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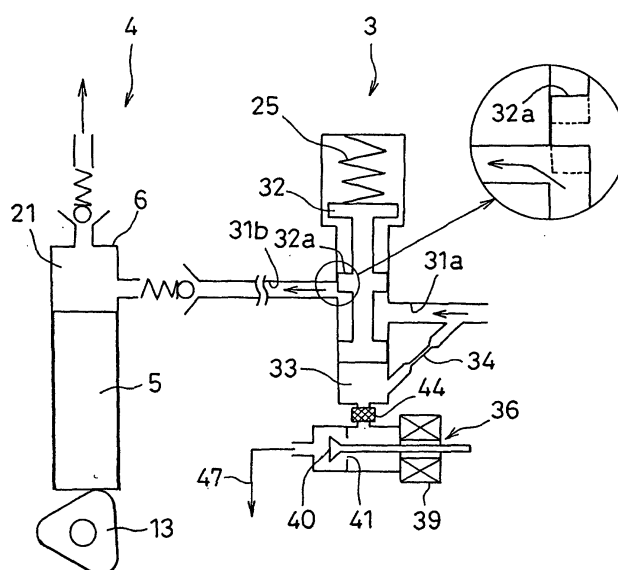
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(54) **HIGH-PRESSURE FUEL FEED PUMP**

(57) A high-pressure fuel feed pump force-feeding fuel to a common rail for storing high-pressure fuel, comprising a fuel force-feeding means for force-feeding fuel and a fuel oil quantity regulating means for regulating the amount of fuel oil flowing into a compression chamber, the fuel oil quantity regulating means further comprising a fuel path leading the fuel sucked from a fuel tank to the compression chamber and a throttle valve

installed in the fuel path and changing the cross-sectional area of the fuel path so as to vary the quantity of the fuel oil passing therethrough, wherein the throttle valve is slid in the direction generally perpendicular to the flowing direction of the fuel passing through the inside of the fuel path so that a valve disc regulating the fuel flow rate can be moved smoothly without being obstructing by a fluid pressure.

FIG. 4



Description

TECHNICAL FIELD

[0001] The present invention relates to a high-pressure fuel feed pump that is employed in a fuel injection system for injecting fuel into the combustion chamber of an internal combustion engine mounted in an automobile or the like to force feed the fuel into a common rail.

BACKGROUND ART

[0002] A fuel injection system that injects fuel into the combustion chamber of an internal combustion engine may be realized as a common rail system 55 shown in FIG. 9. This common rail system 55 raises the pressure of the fuel drawn up from a fuel tank 56 through a high-pressure fuel feed pump 1, stores the pressurized fuel in a common rail 57 and injects the high-pressure fuel stored in the common rail 57 into the combustion chamber of the internal combustion engine via injectors 58. The fuel injection quantity, the injection timing and the like are controlled by an electronic control unit (ECU) 59 based upon vehicle information signals indicating the engine rotation rate, the accelerator pedal position and the like, detected by sensors 60.

[0003] In addition, the high-pressure fuel feed pump 1 often adopts a structure through which the fuel is compressed by a plunger which engages in reciprocal movement by using the internal combustion engine as a drive source and, in such a case, the high-pressure fuel feed pump 1 includes a fuel oil quantity regulating means that regulates the quantity of fuel oil flowing into the compression space where the fuel is compressed. Examples of fuel oil quantity regulating means proposed in the related art include a flow regulating valve (fuel oil quantity regulating means) employed in the fuel injection control apparatus for an internal combustion engine disclosed in Patent Official Gazette No. 2623537. As shown in FIG. 10, this flow regulating valve 70 includes a valve disc 71 provided in the space 73 located halfway through a flow path 72 through which the fuel flows and regulates the flow rate of the fuel by using the forces imparted from a spring 75 and a solenoid 76 to cause the valve disc 71 to move up/down in the figure.

[0004] However, in the flow regulating valve 70 disclosed in Patent Official Gazette No. 2623537 described above in which the valve disc 71 slides along a direction (the direction along which the valve disc 71 moves up/down) extending parallel to the direction along which the fuel flows (the direction running from the top to the bottom), the pressure of the fluid is applied to the valve disc 71 moving upward (along the opening direction) so as to inhibit the movement of the valve disc 71, whereas the pressure of the fluid is applied to the valve disc 71 moving downward (along the closing direction) so as to facilitate the movement of the valve disc 71. Thus, since there is a significant discrepancy in the manner in which

the movement of the valve disc 71 is affected by the fluid pressure applied to the valve disc 71 depending upon the direction in which the valve disc 71 is moving, the valve disc 71 cannot move smoothly, which makes it difficult to achieve stable flow-rate regulation.

[0005] In addition, in a standard common rail system, electronic devices such as electromagnetic valves installed at various positions are controlled by an ECU as explained earlier, and the quantity of and the pressure level of the fuel oil force fed from the high-pressure fuel feed pump are adjusted through control implemented by the fuel oil quantity regulating means (i.e., the flow regulating valve described above) of the high-pressure fuel feed pump so as to sustain the pressure inside the common rail at an ideal level. However, if any failure occurs at the fuel oil quantity regulating means and it becomes no longer possible to reduce the flow rate of the fuel even after the pressure inside the common rail reaches the target pressure level, an excessive quantity of high-pressure fuel is fed from the high-pressure fuel feed pump to allow the pressure inside the common rail to reach an abnormally high level.

[0006] Accordingly, an object of the present invention is to provide a high-pressure fuel feed pump that allows a valve disc provided to regulate the quantity of fuel oil flowing into a fuel force-feeding means to move smoothly without becoming hindered by the fluid pressure and prompts full effective measures to be taken if an abnormality occurs.

DISCLOSURE OF THE INVENTION

[0007] In order to achieve the object described above, in a high-pressure fuel feed pump according to the present invention, which is employed in a fuel injection system for injecting fuel into a combustion chamber of an internal combustion engine and force feeds the fuel into a common rail where high-pressure fuel is stored, comprising a fuel force-feeding means that includes a compression space into which the fuel flows and sends the fuel delivered into the compression space after compressing the fuel in the compression space through a reciprocal movement of a plunger and a fuel oil quantity regulating means that regulates the quantity of fuel oil flowing into the compression space, the fuel oil quantity regulating means includes the fuel path through which the fuel drawn out of a fuel tank is guided into the compression space and a throttle valve that is provided in the fuel path and changes the cross sectional area of the fuel path to vary the quantity of the fuel oil passing through the fuel path, and the throttle valve slides along a direction substantially perpendicular to the direction along which fuel passing through the fuel path flows.

[0008] In this high-pressure fuel feed pump, in which the pressure of the fluid (the fuel) is applied to the throttle valve along the direction substantially perpendicular to the direction in which the throttle valve slides, the sliding

movement of the throttle valve is not inhibited. In addition, since no significant difference manifests in the fluid pressure applied to the throttle valve regardless of which direction the throttle valve is currently sliding, the throttle valve is allowed to move in a smooth manner to achieve stable flow-rate regulation.

[0009] It is desirable that the fuel oil quantity regulating means comprise an elastic member that applies force to the throttle valve along the closing direction, an orifice formed inside the path through which the fuel having been drawn from the fuel tank flows, a pressure chamber provided to apply force to the throttle valve along the opening direction by using the pressure of the fuel having passed through the orifice and flowed therein and a pressure regulating valve that is provided within a first return path connecting the pressure chamber with the fuel tank and is electronically controlled by a specific control device.

[0010] In this structure, in which a constant force is applied to the throttle valve by the elastic member along the closing direction, i.e., the direction along which the cross sectional area of the fuel path through which the fuel drawn up from the fuel tank is guided to the compression space of the fuel force-feeding means is reduced, the throttle valve moves along the opening direction, i.e., the direction along which the cross sectional area of the fuel path increases, against the force applied by the elastic member when the pressure inside the pressure chamber into which the fuel having passed through the orifice flows becomes higher than the level of the force applied by the elastic member, thereby increasing the quantity of fuel flowing into the fuel force-feeding means. The degree to which the throttle valve is opened can be adjusted by adjusting the level of the pressure inside the pressure chamber, and the pressure level inside the pressure chamber, in turn, can be adjusted by implementing open/close control within the specific control device on the pressure regulating valve which may be constituted of an electromagnetic valve provided within the first return path connecting the pressure chamber and the fuel tank and thus by adjusting the quantity of the fuel oil inside the pressure chamber.

[0011] In addition, a second return path communicating with the fuel tank may be connected to the pressure chamber, with an emergency stop valve that opens when specific conditions are present provided in the second return path.

[0012] In the structure described above, the emergency stop valve provided inside the second return path opens if an abnormality occurs. As a result, the pressure inside the pressure chamber falls to allow the throttle valve to be moved to the closing position by the force applied by the elastic member, which, in turn, stops the fuel supply to the fuel force feeding means and ultimately stops the internal combustion engine.

[0013] The specific conditions mentioned above should be; the level of the pressure inside the common rail is equal to or higher than a predetermined level and

the pressure regulating valve has remained in an open state over a predetermined length of time or longer.

[0014] In this high-pressure fuel feed pump, if the level of the pressure inside the common rail is not lowered even when the pressure regulating valve is in an open state, it is decided that an abnormality has occurred and, thus, the emergency stop valve provided in the second return path opens. As a result, the fuel supply to the fuel force-feeding means is stopped, thereby halting the high-pressure fuel feed to the common rail.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 is a sectional view of the structure adopted in a high-pressure fuel feed pump according to the present invention;

FIG. 2 is a sectional view taken along A-A in FIG. 1, further illustrating the structure adopted in the high-pressure fuel feed pump according to the present invention;

FIG. 3 is a sectional view of the structure adopted in the fuel metering unit (FMU) in the high-pressure fuel feed pump achieved in a first embodiment;

FIG. 4 illustrates the structure of the FMU in the high-pressure fuel feed pump achieved in the first embodiment;

FIG. 5 illustrates the structure adopted in the FMU achieved in a second embodiment;

FIG. 6 presents a system diagram of the structure adopted in the FMU in the second embodiment;

FIG. 7 presents a flowchart of the control implemented on the emergency stop valve;

FIG. 8 presents a flowchart of the control implemented on the emergency stop valve;

FIG. 9 schematically illustrates a common rail system; and

FIG. 10 is a sectional view of a fuel oil quantity regulating means (a flow regulating valve) in the related art.

BEST MODE FOR CARRYING OUT THE INVENTION

[0016] The following is an explanation of the embodiments of the present invention, given in reference to the drawings.

[0017] A high-pressure fuel feed pump 1 shown in FIGS. 1 and 2 is used as part of a common rail system 55 shown in FIG. 9. The common rail system 55 comprises a fuel tank 56, the high-pressure fuel feed pump 1, a common rail 57, injectors 58, an electronic control unit (ECU) 59 that controls the various components and sensors 60.

[0018] The high-pressure fuel feed pump 1 which is connected to the common rail 57 via a piping raises the pressure of the fuel oil drawn up from the fuel tank 56 and feeds the pressurized fuel oil to the common rail 57.

The high-pressure fuel force fed from the high-pressure fuel feed pump 1 is stored in the common rail 57 and is then distributed to the injectors 58. The injectors 58 inject the high-pressure fuel delivered from the common rail 57 to a fuel chamber of an internal combustion engine (not shown) with specific timing. The ECU 57 implements integrated control with regard to the fuel feed / injection quantities, the timing with which the fuel is fed / injected and the like by outputting a control signal to electronic devices such as electromagnetic valves provided at the high-pressure fuel feed pump 1, the common rail system 57 and the injectors 58 based upon vehicle information signals indicating the engine rotation rate, the accelerator opening degree, the fuel oil temperature and the like detected by the sensors 60.

[0019] In addition, the common rail 57 in the embodiment, which includes a return path 47 connecting the three components, i.e., the high-pressure fuel feed pump 1, the common rail 57 and the injectors 58, with the fuel tank 56 and the fuel returning means such as the electromagnetic valves provided at these components 1, 57 and 58 and controlled by the ECU as shown in FIG. 8, allows any excess fuel at the individual components 1, 57 and 58 to return to the fuel tank 56.

[0020] The following is an explanation of the structure adopted in the high-pressure fuel feed pump 1, given in reference to FIGS. 1 and 2. The high-pressure fuel feed pump 1 is constituted by assembling a feed pump 2, a fuel metering unit (FMU: fuel oil quantity regulating means) 3 and a supply pump (fuel force-feeding means) 4.

[0021] The feed pump 2, which draws up the fuel oil from the fuel tank 56 and feeds fuel oil to the FMU 3 to be detailed later, is mounted with a bolt or the like so as to close off an opening at a housing member 8c of a pump housing 8. The internal structure of the feed pump 2 includes an inner gear secured to an end of a camshaft 7, a drive gear that interlocks with the inner gear, a main gear linked with the drive gear via a shaft and a slave gear that interlocks with the main gear, and the main gear and the slave gear are caused to rotate as the camshaft 7 rotates so as to draw up the fuel oil from the fuel tank 56 with a gear pump constituted of the two gears to feed the drawn fuel oil to the FMU 3 via a fuel filter.

[0022] The fuel metering unit (FMU) 3 shown in FIGS. 1 and 3 has a function of supplying to the supply pump 4 to be detailed later the fuel fed from the feed pump 2 after regulating the fuel oil quantity so as to achieve the fuel pressure level required in the internal combustion engine.

[0023] This FMU 3 includes a fuel intake 30 through which the fuel drawn up from the fuel tank 56 by the feed pump 2 is taken in and fuel paths 31a and 31b through which the fuel thus taken in is guided to the supply pump 4, with a throttle valve 32 provided in the fuel paths 31a and 31b. A pressure chamber 33 into which the fuel flows via an orifice 34 is formed at one end of the throttle valve 32, and a spring 25 which applies a force to the

throttle valve 32 toward the pressure chamber 33 is provided at the other end, and, as a result, the throttle valve 32 is made to stop at a position at which the pressure inside the pressure chamber 33 and the force applied by the spring 25 are in balance.

[0024] The collar portion 32a, the circumference of which is made to distend relative to the remaining portion of the throttle valve 32 is formed at an approximate center of the throttle valve 32, and the cross sectional (opening) area of the fuel path 31b on the downstream side can be varied by the collar portion 32a. In addition, the pressure chamber 33 communicates with a first path 37 (see FIG. 3) connecting with the return path 47, and a pressure regulating valve 36 constituted of an electromagnetic valve electronically controlled by the ECU 59 is provided in the first path 37. By controlling the opening degree of the pressure regulating valve 36, the pressure inside the pressure chamber 33 is adjusted and thus, the position at which the throttle valve 32 stops, i.e., the degree to which the sectional area of the fuel path 31b is reduced by the collar portion 32a can be regulated, to control the quantity of fuel oil supplied to the supply pump 4.

[0025] As shown in FIGS. 1 and 2, the supply pump 4 comprises plungers 5, plunger barrels 6, tappets 9, cams 13 and the camshaft 7, which is supported at the pump housing 8 with one end thereof projecting to the outside through the pump housing 8 to rotate upon receiving drive torque from the internal combustion engine (not shown).

[0026] The pump housing 8 is constituted of a housing member 8a having longitudinal holes 10, at which the plunger barrels 6 are mounted, formed therein and housing members 8b and 8c secured to the housing member 8a with bolts or the like to rotatably hold the areas near the two ends of the camshaft 7. In this example, two longitudinal holes 10 are formed at the housing member 8a, and the plunger barrels 6 are secured to the housing member 8a through the longitudinal holes 10 with the plungers 5 slidably inserted at the plunger barrels 6.

[0027] The lower end of each plunger 5 is placed in contact with the corresponding cam 13 via the tappet 9, and a spring 17 is provided between a spring receptacle 15 provided at the housing member 8a and a spring receptacle 16 provided at the bottom of the plunger 5 so that the plunger 5 engages in reciprocal movement along the contour of the cam 13 in cooperation with the spring 17 as the camshaft 7 rotates.

[0028] At the top of each plunger barrel 6, an inlet-outlet (I/O) valve 20 is provided in the space between the plunger barrel 6 and a delivery valve holder 19. Between the I/O valve 20 and the plunger 5, a compression space 21 is formed, and a fuel outlet 22 formed at the delivery valve holder 19 is set above the I/O valve 20.

[0029] The I/O valve 20 has a function of supplying the fuel oil delivered from the FMU 3 to the compression space 21 and sending out the fuel oil compressed by

the plunger 5 through the fuel outlet 22 so that the compressed fuel oil does not flow back to the FMU 3. The I/O valve 20 is constituted of a valve body 23 mounted at the top of the plunger barrel 6, an inlet valve 25 with one end thereof communicating with the fuel path 31b (see FIG. 3) at the FMU 3 and the other end thereof opening/closing a fuel path 24 communicating with the compression space 21, which applies a constant force to the fuel path 24 along the closing direction by imparting a force against the pressure of the fuel from the FMU 3 and an outlet valve 27 with one end thereof communicating with the compression space 21 and the other end thereof applying a constant force to a fuel path 26 communicating with the fuel outlet 22 along the closing direction. As the plunger 5 starts a descending stroke, the outlet valve 27 closes, causing the inlet valve 25 to be pushed up by the fuel oil from the FMU 3, which, in turn, allows the fuel oil to flow into the compression space 21. As the plunger 5 starts an ascending stroke, the pressurized fuel oil closes the inlet valve 25 to push up the outlet valve 27 and the fuel oil is force fed through the fuel outlet 22.

[0030] In the structure described above, the high-pressure fuel feed pump 1 draws up fuel oil from the fuel tank 56 through the feed pump 2 and feeds the drawn fuel oil to the FMU 3. The FMU 3, in turn, first adjusts the flow rate of the fuel oil and delivers the fuel oil to the individual compression spaces 21 at the supply pump 4 via the I/O valves 20. The supply pump 4 supplies the fuel oil pressurized by the plungers 5 to the common rail 57 (see FIGS. 8 and 9) through the fuel outlets 22.

[0031] The following is the features of the FMU 3 achieved in the first embodiment, given in reference to FIG. 4. The FMU 3 achieved in the first embodiment includes the fuel paths 31a and 31b through which the fuel is guided to the compression spaces 21 at the supply pump 4 and the throttle valve 32 which regulates the fuel flow rate by varying the cross sectional area of the fuel path 31b is provided between the fuel paths 31a and 31b as explained earlier. The opening degree of the throttle valve 32 is adjusted by controlling the pressure regulating valve 36 and changing the pressure level inside the pressure chamber 33. The pressure regulating valve 36 is constituted of a solenoid which is magnetically excited in response to a control signal provided from the ECU 59 (see FIG. 9), a valve disc 40 which is caused to move by the excitation force generated at the solenoid 39 and a valve seat 41 which seats the valve disc 40. When the valve disc 40 is not seated at the valve seat 41 (when the valve is open), the fuel inside the pressure chamber 33 is allowed to travel through a filter 44 provided within the first path 37 and the return path 47 (see FIG. 8) to return to the fuel tank 56 (see FIG. 9).

[0032] As the pressure inside the pressure chamber 33 changes and the balance between the pressure inside the pressure chamber 33 and the force applied by the springs 25 also changes, the throttle valve 32 is allowed to slide along the vertical direction in the figure.

The direction along which the throttle valve 32 slides is almost perpendicular to the direction in which the fuel flows through the fuel paths 31a and 31b. Thus, since the pressure of the fluid (the fuel) does not greatly affect the movement of the throttle valve 32 and the degree to which the movement of the throttle valve 32 is influenced by the fluid pressure does not change greatly either regardless of whether the throttle valve 32 is moving along in the opening direction or the closing direction, the throttle valve 32 achieves a smooth movement to enable a stable fuel flow-rate regulation.

[0033] It is to be noted that it is assumed that in the fuel oil quantity regulating means in the high-pressure fuel feed pump according to claim 1 of the present invention, the direction along which the fuel flows (the direction running from the right to the left in the figures) and the direction along which the throttle valve 32 slides (the vertical direction in the figures) are still substantially perpendicular to each other even when the upstream side fuel path 31a and the downstream side fuel path 31b form a stage and the upstream side fuel path 31a is slightly inclined toward the downstream side as in the FMU 3 shown in FIGS. 1 and 3.

[0034] In the following explanation of another embodiment of the present invention, the same reference numerals are assigned to components identical to, and components achieving functions identical to those in the first embodiment described above to preclude the necessity for a repeated explanation thereof.

[0035] FIGS. 5 and 6 show the structure assumed in a fuel metering unit (FMU) 3 of the high-pressure fuel feed pump 1 achieved in the second embodiment. In the FMU 3 in the second embodiment, a second path 50 communicating with the return path 47, which is different from the first path 37, is connected to the pressure chamber 33, with an emergency stop valve 51 to be detailed later provided at the second path 50.

[0036] The emergency stop valve 51 is constituted of a solenoid 52 which is magnetically excited in response to a control signal provided by the ECU 59 (see FIG. 9), a valve disc 53 that is caused to move by the excitation force generated at the solenoid 52 and a valve seat 54 that seats the valve disc 53. The valve disc 53 is seated at the valve seat 54 (the valve is closed) while the system is functioning normally. However, if specific conditions are present and thus it is determined that an abnormality has occurred, the emergency stop valve 51 opens to allow the pressure chamber 33 to communicate with the return path 47 via the second path 50 and, as a result, the fuel inside the pressure chamber 33 is allowed to return to the fuel tank 56.

[0037] The following is an explanation of the emergency stop control implemented to open the emergency stop valve 51, given in reference to the flowchart presented in FIG. 7. This control is executed on a regular basis from a specific main routine. First, the pressure P_c inside the common rail 57 is detected by a pressure sensor (not shown) installed at the common rail 57 (see

FIG. 9), and a decision is made as to whether or not the detected common rail pressure P_c is higher than a preset pressure upper limit P_0 (step 100). If it is decided that the common rail pressure P_c is not higher than the pressure upper limit P_0 , the operation returns to the main routine.

[0038] If it is decided in step 100 that the common rail pressure P_c is higher than the pressure upper limit P_0 , a decision is made as to whether or not the pressure regulating valve 36 is in an open state by employing a specific sensor (not shown) (step 101). If it is decided that the pressure regulating valve 36 is not in an open state, a specific control flow for implementing open/close control on the pressure regulating valve is executed (step 103). If, on the other hand, it is decided in step 101 that the pressure regulating valve 36 is in an open state, a decision is made as to whether or not a predetermined length of time t_s has elapsed since the pressure regulating valve 36 opened (step 102).

[0039] If it is decided in step 102 that the predetermined length of time t_s has not yet elapsed, the operation returns to step 100 to check the common rail pressure P_c again, whereas if it is decided that the predetermined length of time t_s has elapsed, a signal for opening and the emergency stop valve 51 is output from the ECU 59 to the solenoid 52 of the emergency stop valve 51 (step 104).

[0040] Through the control described above, the emergency stop valve 51 opens if the common rail pressure P_c becomes higher than the preset pressure upper limit P_0 and the state in which the pressure regulating valve 36 remains in an open state continues over the predetermined length of time t_s or longer. As a result, if the pressure P_c inside the common rail does not become lowered even though the pressure regulating valve 36 is in an open state, e.g., if the filter 44 (see FIG. 5) installed inside the first path 37 becomes clogged and the fuel cannot pass through the first path 37, the emergency stop valve 51 opens to release the fuel inside the pressure chamber 33 through the second path 50, thereby setting the throttle valve 32 in a closed state. Thus, the fuel supply to the compression spaces 21 at the supply pump 4 stops to stop the force feed of fuel to the common rail 57.

[0041] In addition, since the fuel oil, the pressure of which has not yet been raised at the supply pump 4, is returned to the fuel tank 56 if an abnormality occurs in the high-pressure fuel feed pump 1 adopting the structure described above, reliability is assured in the execution of an emergency stop.

INDUSTRIAL APPLICABILITY

[0042] As described above, since the throttle valve slides along a direction substantially perpendicular to the direction along which the fuel flows within the fuel oil quantity regulating means (FMU) according to the present invention, the pressure of the fluid does not

greatly affect the movement of the throttle valve. Thus, the throttle valve achieves a smooth movement to enable a stable flow-rate regulation.

[0043] In addition, if the pressure inside the common rail rises to an abnormal level and the control can no longer be implemented through the normal means (the pressure regulating valve), the emergency stop valve is engaged in operation to stop the force feed of the fuel into the common rail.

Claims

1. A high-pressure fuel feed pump that is employed in a fuel injection system for injecting fuel into a combustion chamber of an internal combustion engine to force feed the fuel into a common rail where high-pressure fuel is stored, comprising:

a fuel force-feeding means that includes a compression space into which the fuel flows and sends out the fuel delivered into said compression space after compressing the fuel in said compression space through a reciprocal movement of a plunger; and

a fuel oil quantity regulating means that regulates the quantity of fuel oil flowing into said compression space, **characterized in that:**

said fuel oil quantity regulating means includes a fuel path through which the fuel drawn out of a fuel tank is guided into said compression space and a throttle valve that is provided in said fuel path and changes the cross sectional area of said fuel path to vary the quantity of said fuel oil passing through said fuel path; and said throttle valve slides along a direction substantially perpendicular to the direction along which fuel passing through said fuel path flows.

2. A high-pressure fuel feed pump according to claim 1, **characterized in that:**

said fuel oil quantity regulating means comprises:

an elastic member that applies force to said throttle valve along the closing direction; an orifice formed inside the said path through which the fuel having been drawn from said fuel tank flows; a pressure chamber provided to apply force to said throttle valve along the opening direction by using the pressure of the fuel having passed through said orifice and flowed therein; and

a pressure regulating valve that is provided within a first return path connecting said pressure chamber with said fuel tank and is electronically controlled by a specific control device.

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3. A high-pressure fuel feed pump according to claim 2, **characterized in that:**

a second return path communicating with said fuel tank is connected to the pressure chamber; and
an emergency stop valve that opens when specific conditions are present is provided in said second return path.

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4. A high-pressure fuel feed pump according to claim 3, **characterized in that:**

said specific conditions are;
the level of the pressure inside said common rail is equal to or higher than a predetermined level and said pressure regulating valve has remained in an open state over a predetermined length of time or longer.

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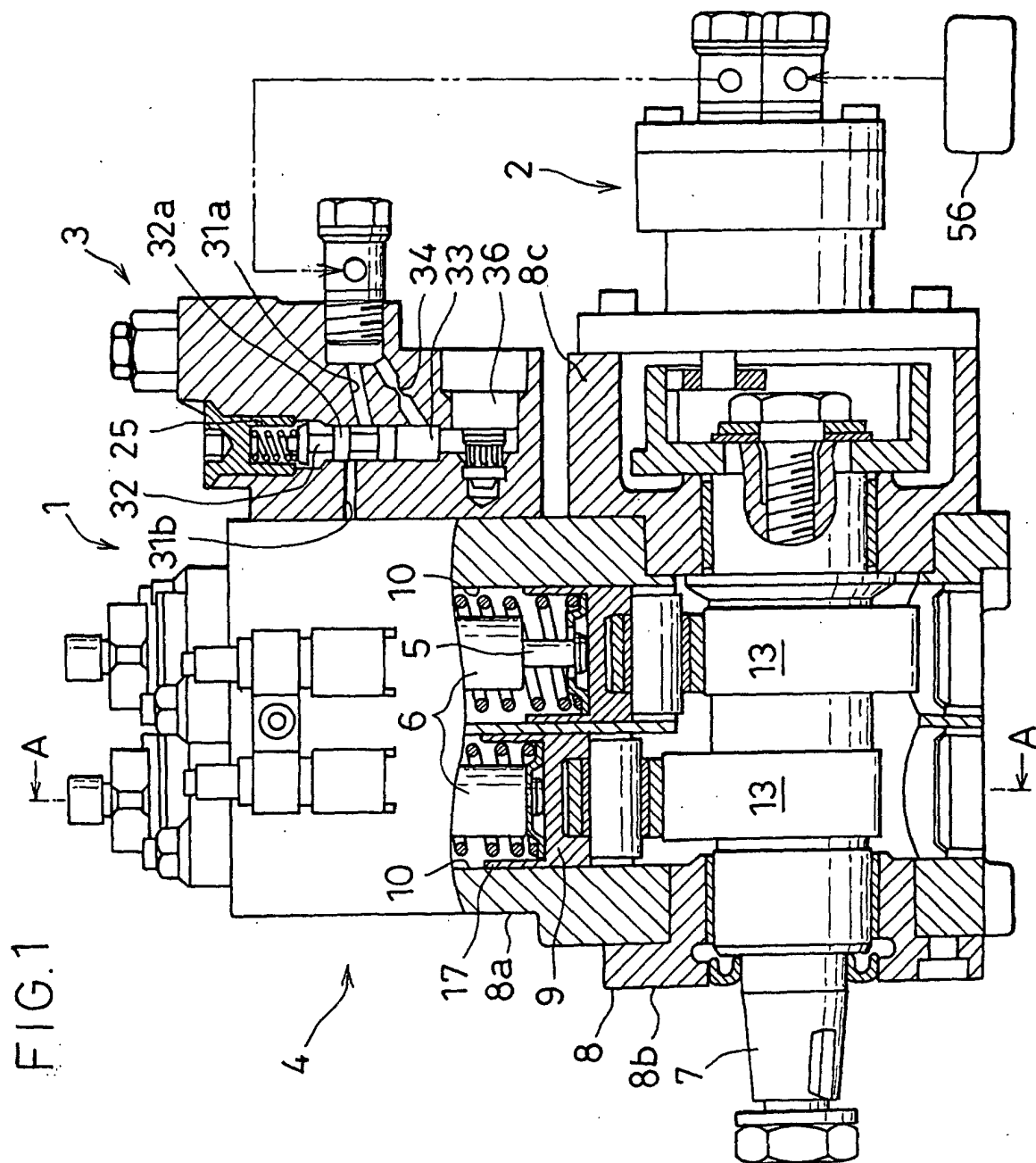


FIG. 2

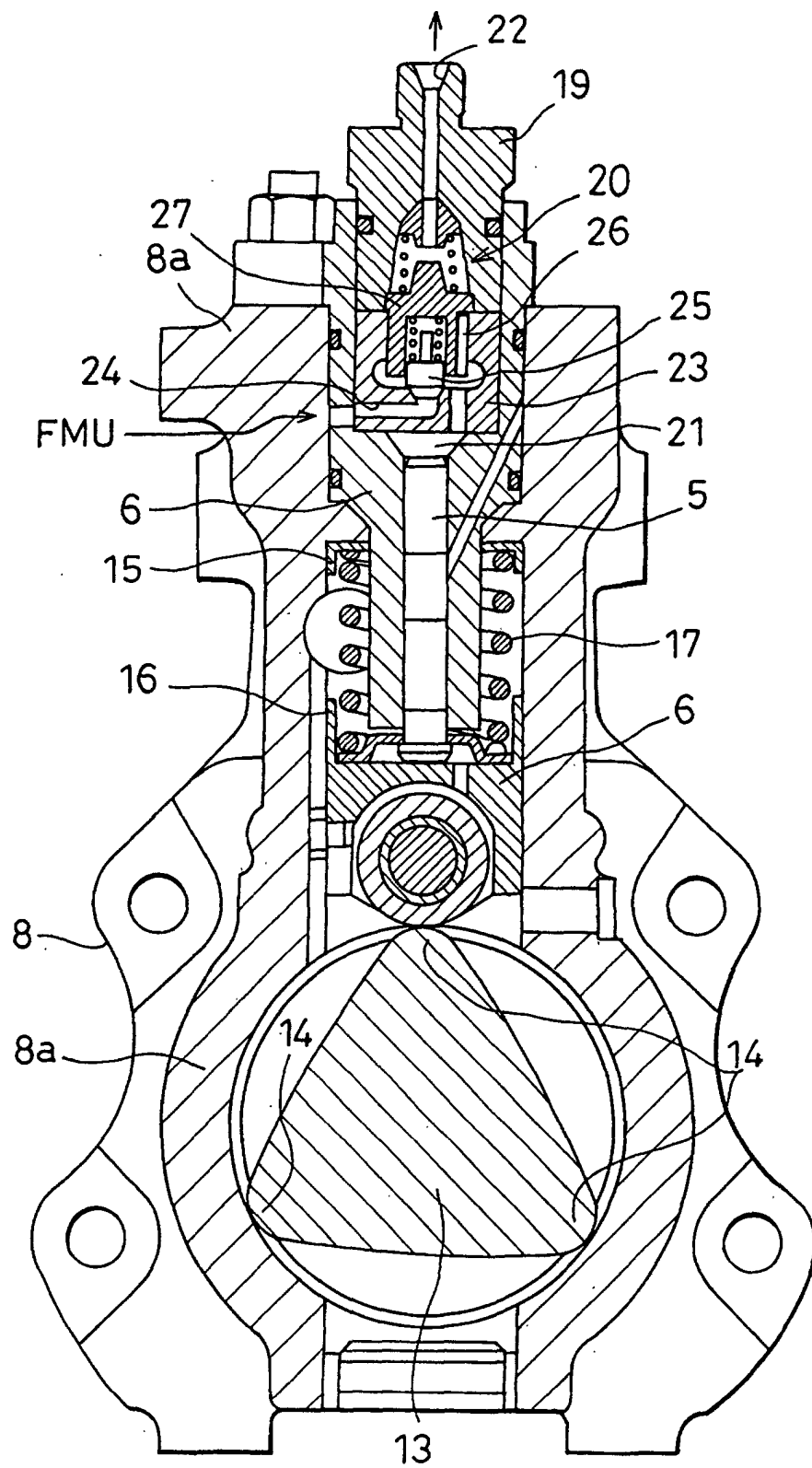


FIG. 3

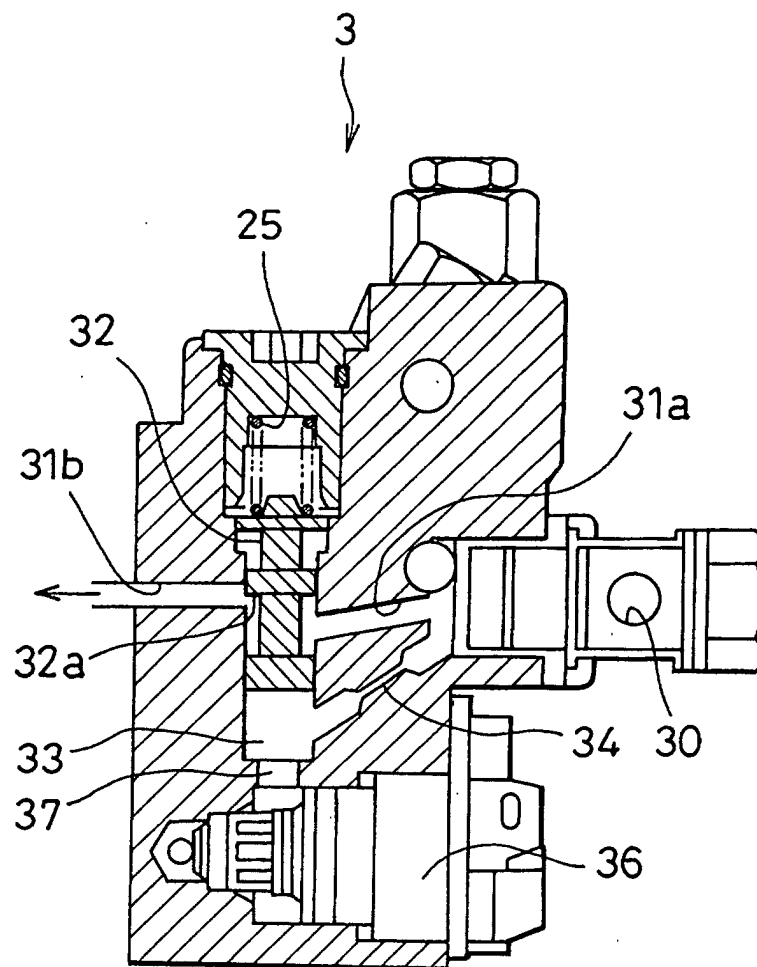


FIG. 4

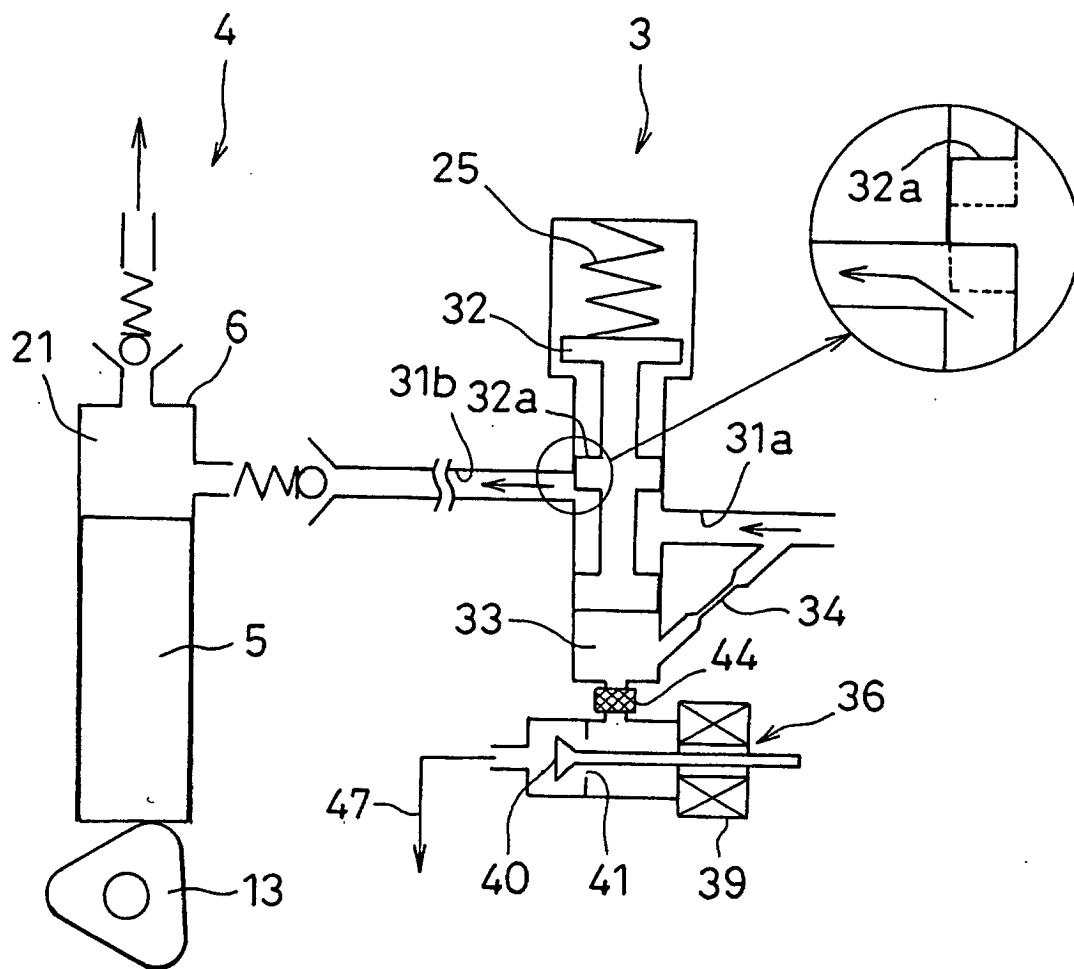


FIG. 5

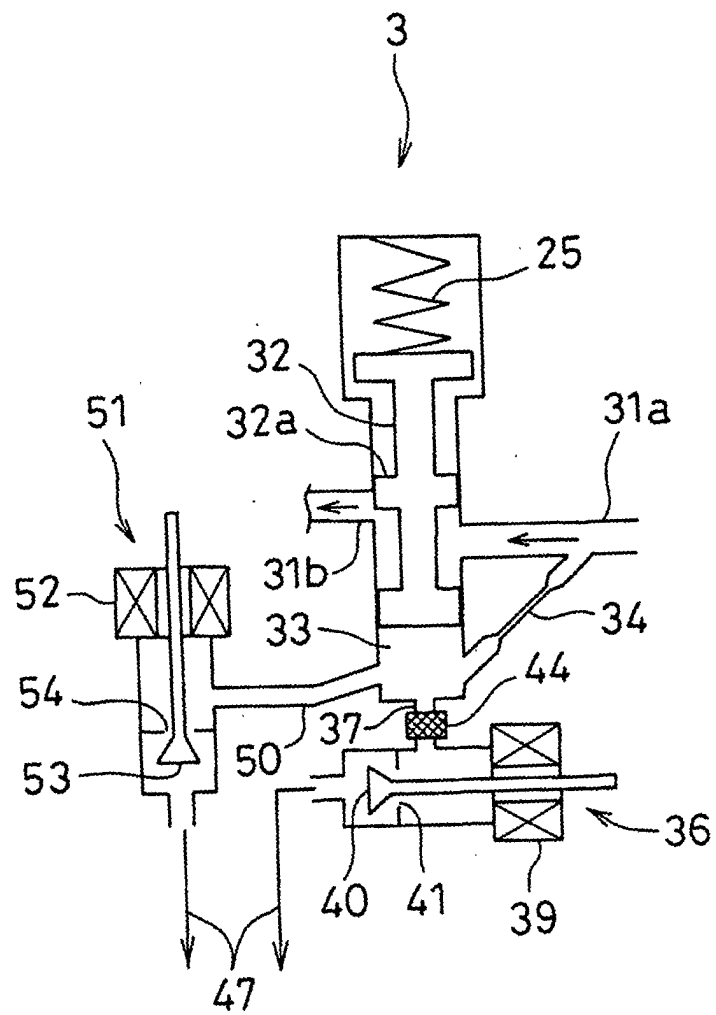


FIG. 6

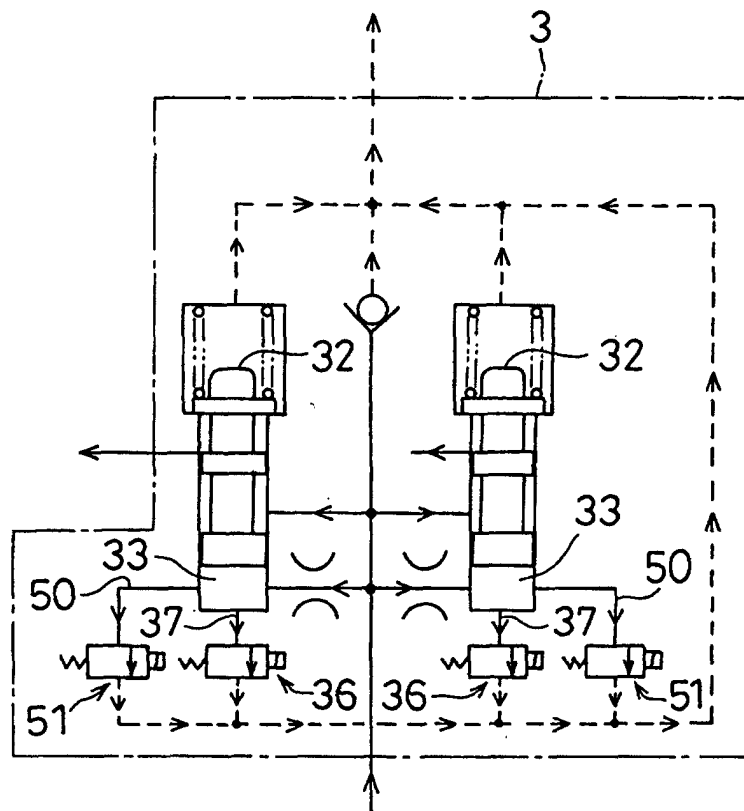


FIG. 7

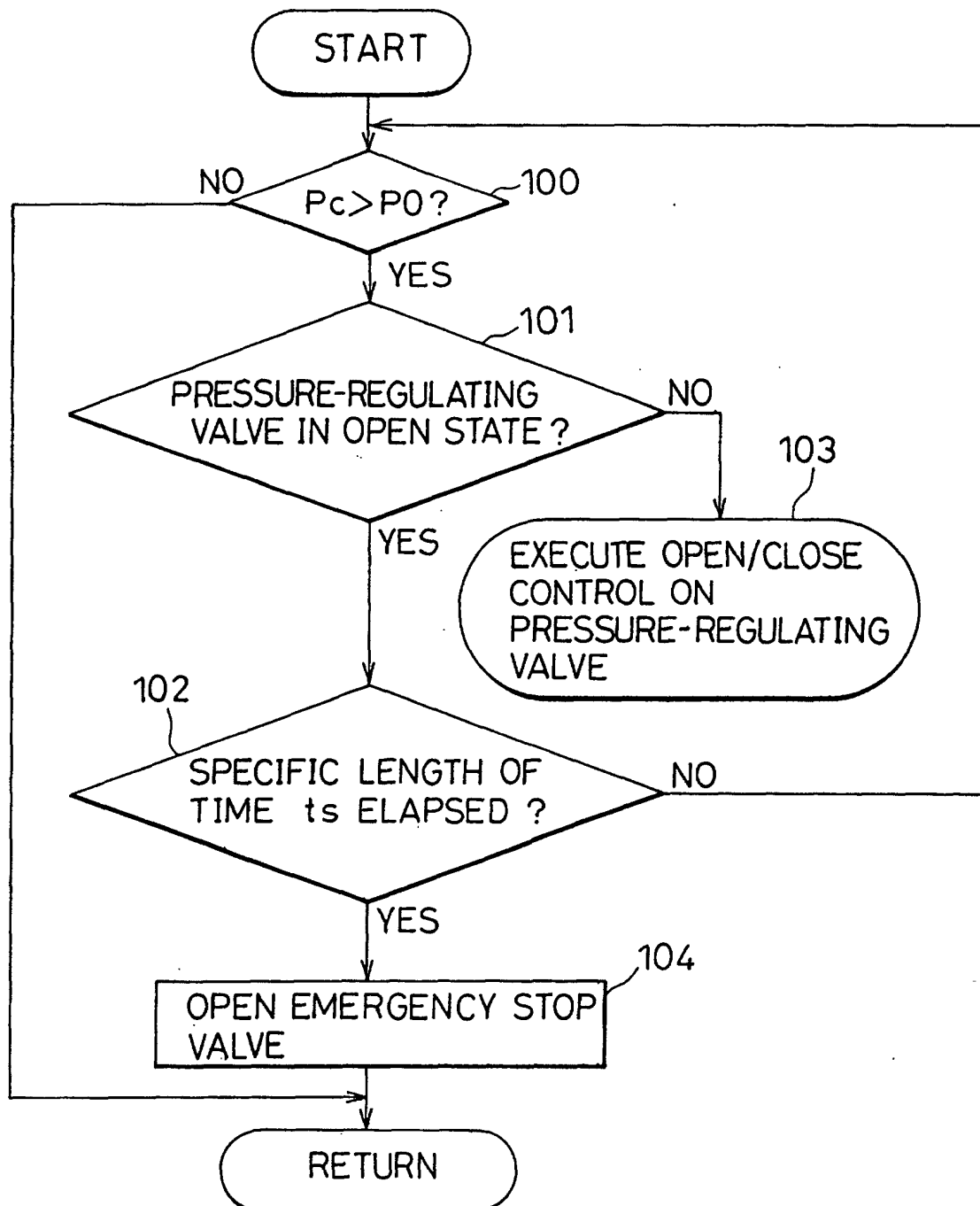


FIG. 8

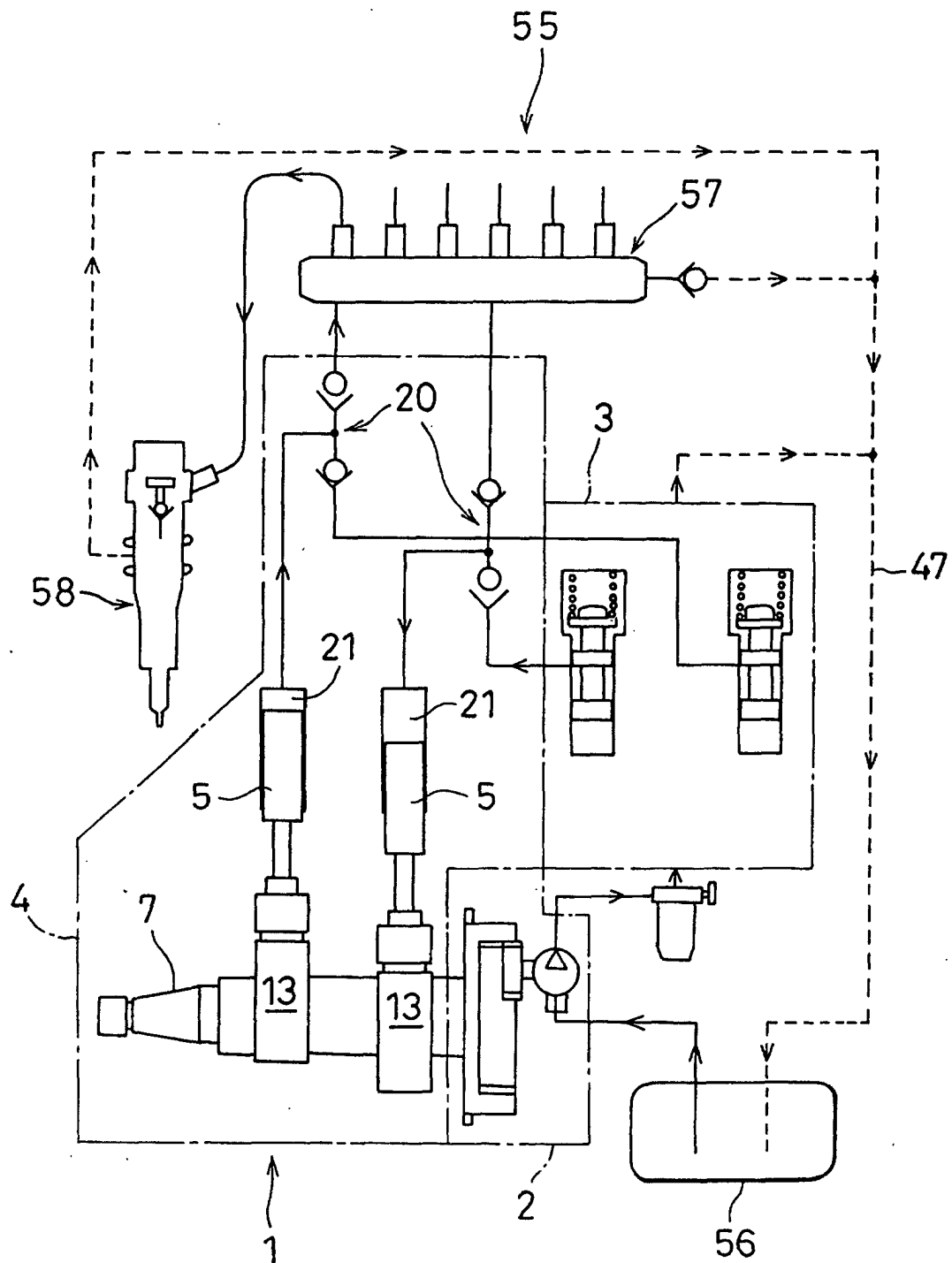


FIG. 9

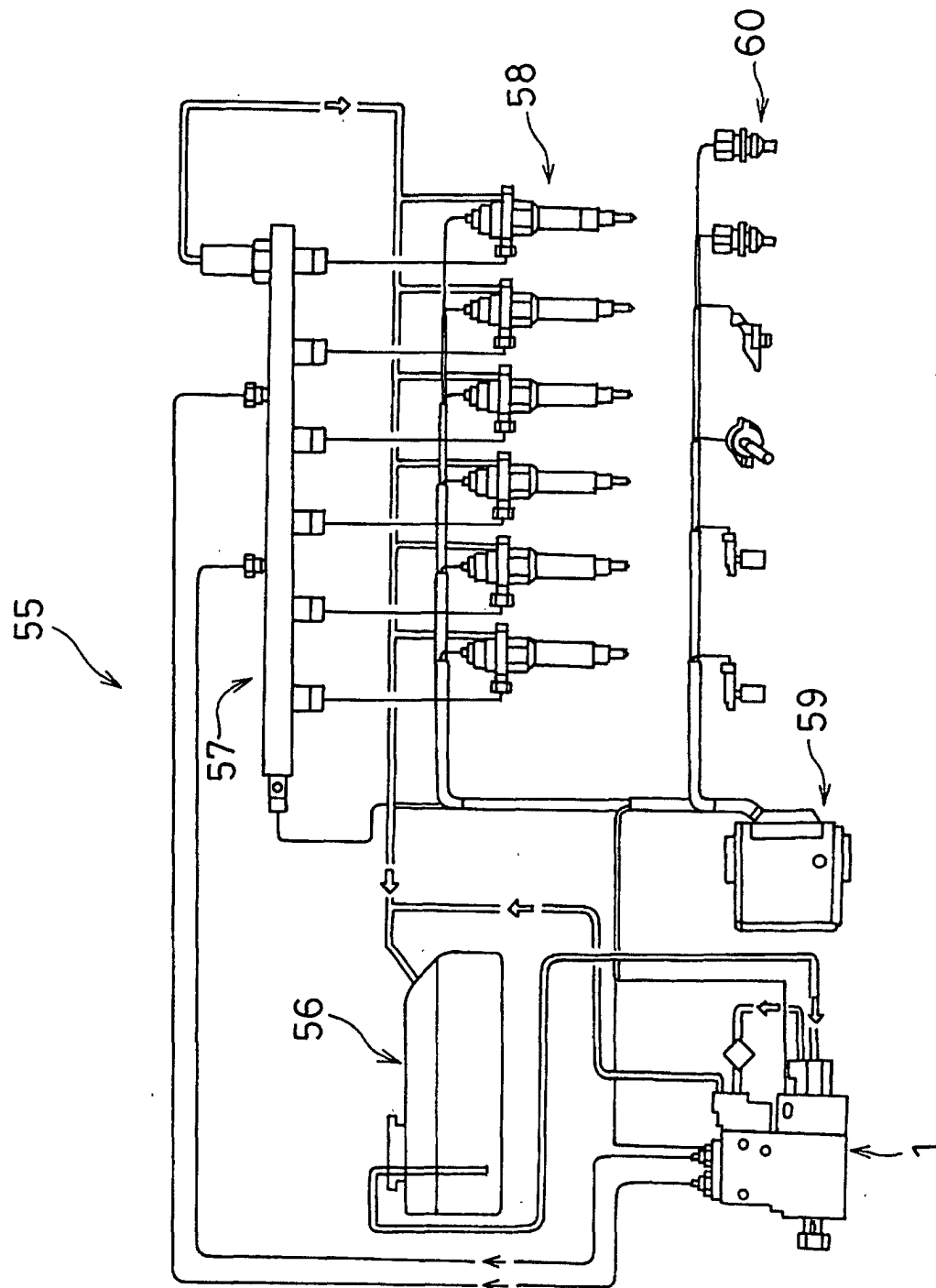
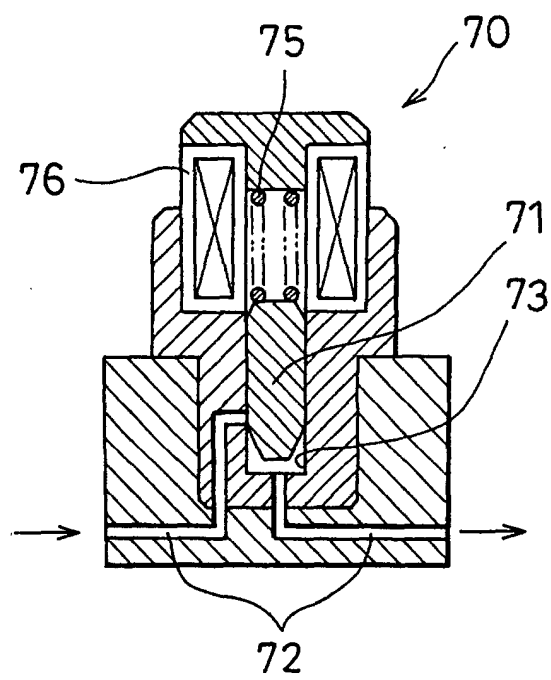


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/03305

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl⁷ F02M59/34, 46, 63/00, 47/00

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.Cl⁷ F02M59/34-36, 46, 63/00, 47/00-02

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

Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-2001
 Kokai Jitsuyo Shinan Koho 1971-2001 Jitsuyo Shinan Toroku Koho 1996-2001

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.
X	JP, 11-294292, A (Denso Corporation, Toyota Motor Corporation), 26 October, 1999 (26.10.99), Full text; all drawings (Family: none)	1
Y		2-3
A		4
Y	JP, 1-255774, A (Ebara Corporation), 12 October, 1989 (12.10.89), Full text; all drawings (Family: none)	2-3
A		4
Y	Microfilm of Japanese Utility Model Application No. 69725/1971 (Laid-open No. 28123/1973), (Nippon Oil Seal Kogyo K.K.), 05 April, 1973 (05.04.73), Full text; all drawings (Family: none)	2-3
A		4

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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29 June, 2001 (29.06.01)Date of mailing of the international search report
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 60-32971, A (Nissan Motor Co., Ltd.), 20 February, 1985 (20.02.85), Full text; all drawings	3
A	(Family: none)	4

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