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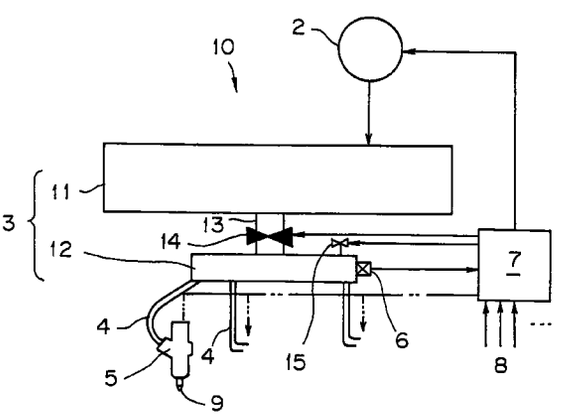
(54) Accumulated pressure type fuel injection apparatus

(57) An accumulated-pressure type fuel injection apparatus 10 is provided that in an electronically-controlled fuel injection apparatus enables pressure in a common rail to be controlled to rapidly decrease the pressure as well as raise the pressure from low to high.

Fig.1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an accumulated pressure type fuel injection apparatus, and more particularly to an accumulated pressure type fuel injection apparatus that enables fuel pressure in a common rail to be promptly controlled.

Prior Art Statement

A conventional electronically-controlled fuel injection apparatus 1 will be described with reference to Figures 1 and 2. Figure 2 is a schematic diagram illustrating the arrangement of the electronically-controlled fuel injection apparatus 1, which has a fuel pump 2, a common rail (high-pressure accumulator) 3, a plurality of fuel injection tubes 4 connected to the common rail 3, an injector 5 connected to each of the fuel injection tubes 4, a pressure sensor 6, and a control means 7.

In response to fuel pressure signals from the pressure sensor 6, engine load signals, engine cylinder identification signals, engine speed (rpm) signals and crank angle signals, together with signals 8 indicating atmospheric pressure, fuel temperature and other such conditions, the control means 7 operates the fuel pump 2 to maintain a constant fuel pressure in the common rail 3, and operates the nozzle 9 of the injector 5 to inject the fuel.

In the electronically-controlled fuel injection apparatus 1 thus configured, operating the nozzle 9 causes large variation in fuel pressure. The common rail 3 is provided in the high-pressure fuel supply passage near the injector 5 to enable fuel pressure variation to be absorbed, utilizing the volume elasticity of the fuel.

Moreover, the electronically-controlled fuel injection apparatus 1 enables fuel injection pressure to be set independently of the engine speed or load. Changing the injection pressure from low to high is readily effected by closing a pump control valve (not shown) in the fuel supply pump 2 to pump the fuel to the common rail 3. With this arrangement high pressure can be attained with just a few such pumping operations.

However, there is a drawback that the only means of reducing the pressure from high to low is by the injection of fuel from the injector 5, so the pressure can only be reduced by the injection amount. That is, common rail 3 pressure change Δ Pc is as follows.

$$\Delta Pc = E \cdot \text{Fuel Injection Amount} \cdot \text{Number of Injections}/Vc \quad (1)$$

where E is the elastic coefficient of the fuel and Vc is the dead volume of the common rail 3.

Therefore, as shown by the solid line in the example illustrated by Figure 3, when it is desired to reduce rapidly the fuel pressure from high-pressure full injection to low-pressure reduced injection, for example a rapid reduction from the torque point (a common rail pressure of 120 MPa and an injection amount of 200 mm^3/st, for example) to idling (a common rail pressure of 30 MPa and an injection amount of 10 mm^3/st), the pressure in the common rail is only decreased by the amount injected by the injector 5. Therefore, many injections are required for the pressure to be reduced to the desired level. This takes time, during which a marked degradation takes place in the transient characteristics of the engine.

In the disclosure of JP-A-2-112643, a common rail is used that is divided into parallel rails, each of which is connected to an injector. In this arrangement, if any of the fuel injection valves malfunction, the common rail connected to the malfunctioning injection valve is closed and fuel continues to be supplied to the other common rails. This ensures continued operation of the engine. However, this arrangement is not directly concerned with high-low control of the common rail pressure itself.

In the accumulated-pressure type fuel injection apparatus of JP-A-4-234562, the common rail is provided with a pressure reduction valve, so that in the event of a malfunction that leads to loss of control of the high-pressure pump or injector, pressure in the common rail is reduced by opening the pressure reduction valve to release the pressure. However, this is merely a pressure reducing arrangement and has many energy inefficiencies.

In the fuel injection apparatus of JP-A-5-321787, a pressure control system is provided in the form of an auxiliary starting pump or assist pump or the like, the aim of which is rapid reduction of fuel pressure during engine starting and stopping and the like. However, this arrangement requires the provision of the auxiliary starting pump or assist pump, which increases both the cost and the complexity.

In the fuel injection apparatus of JP-A-5-149209, a damping chamber is provided between the supply pump and the common rail to reduce pulses produced by the supply pump. However, this arrangement is not directly concerned with high-low control of the common rail pressure itself.

In the disclosure of JP-A-6-58219, the common rail is arranged as at least a double structure of central and side chambers, to reduce pressure variation in the central chamber. However, this arrangement is not directly concerned with high-low control of the common rail pressure itself.

The accumulated-pressure type fuel injection apparatus of JP-A-6-93936 has a high-pressure first accumulator and a low-pressure second accumulator, with the first accumulator being used for main injection and the second accumulator for pilot injection. However, this arrangement is not directly concerned with high-low control of the common rail pressure itself.

SUMMARY OF THE INVENTION

An object of a first aspect of the invention is to provide an accumulated pressure type fuel injection apparatus that enables prompt control of pressure in the common rail, such as to, in an electronically-controlled fuel injection apparatus, rapidly lower the common rail pressure or increase the pressure from low to high.

Another object of the invention is to provide an accumulated pressure type fuel injection apparatus in which load on the fuel supply pump and loss accompanying high-to-low common rail pressure transition can be avoided whenever possible.

A further object of the invention is to provide an accumulated pressure type fuel injection apparatus that controls the common rail pressure using a structurally straightforward and cost-effective arrangement.

For achieving the above objects, the present invention provides an accumulated pressure type fuel injection apparatus having a fuel supply pump, a common rail that accepts fuel from the fuel supply pump in a high-pressure state and an injector connected to the common rail, said accumulated pressure type fuel injection apparatus being characterized in that the common rail is divided into at least a pressure maintenance common rail and a pressure control common rail, a means is provided for switching communication states between the pressure maintenance common rail and the pressure control common rail, and the injector is connected to the pressure control common rail.

The volume of the above pressure maintenance common rail can be increased while at the same time decreasing the volume of the above pressure control common rail. The pressure control common rail can be provided with a pressure reduction valve. Control of the pressure in the pressure control common rail can be enabled by equipping the pressure control common rail with a pressure sensor.

The accumulated pressure type fuel injection apparatus according to this invention is provided with two common rails, one for maintaining pressure and one for controlling pressure, by dividing the common rail into at least one larger part and one smaller part. This facilitates controlling pressure changes from high to low and from low to high. That is, the amount of common rail pressure change ΔPc can be increased by decreasing the size of the common rail dead volume Vc of equation (1) from the total volume of the pressure maintenance common rail and pressure control common rail to the volume of the pressure control common rail.

Thus, by closing communication between the pressure maintenance common rail and pressure control common rail, using a solenoid valve or other such means of switching communication states, pressure in the common rail can be rapidly decreased by the decrease in pressure in the pressure control common rail that occurs as fuel is injected by the injector, while at the same time the pressure is maintained unchanged in the pressure maintenance common rail.

Pressure can be increased from low to high by operating the communication state switching means to open communication between the pressure maintenance common rail and the pressure control common rail. As a result, the pressure in the pressure control common rail can be immediately increased by the operation of the fuel supply pump while at the same time the pressure is maintained unchanged in the pressure maintenance common rail. Thus, in each case the demands of the engine are met.

The above and other features of the present invention will become apparent from the following description made with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an explanatory diagram of an accumulated-pressure type fuel injection apparatus 10 according to an embodiment of the present invention.

Figure 2 is an explanatory diagram of a conventional electronically-controlled fuel injection apparatus 1.

Figure 3 is a graph showing changes in common rail pressure with the passage of time.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the accumulated-pressure type fuel injection apparatus 10 according to the present invention will now be described with reference to Figure 1. Parts that are the same as those in Figure 2 have been given identical reference numerals, and further explanation thereof is omitted.

In place of the conventional common rail 3 arrangement of the electronically-controlled fuel injection apparatus 1, the accumulated-pressure type fuel injection apparatus 10 shown in Figure 1 has a pressure maintenance common rail 11 and a pressure control common rail 12, a pipe 13 that connects the pressure maintenance common rail 11 with the pressure control common rail 12, and a means of opening and closing communication between common rails 11 and 12, constituted by a solenoid valve 14 in the connecting pipe 13. As shown, the pressure maintenance common rail 11, pressure control common rail 12 and injector 5 are arranged in series.

The sum of the dead volumes of the pressure maintenance common rail 11 and pressure control common rail 12 can be made the same as the dead volume of the common rail 3.

The pressure sensor 6 is provided on the pressure control common rail 12.

With the accumulated-pressure type fuel injection apparatus 10 thus arranged, the dead volume of the common rail 3 can be instantly reduced by separating the pressure control common rail 12 from the pressure maintenance common rail 11 by closing the solenoid valve 14, whereby the fuel injection by the injector 5 is accompanied by a prompt drop in injection pressure. This is indicated by the broken line in Figure 3.

With the pressure in the pressure control common rail 12 being detected by the pressure sensor 6, a desired pressure can be maintained by appropriately opening and closing of the solenoid valve 14. With respect to when the pressure to the injector 5 is to be raised from a low pressure to a high pressure, since the pressure in the pressure maintenance common rail 11 can be promptly transferred to the pressure control common rail 12 by opening the solenoid valve 14, the time taken for the pressure to be increased by the operation of the fuel supply pump 2 can be reduced.

Moreover, since the pressure in the pressure control common rail 12 is rapidly decreased while at the same time maintaining the high pressure in the pressure maintenance common rail 11, there is less pressure loss compared to a conventional arrangement. Also, with the conventional arrangement in which the high pressure is released, a large motive force is needed to drive the fuel supply pump 2, and loss is also large. Furthermore, separating the pressure maintenance common rail 11 and pressure control common rail 12 also has the effect of damping pressure variation from the fuel supply pump 2.

The pressure control common rail 12 pressure reduction effect produced by the injection of fuel by the injector 5 when the solenoid valve 14 is closed can be enhanced by providing the pressure control common rail 12 with a pressure reduction valve 15.

The ratio between the dead volumes of the pressure maintenance common rail 11 and pressure control common rail 12 may be set as desired, in accordance with the delivery capability of the fuel supply pump 2, injection amount of the injector 5 and other such factors. However, decrease/increase of pressure in the pressure control common rail 12 can be effected more promptly by using a pressure maintenance common rail 11 that is larger than the pressure control common rail 12.

As described in the foregoing, in accordance with this invention the common rail is divided into a pressure maintenance common rail and a pressure control common rail, providing the dual functions of both controlling and maintaining the pressure in the common rail, which is not possible with the conventional arrangements. In particular, the arrangement of this invention allows the pressure in the common rail to be rapidly decreased.

Claims

1. An accumulated pressure type fuel injection apparatus having a fuel supply pump 2,
   a common rail 3 that accepts fuel from the fuel supply pump 2 in a high-pressure state, and
   an injector 5 connected to the common rail 3,
   said accumulated pressure type fuel injection apparatus being characterized in that the common rail 3 is divided into at least a pressure maintenance common rail 11 and a pressure control common rail 12,
   a switching means 14 is provided for switching communication states between the pressure maintenance common rail 11 and the pressure control common rail 12, and
   the injector 5 is connected to the pressure control common rail 12.

2. An accumulated pressure type fuel injection apparatus according to claim 1 wherein the pressure maintenance common rail 11 is given a larger volume and the pressure control common rail 12 is given a smaller volume.

3. An accumulated pressure type fuel injection apparatus according to claim 1 wherein the pressure control common rail 12 is provided with a pressure reduction valve 15.

4. An accumulated pressure type fuel injection apparatus according to claim 1 wherein the pressure maintenance common rail 11, pressure control common rail 12 and injector 5 are arranged in series.

5. An accumulated pressure type fuel injection apparatus according to claim 1 wherein the pressure maintenance common rail 11 and pressure control common rail 12 are comprised by mutually independent containers.

6. An accumulated pressure type fuel injection apparatus according to claim 1 wherein the pressure control common rail 12 is provided with a pressure sensor 6 and the switching means 14 is operated in accordance with signals from the pressure sensor 6.

7. An accumulated pressure type fuel injection apparatus according to claim 1 wherein the switching means is a solenoid valve 14.

8. An accumulated pressure type fuel injection apparatus according to claim 1 wherein the pressure maintenance common rail 11 and pressure control common rail 12 are connected by a pipe 13.

9. An accumulated pressure type fuel injection apparatus according to claim 8 wherein the switching means 14 is provided in the pipe 13.

Fig.1

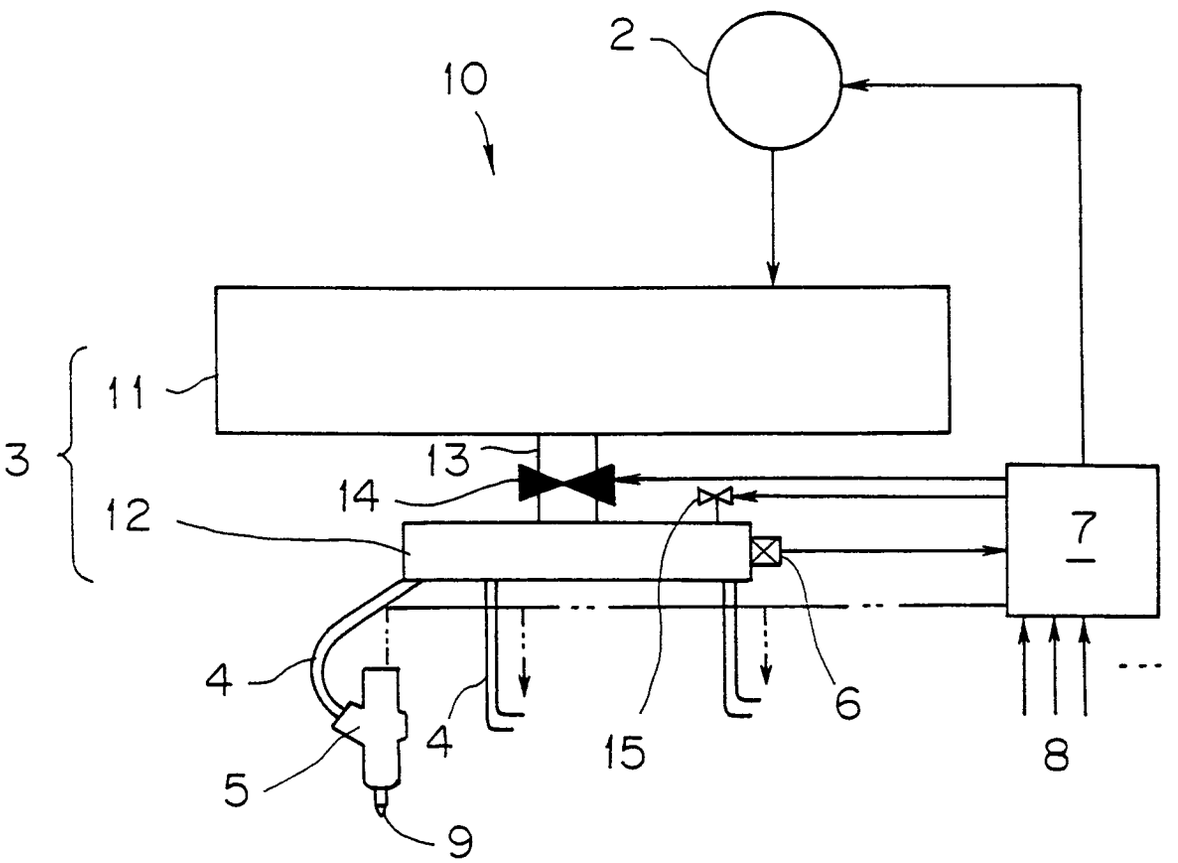


Fig.2

PRIOR ART

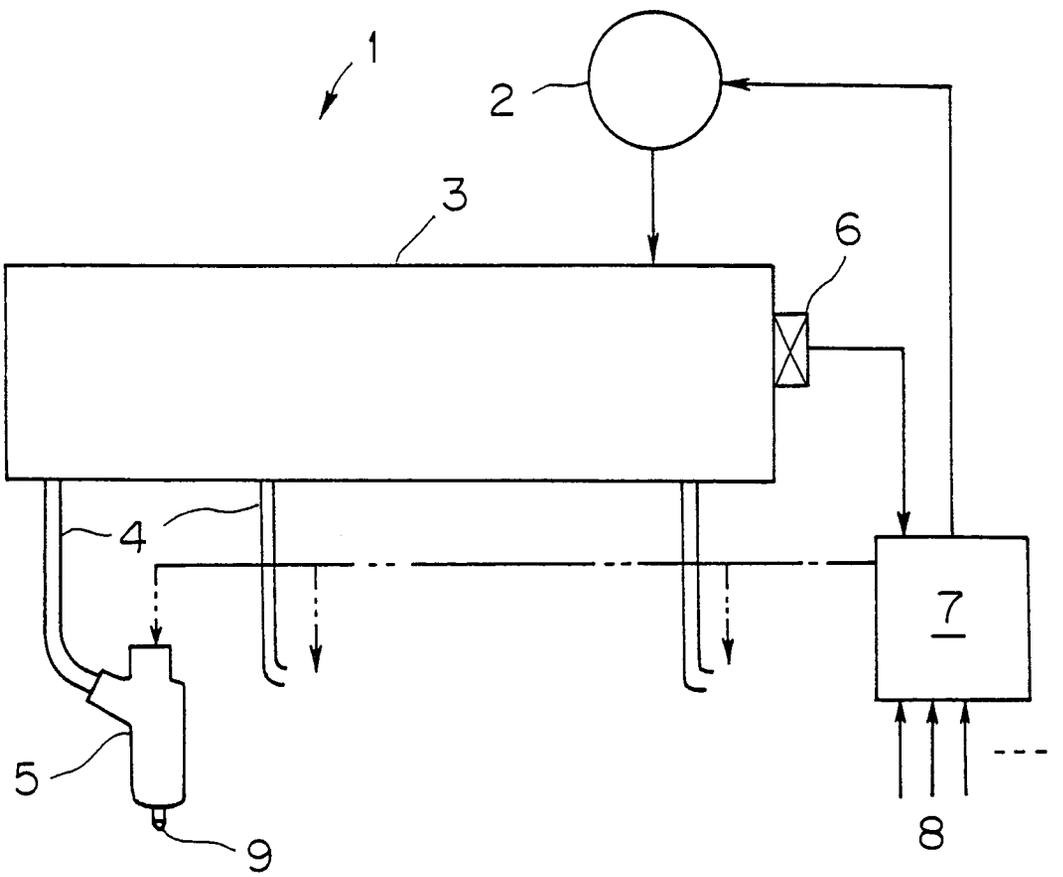
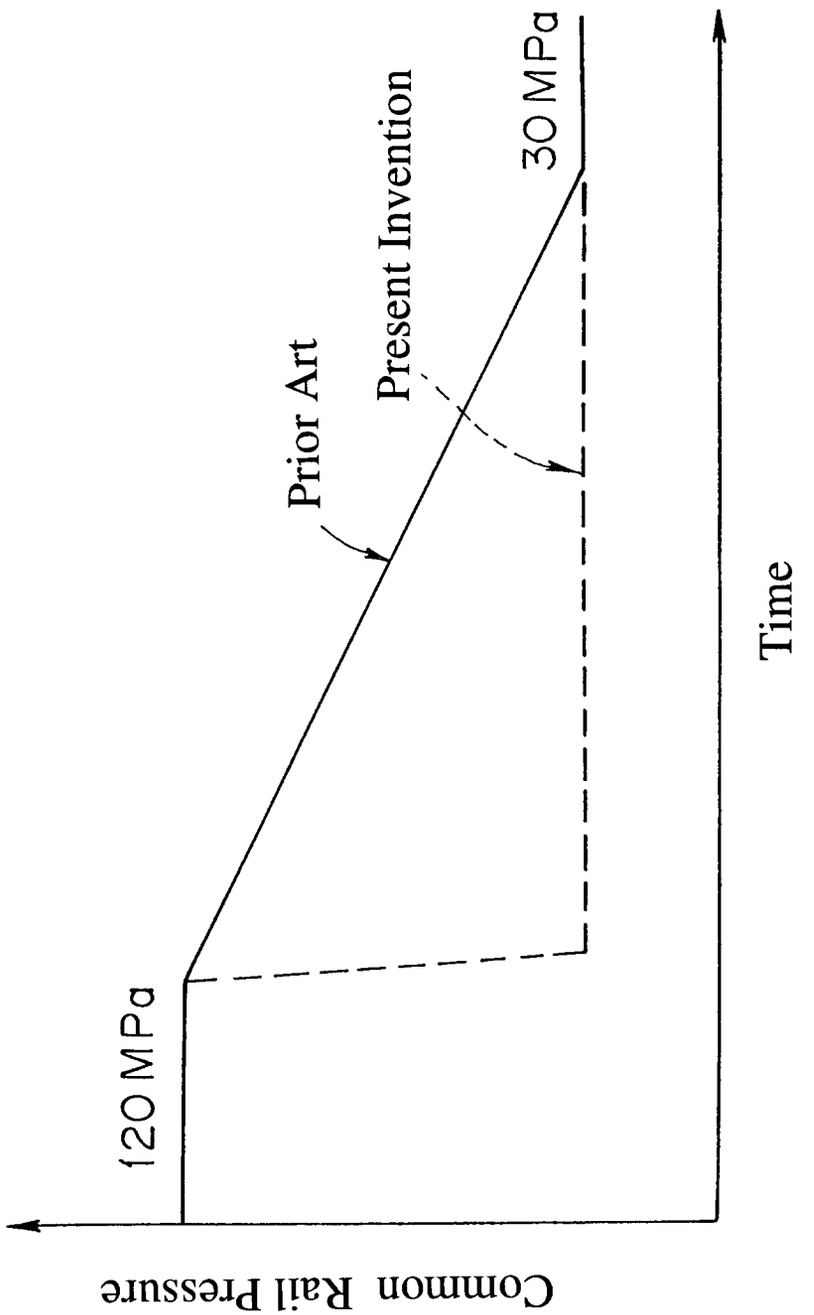


Fig.3


Common Rail Pressure
120 MPa
30 MPa
Prior Art
Present Invention
Time

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 11 2465

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 12 no. 321 (M-736) ,31 August 1988 & JP-A-63 090658 (TOYOTA MOTOR CORP) 21 April 1988, * abstract * ---	1	F02M55/02 F02M69/46
A	DE-A-32 26 277 (DIESEL KIKI) * abstract; claim 1; figure 1 * ---	1	
A	OLHYDRAULIK UND PNEUMATIK, vol. 36, no. 5, 1 May 1992 pages 304-310, XP 000270195 SCHNEIDER W 'PUMPEN FUER ZUKUENFTIGE DIESELEINSPRITZSYSTEME' -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6) F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 October 1995	Wassenaar, G

CATEGORY OF CITED DOCUMENTS

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