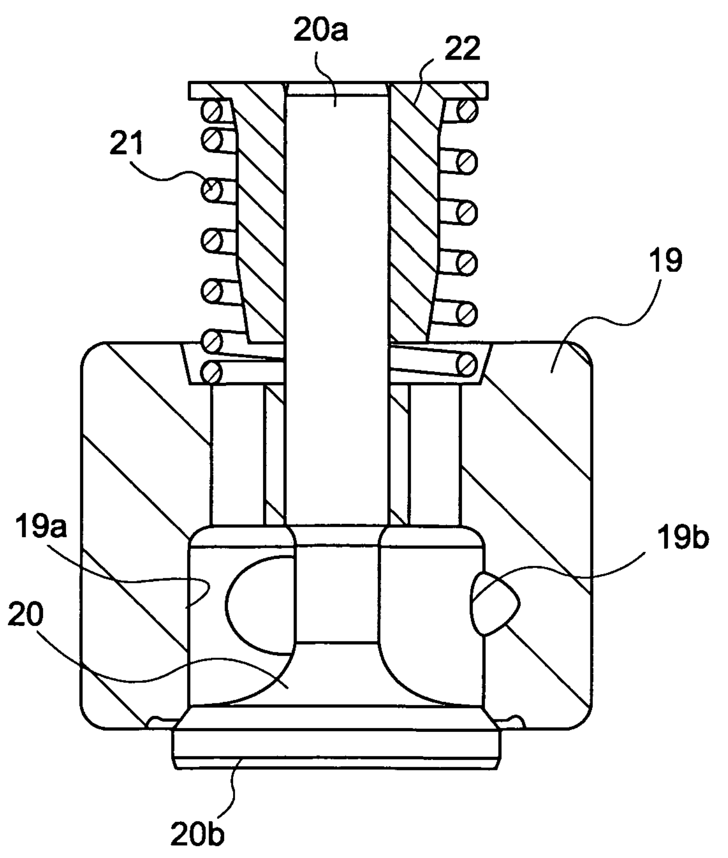


Fig. 2

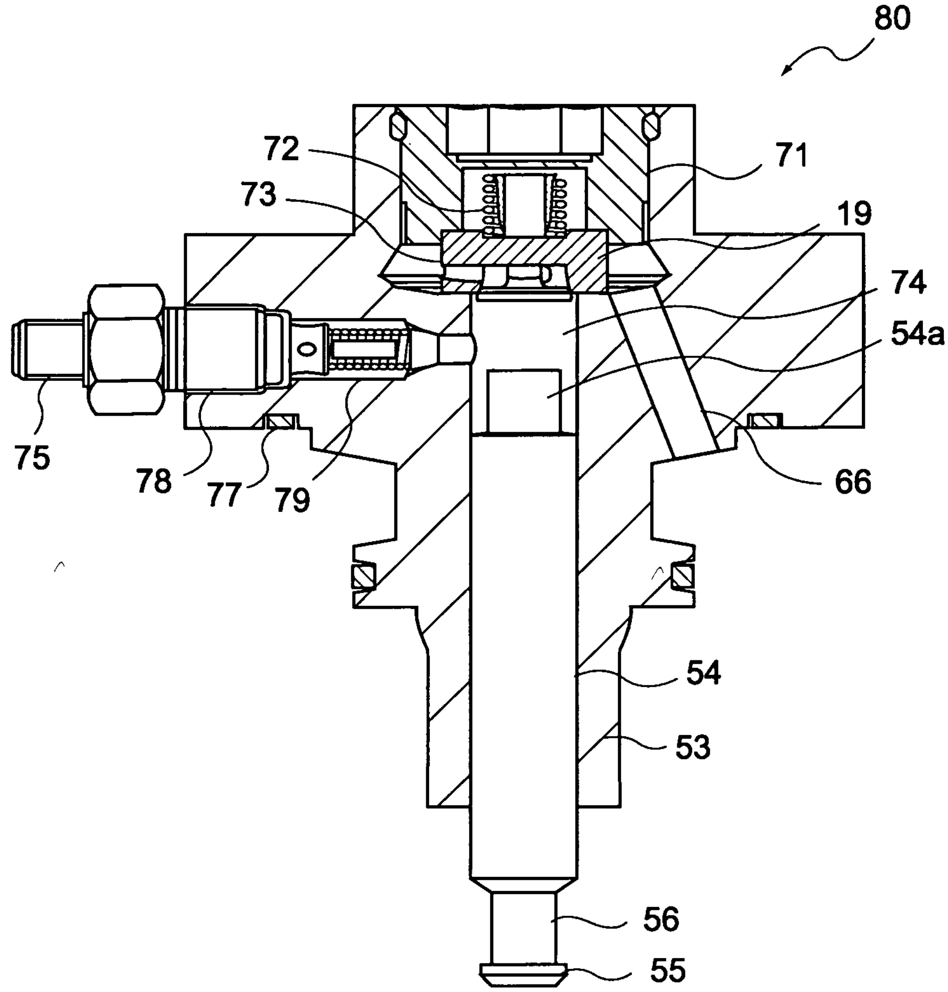


Fig. 3

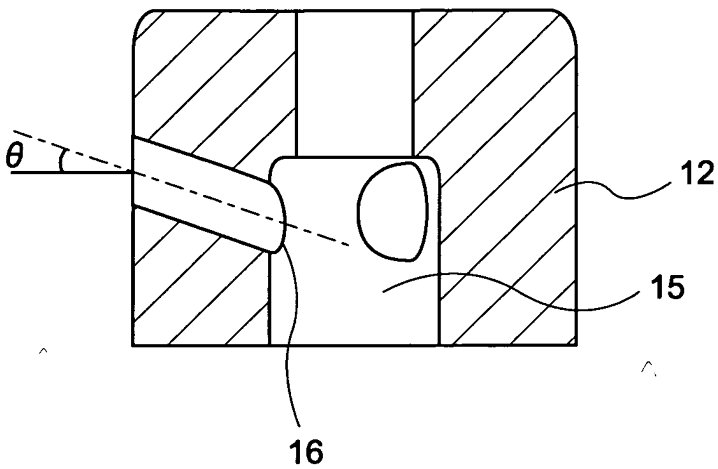


Fig. 4

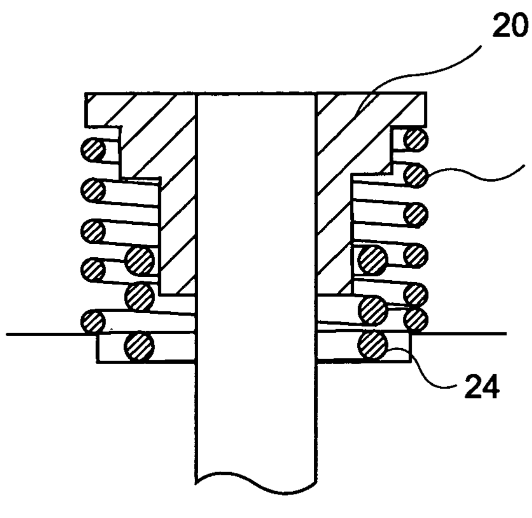


Fig.5

(a)

(b)

(c)

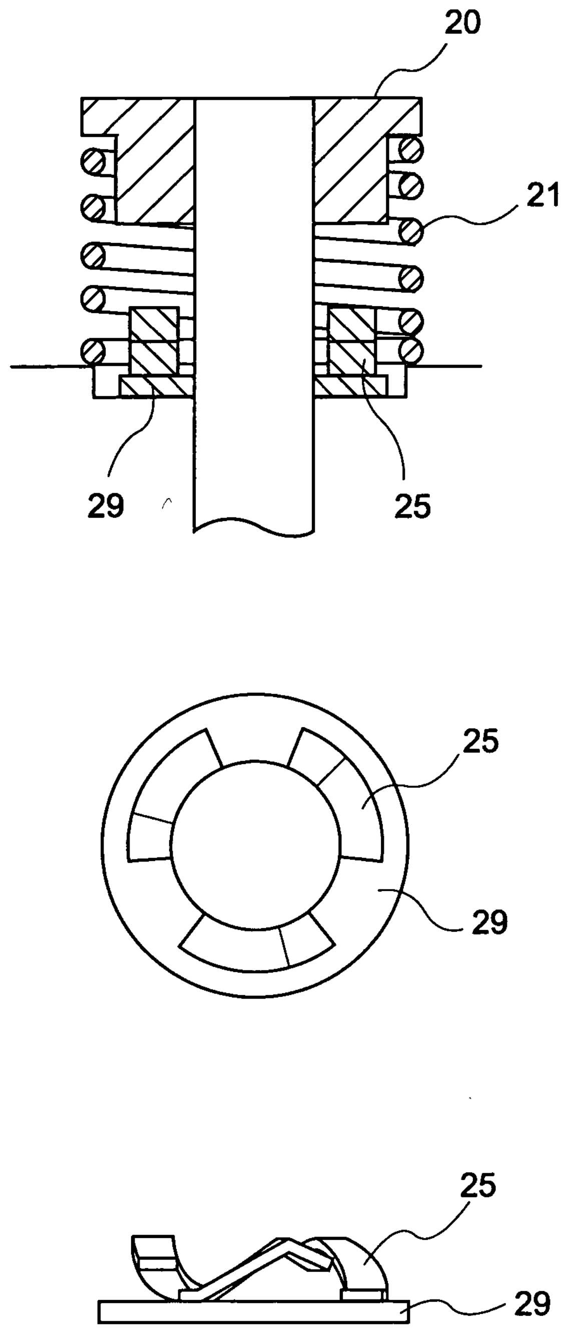


Fig.6

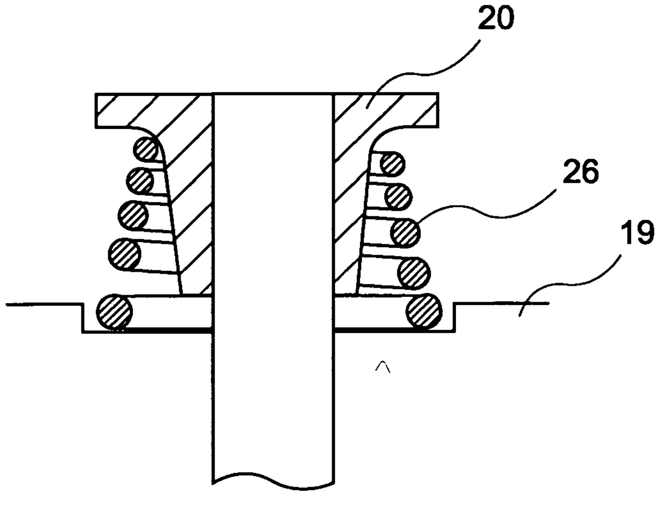


Fig. 7

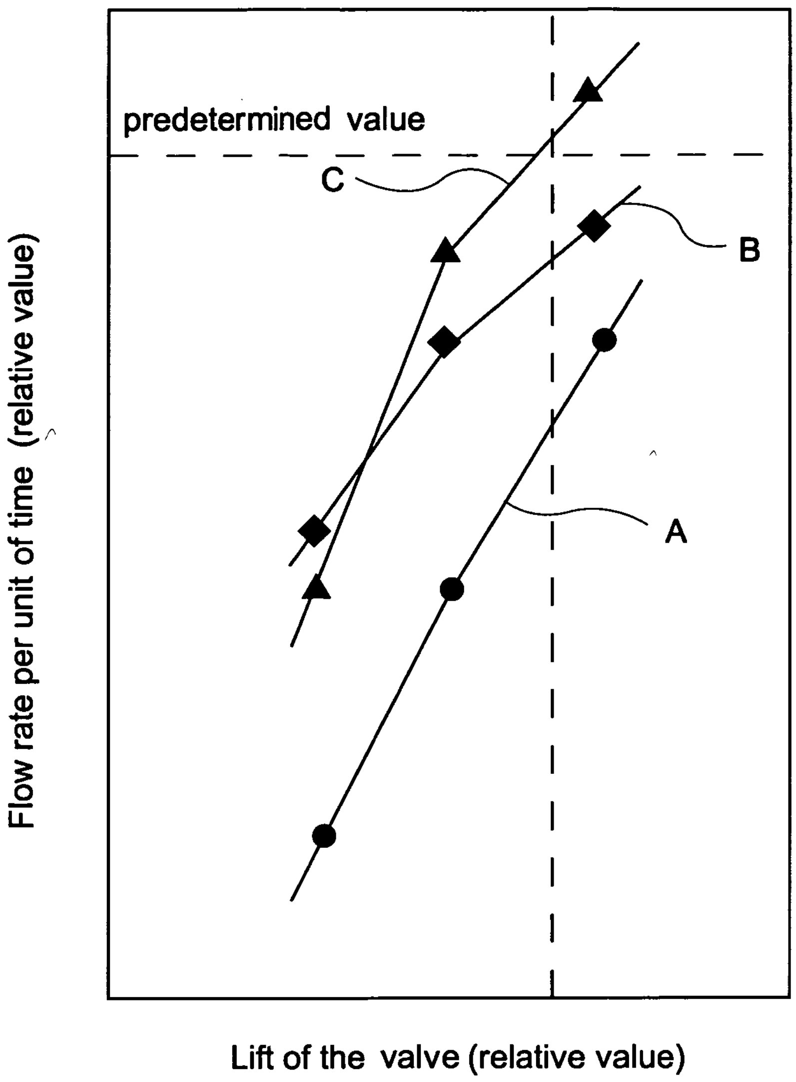
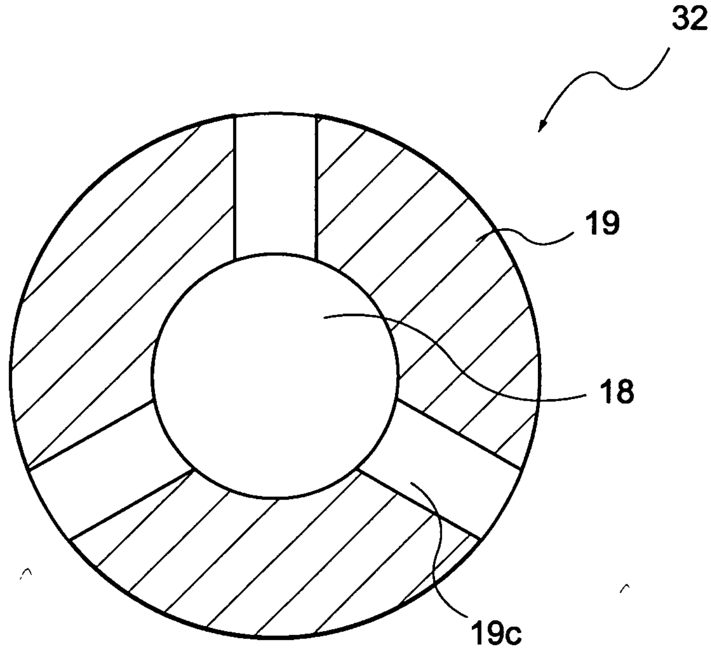

predetermined value
C
B
A
Flow rate per unit of time (relative value)
Lift of the valve (relative value)

Fig. 8

(a)



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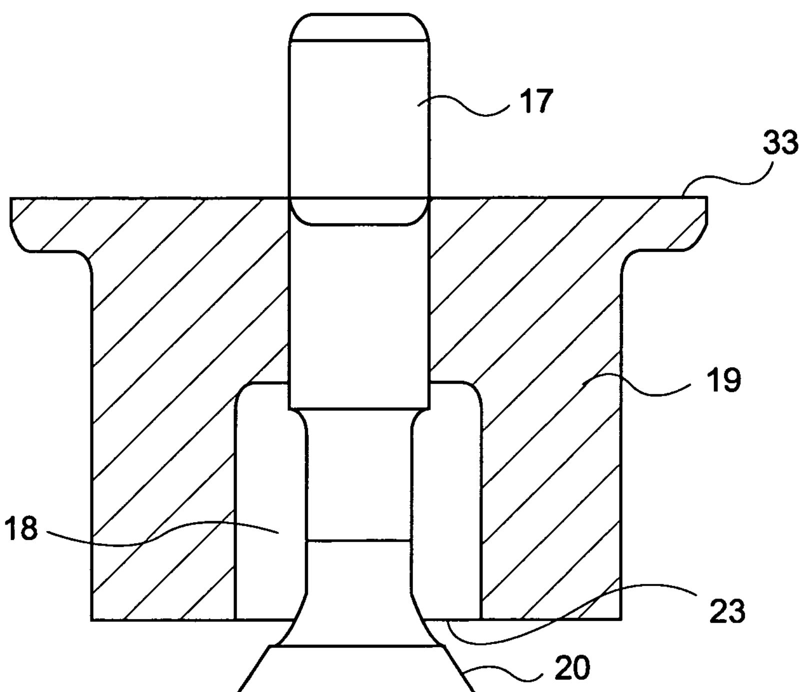
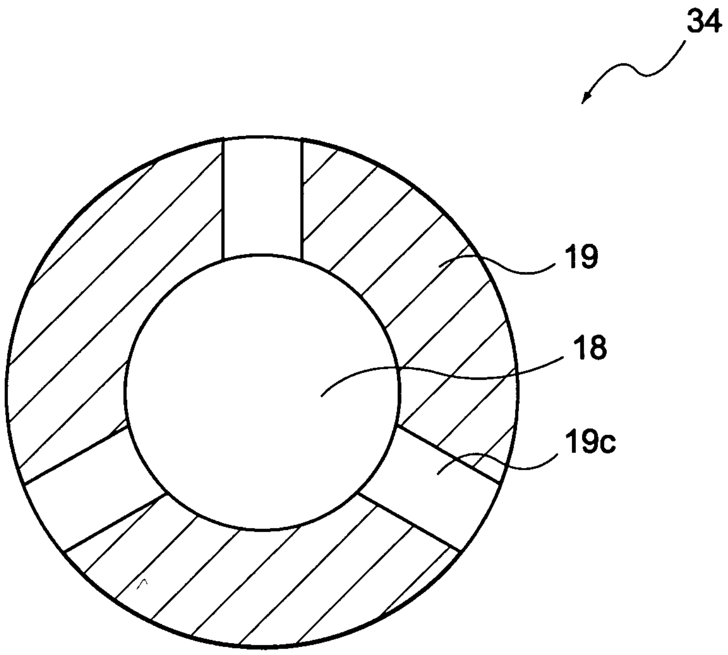


Fig. 9

(a)



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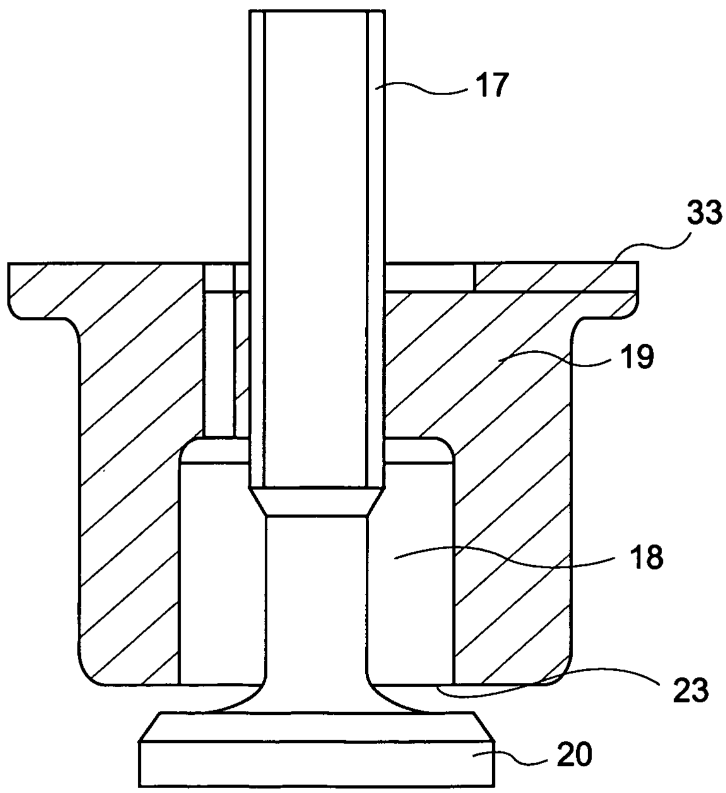
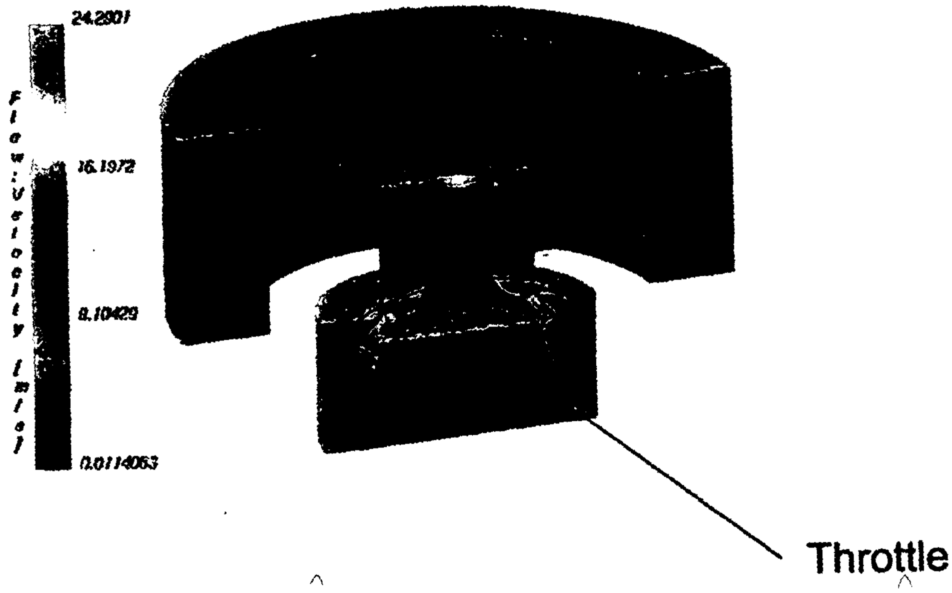


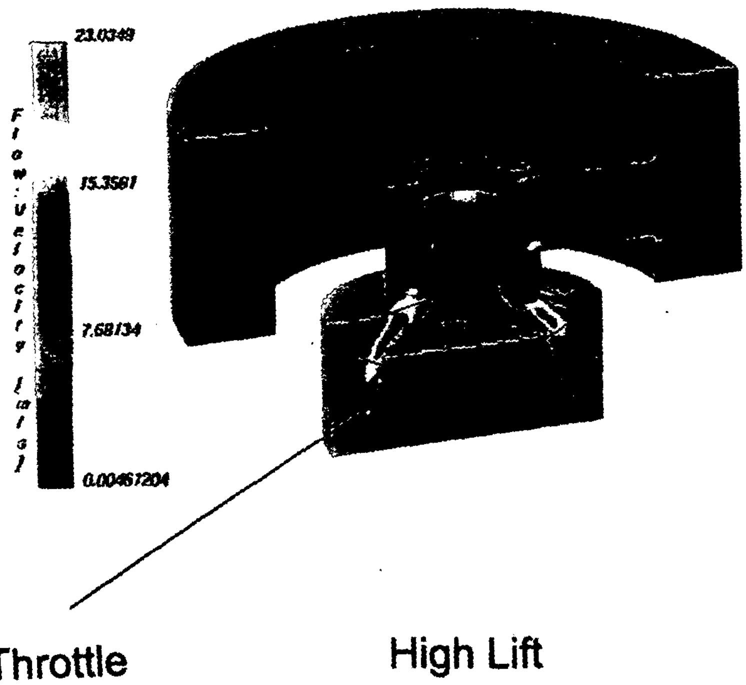
Fig.10

(a)



Low Lift

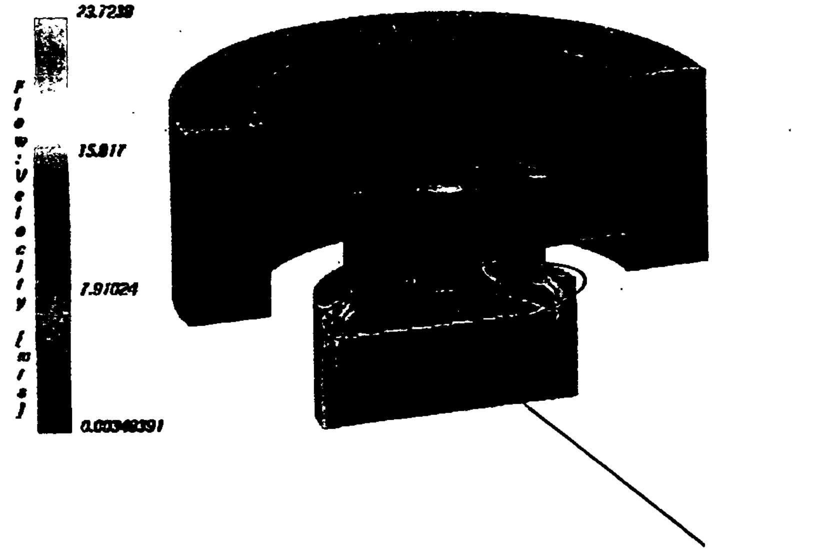
(b)



High Lift

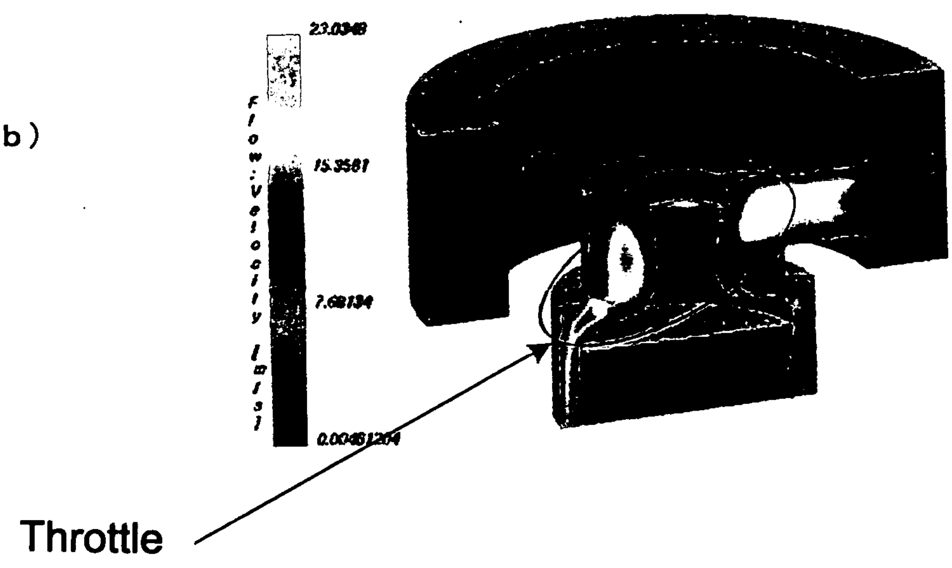
Fig.11

(a)



Low Lift

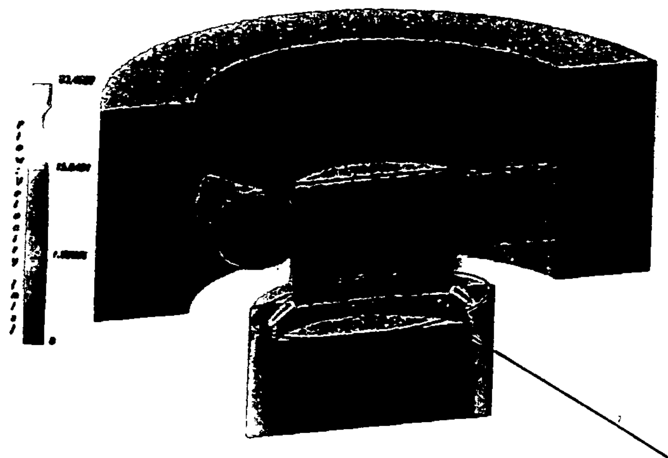
(b)



High Lift

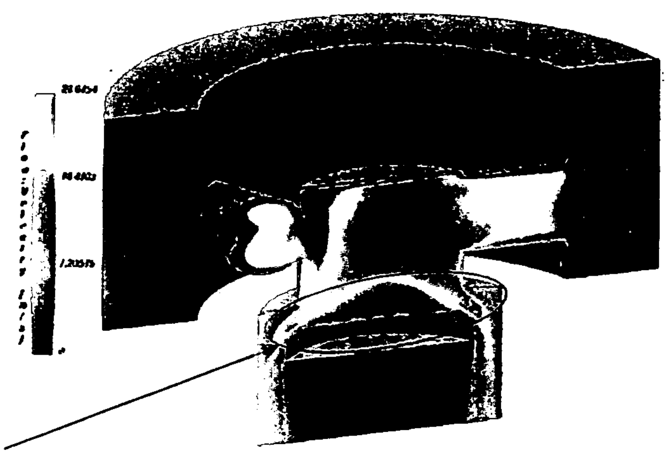
Fig.12

(a)



Low Lift

(b)



High Lift

Fig.13

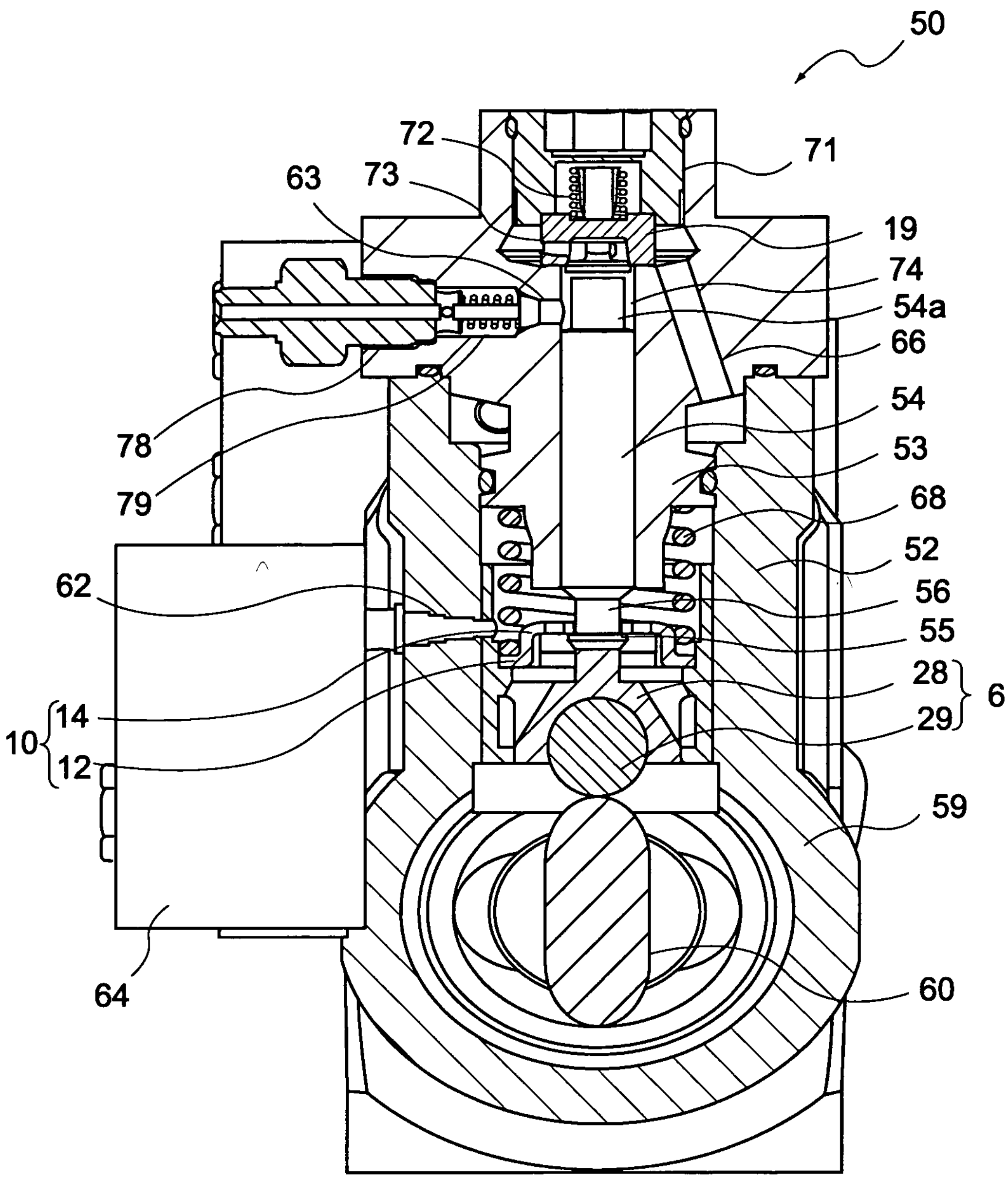

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Fig.14

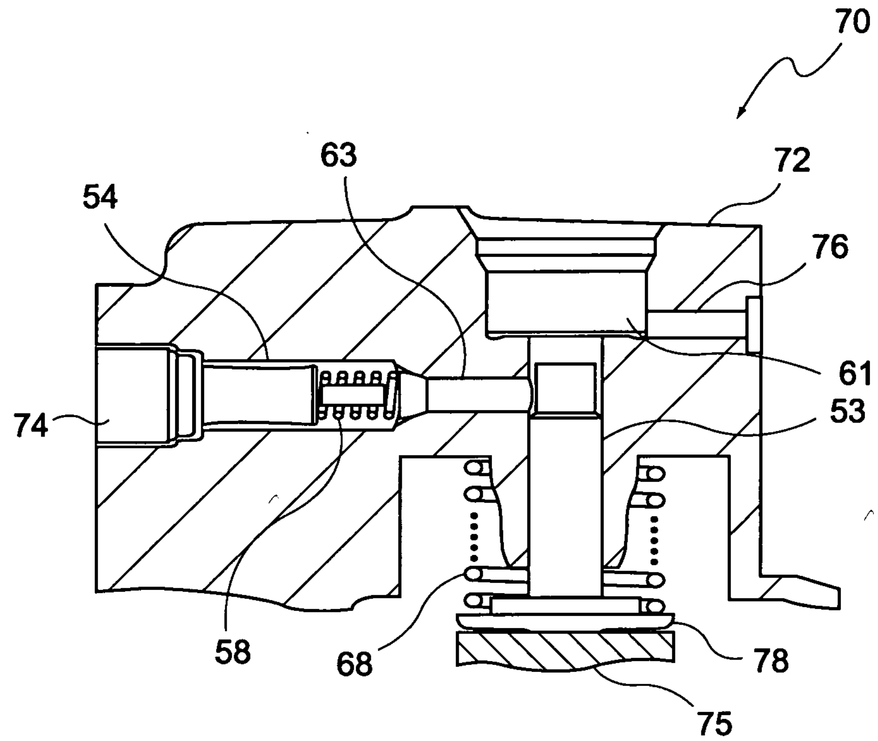

Fig. 15

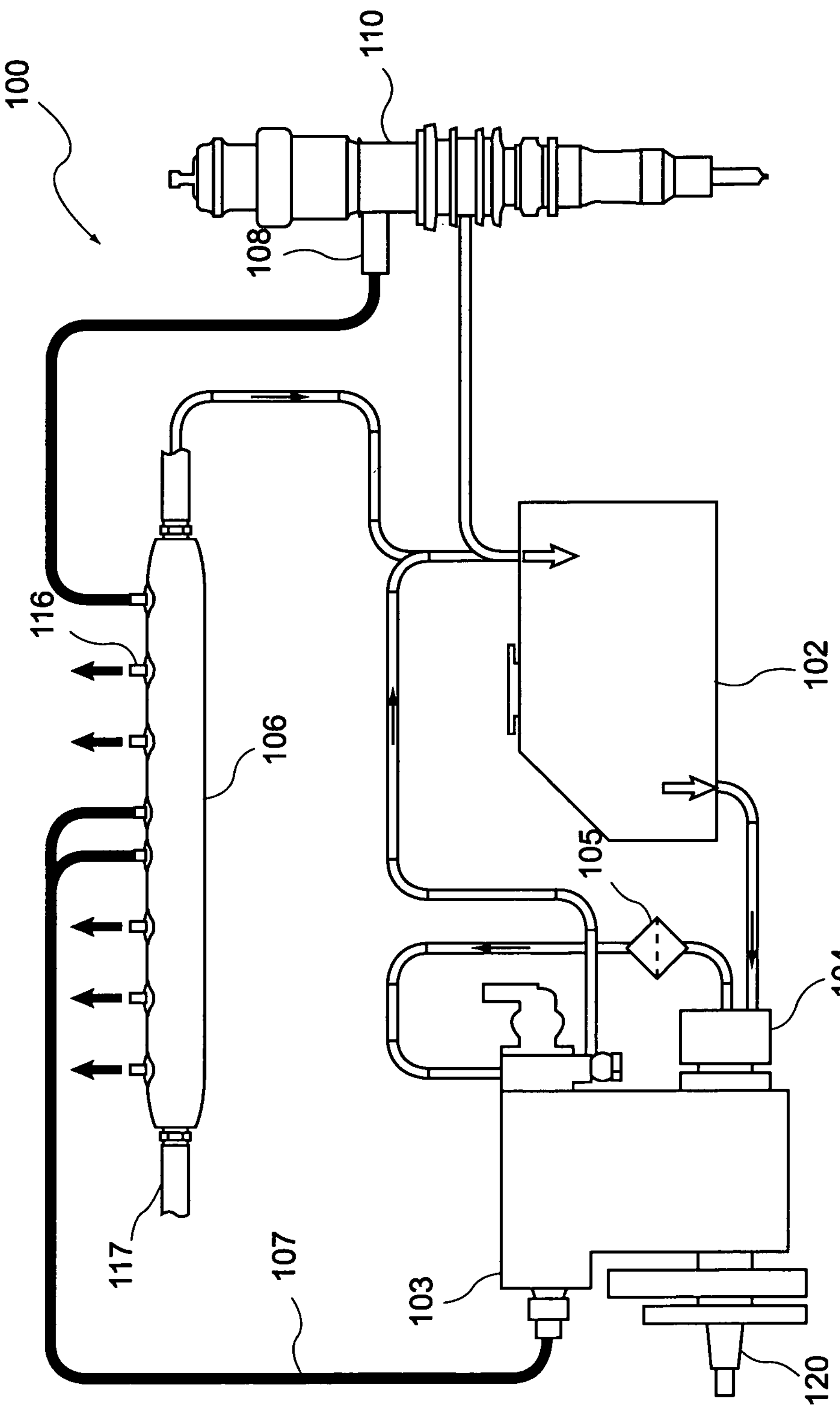

Fig. 16

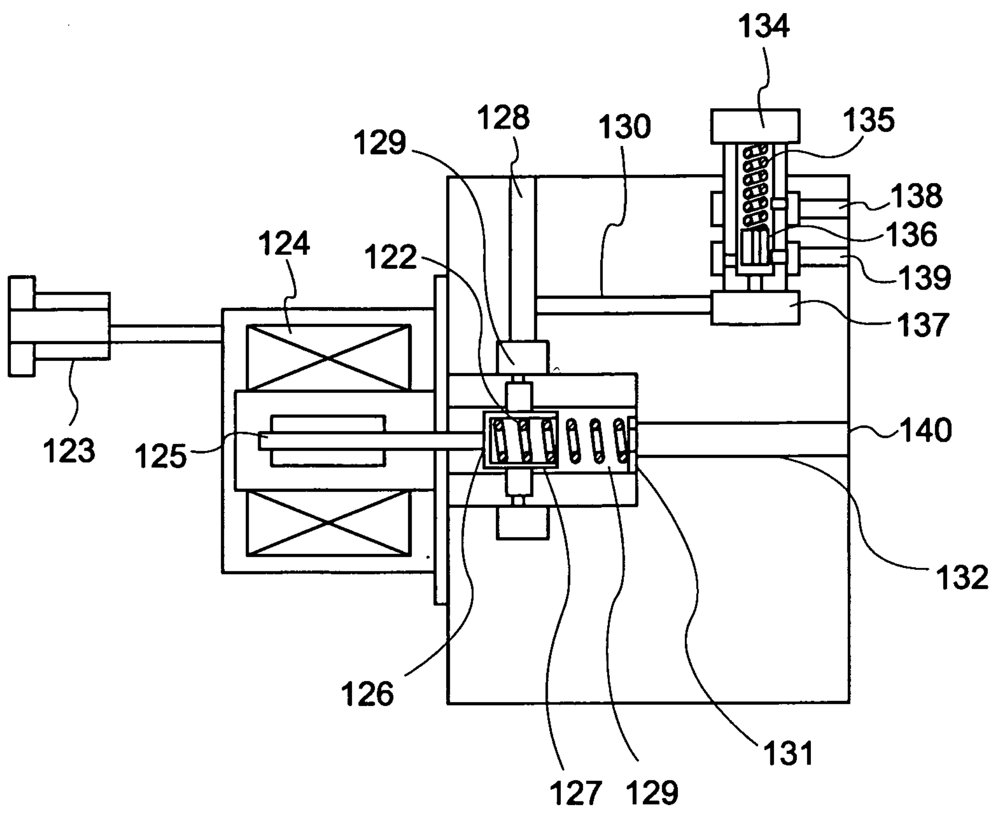
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Fig. 17

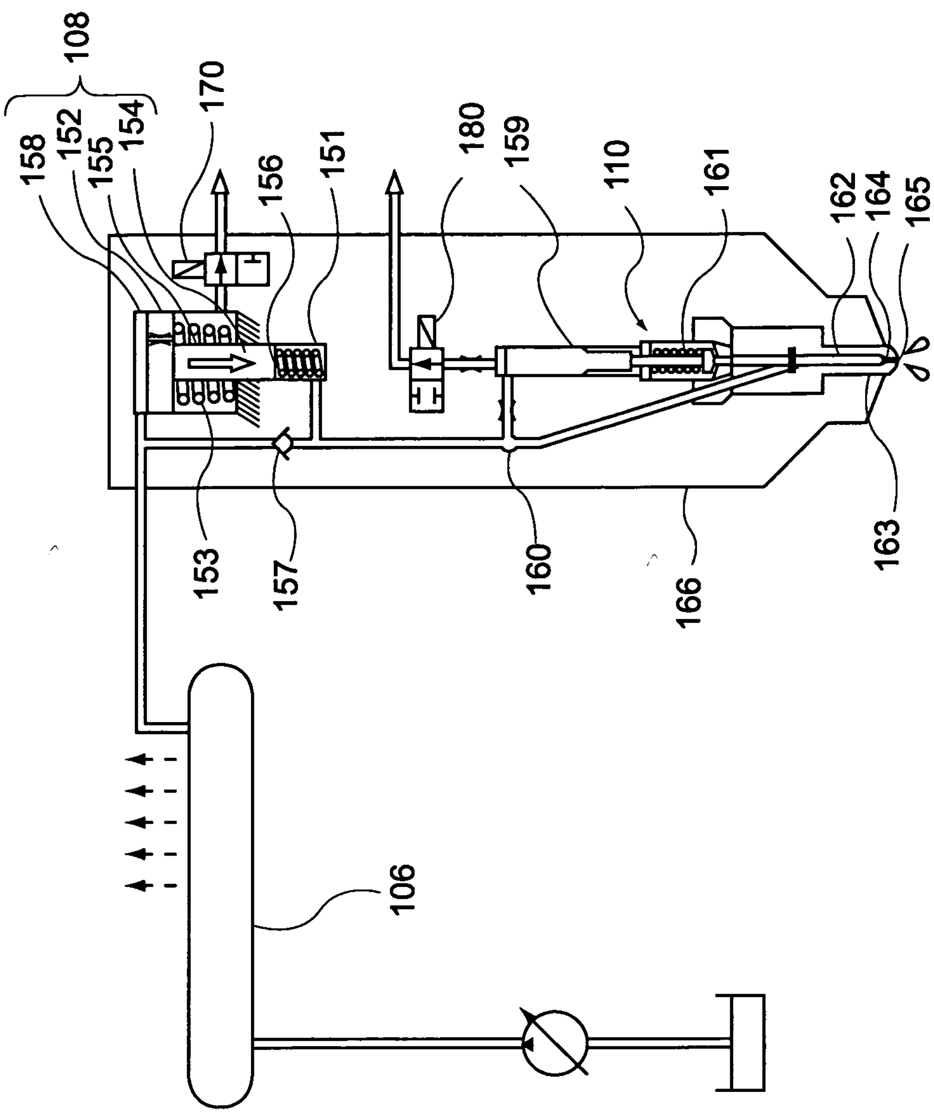
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Fig.18

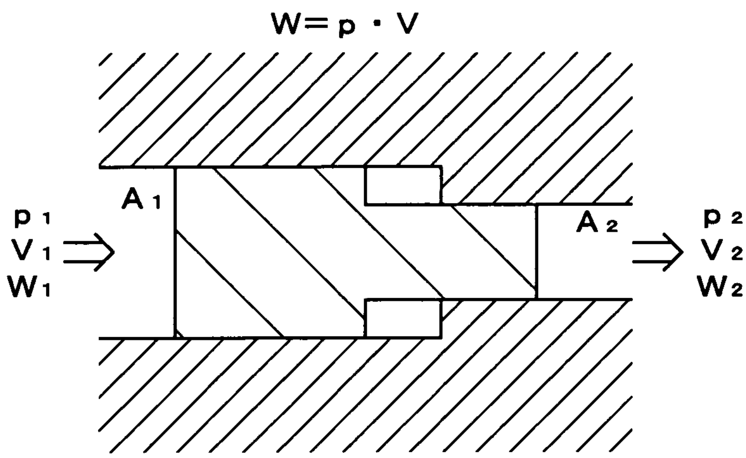

Fig.19

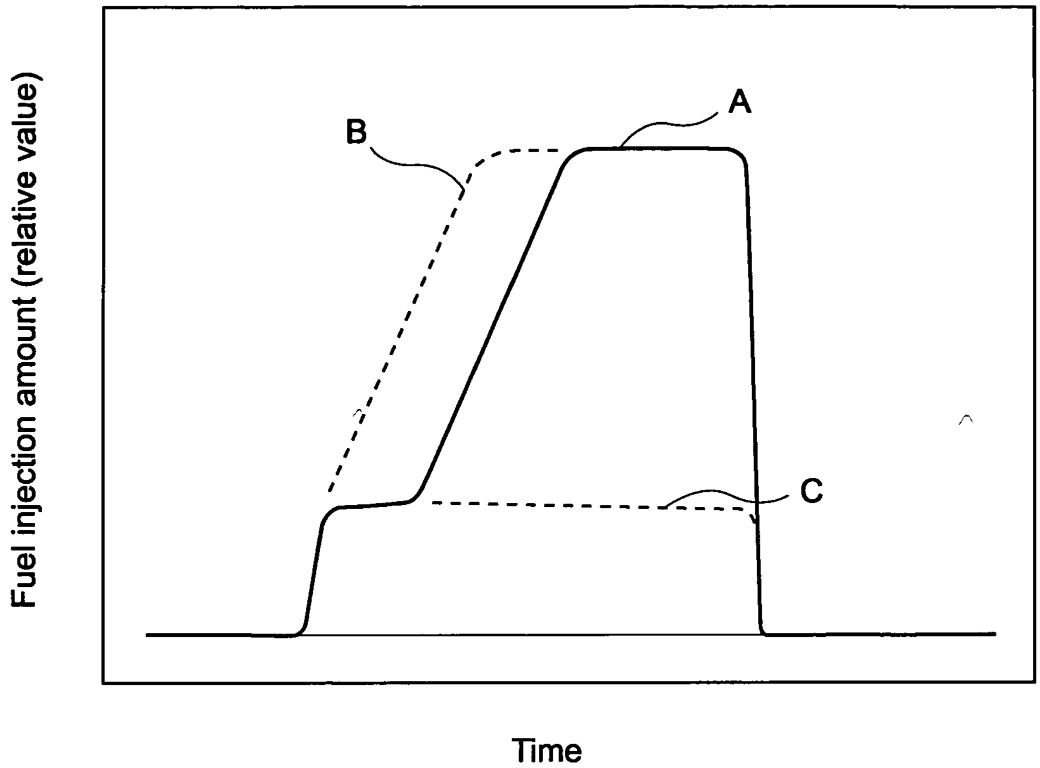

Fig. 20

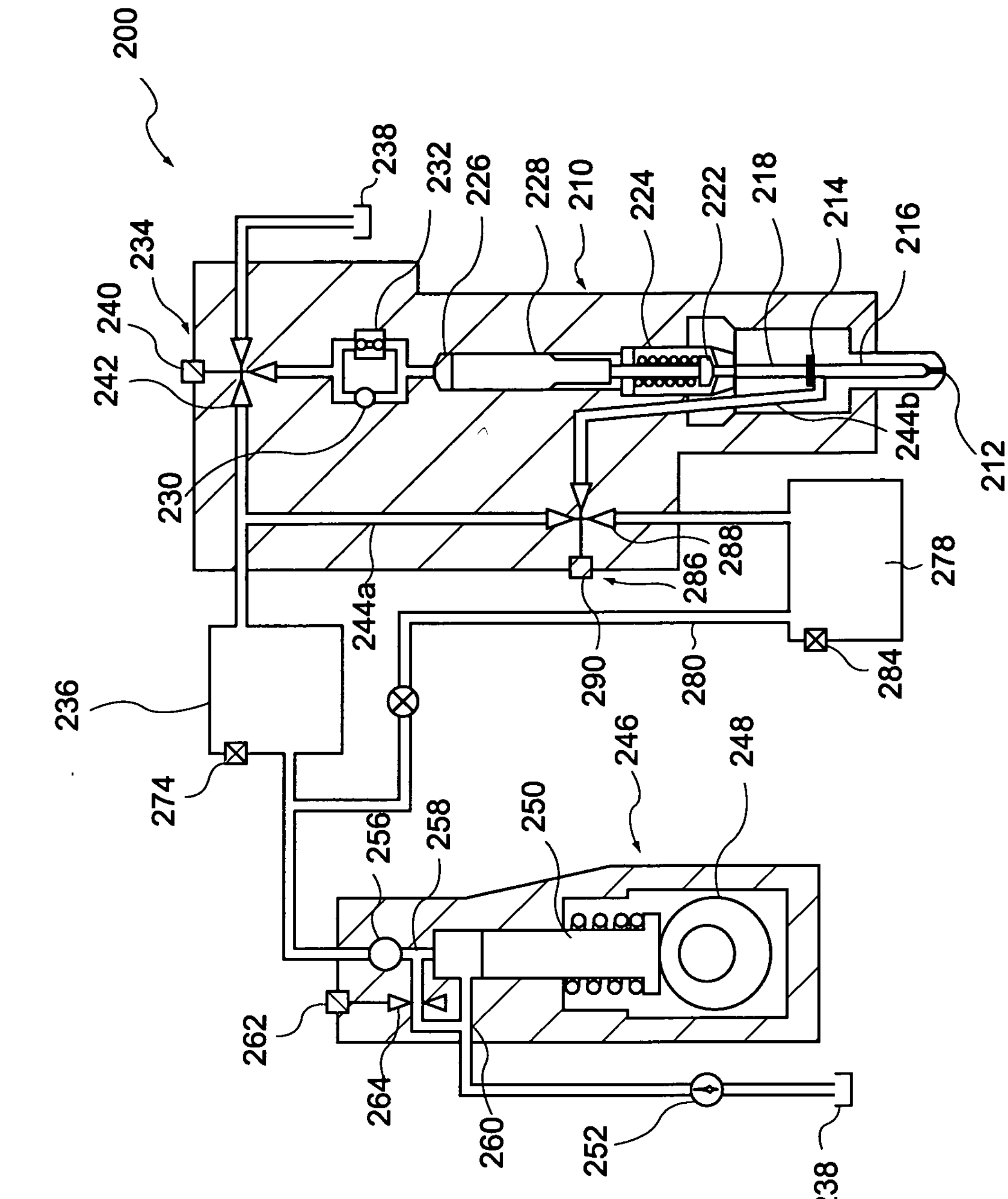
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Fig. 21

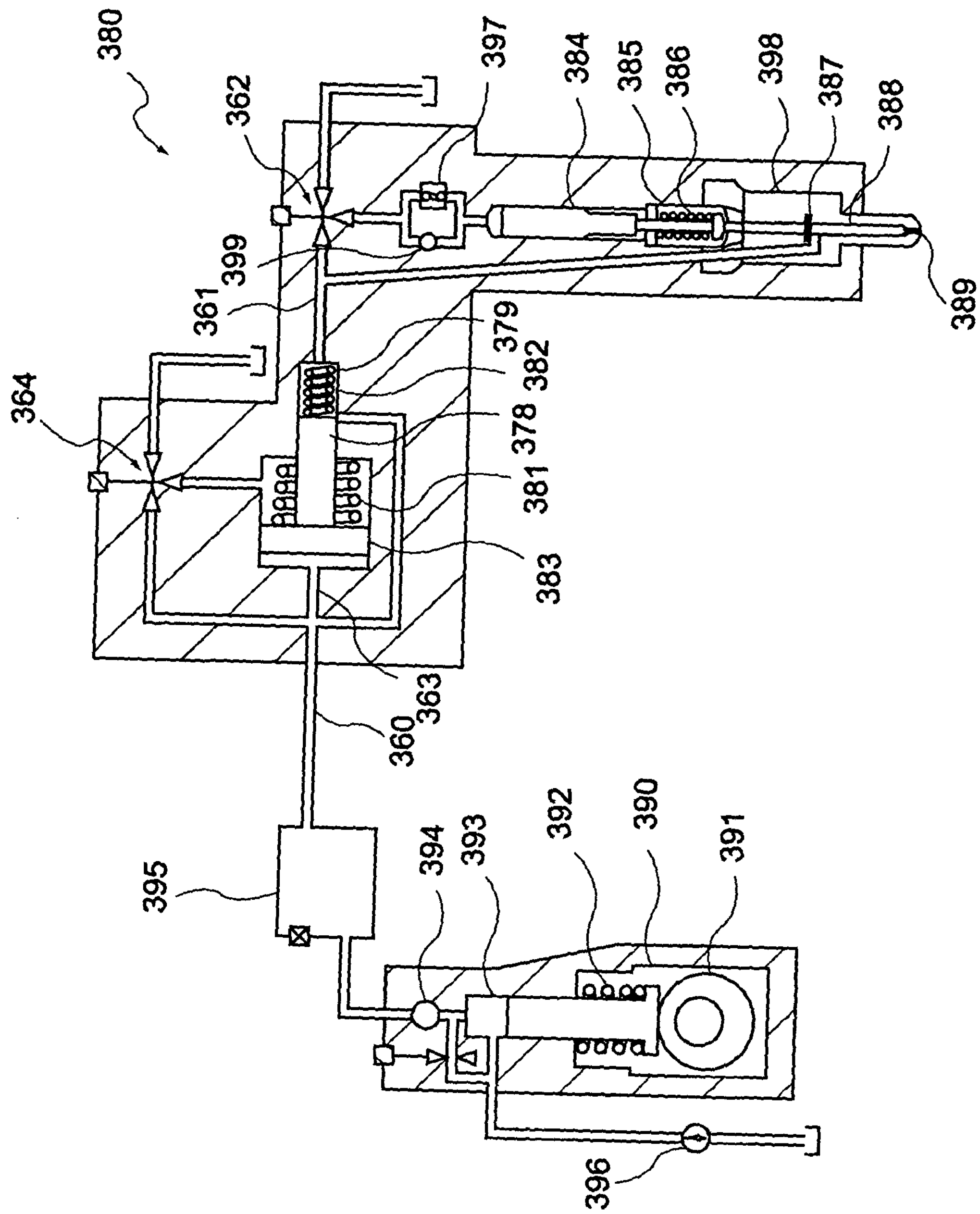
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Fig. 22

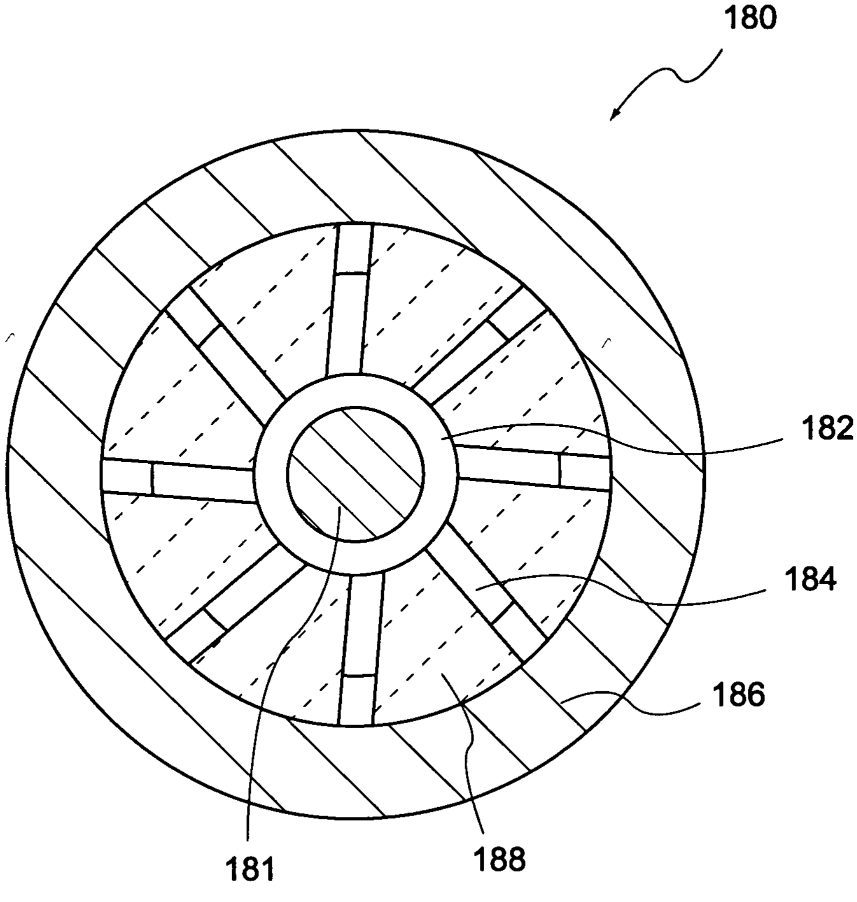
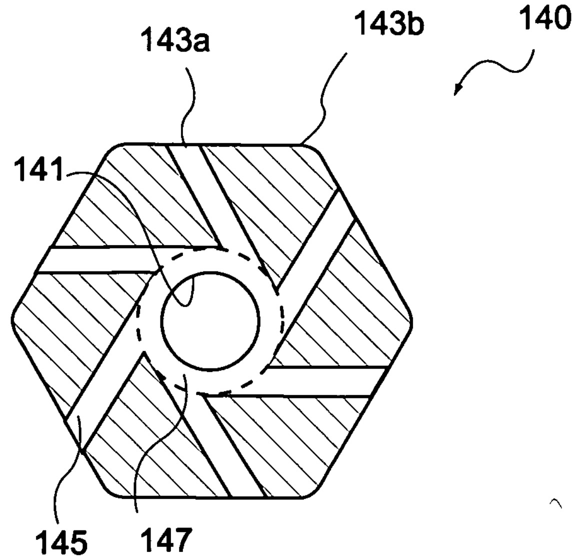


Fig. 23

(a)



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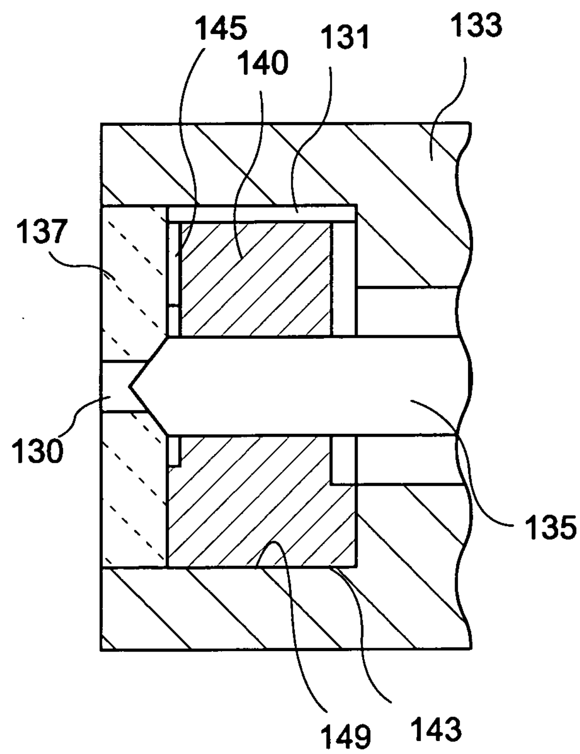

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/13687

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F02M59/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] F02M59/46

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2004
Kokai Jitsuyo Shinan Koho	1971-2004	Jitsuyo Shinan Toroku Koho	1996-2004

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2352780 A (Nachi-Fujikoshi Corp.), 07 February, 2001 (07.02.01), Full text; Figs. 2, 3 & WO 00/57051 A1	1-8
Y	JP 59-140972 A (Yamatake-Honeywell Co., Ltd.), 13 August, 1984 (13.08.84), Page 2, upper left column, line 3 to upper right column, line 3; page 3, upper right column, lines 7 to 20; all drawings (Family: none)	1-8

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 08 January, 2004 (08.01.04)	Date of mailing of the international search report 27 January, 2004 (27.01.04)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/13687

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 22283/1988(Laid-open No. 125862/1989) (Mitsuba Electric Mfg. Co., Ltd.), 28 August, 1989 (28.08.89), Page 7, lines 9 to 12; page 8, lines 3 to 9; Figs. 1 to 4 (Family: none)	1-8

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