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(54) **Common rail fuel injection system**

Common-Rail-Kraftstoffeinspritzsystem

Système d'injection de carburant à rampe commune

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Description

[0001] The present invention relates to a common rail type fuel injection system that supplies high-pressure fuel, accumulated in a common pressurized rail, to combustion chamber engine cylinders by injection through injectors. Specifically, the present invention relates to an improvement in detecting accuracy of the pressure in a common rail of a common rail type fuel injection system having a plurality of pressure sensors in the common rail.

[0002] Generally, an electronically controlled common rail type fuel injection systems that pressurize fuel and supply the high-pressure fuel under pressure to a common rail, in which the fuel is accumulated under pressure, by a high-pressure supply pump driven and driven by an engine, such as a multi-cylinder diesel engine, is known, as described in Japanese Patent Application Examined Publication No. 1995-122422. The fuel injection system distributes the high-pressure fuel accumulated in the common rail to injectors mounted in the engine cylinders and injects the high-pressure fuel to the cylinder combustion chambers.

[0003] The common rail type fuel injection system has only one common rail pressure sensor. The fuel injection system calculates injection pulse duration and injection periods based on a target injection quantity. The target injection quantity is set in accordance with pressure in the common rail, detected by the common rail pressure sensor, and driving conditions of the engine. The fuel injection system applies injection pulses, corresponding to the injection pulse duration, to the injectors. Thus, the fuel injection system controls the fuel injection so that the quantity of the fuel injected to the combustion chambers of the respective cylinders is equal to an optimum value corresponding to the operating conditions of the engine.

[0004] The common rail type fuel injection system is capable of injecting high-pressure fuel and is very flexible with regard to control. However, there is increasing need to reduce variations in injected fuel quantities by the entire fuel injection system. This is due, in part, to strengthening gas emission regulations. Specifically, in terms of the entire fuel injection system, it is known that the accuracy of fuel injection quantities deteriorates due to drops in pressure detection accuracy in the common rail by the common rail pressure detecting means.

[0005] However, if a standard (threshold) of characteristics (values) of the common rail pressure sensor is raised or a range of tolerance thereof is narrowed in order to improve the detection accuracy of the pressure in the common rail, an extraction (failure) rate of the common rail will increase. The number of the common rail pressure sensors below the standard of characteristics or outside the tolerance range will increase, and the number of the common rail pressure sensors above the characteristics standard or inside the tolerance range will decrease compared with the current situation. As a result, productivity will deteriorate and per unit cost will increase.

[0006] Further, document DE 196 26 537 C shows a fuel pressure control apparatus, wherein two different standard pressure sensors are provided for measuring the common rail fuel pressure. The first sensor has a broad measurement range, which thus has a relatively low accuracy of measurement. The second sensor has a more narrow measurement range which is within the measurement range of the first sensor:und which has a higher accuracy of measurement. Accordingly, the pressure can be measured in a very broad range and, nevertheless, the accuracy is sufficiently high in a narrow operational range wherein fuel injection is performed. Since the present pressure is either the pressure signal of the first pressure sensor or the pressure signal of the second pressure sensor no higher accuracy of the measurement is provided by combining the two sensors. The signals of both sensors are just compared to observe the proper function of the sensors.

Summary of the invention

[0007] It is the object of the present invention to provide a common rail type fuel injection system that is capable of improving the detection accuracy of pressure in a common rail.

[0008] This object is achieved with a system comprising the features of claim 1. Further features are described in the dependent claims.

[0009] According to a first aspect of the invention, a standard of characteristics (threshold of a value) or a range of tolerance of a fuel pressure sensor that outputs a fuel pressure signal corresponding to a fuel injection pressure is divided into two parts (ranges). Two fuel pressure sensors within the divided characteristics standards or ranges of the tolerance is disposed in the common rail type fuel injection system. A common rail pressure corresponding to the fuel injection pressure is detected by averaging respective fuel pressure signals output by the two fuel pressure sensors disposed in the common rail fuel injection system. Accordingly, the detection accuracy of the common rail pressure by the common rail pressure detecting means is improved. As a result, the fuel injection accuracy in the common rail type fuel injection system is improved without increasing an extraction rate of the fuel pressure sensor. The extraction rate is the failure rate of the fuel pressure sensor. That is, a sensor is extracted, or pulled from manufacturing, when some of its physical quantities are not within the permissible range or tolerance.

[0010] According to a second aspect of the invention, injection duration is determined based on a target injection quantity set in accordance with operating conditions of an engine and a common rail pressure detected by a common rail pressure detecting means. Injection quantity to the respective cylinders of the engine is precisely controlled by

outputting driving signals corresponding to the injection duration to a plurality of injectors. Accordingly, the fuel injection quantities are controlled to optimum values in accordance with the operating conditions of the engine.

[0011] According to a third aspect of the invention, a quantity of fuel supplied from a fuel supply pump to a common rail is determined based on a common rail pressure detected by a common rail pressure detecting means. The common rail pressure is controlled by outputting driving signals in accordance with the determined injection quantity to the fuel supply pump. Thus, variations in fuel injection are reduced. In yet another aspect, two fuel pressure sensors are disposed integrally within a housing mounted in a common rail. Therefore, space for installation, labor hours for assembling, and a number of parts are reduced.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

FIG. 1 is a schematic view showing the construction of a common rail type fuel injection system according to a first embodiment of the present invention;

FIG. 2 is a cross-sectional view showing a common rail pressure sensor according to the first embodiment;

FIG. 3 is an explanatory diagram showing an example in which a standard characteristics range of a conventional common rail pressure sensor is divided into two parts according to the first embodiment;

FIG. 4 is an explanatory diagram showing an example in which a standard characteristics range of a conventional common rail pressure sensor is divided into three parts not according to the invention;

FIG. 5 is an explanatory diagram showing an example in which a standard characteristics range of a conventional common rail pressure sensor is divided into four parts not according to the invention;

FIG. 6 is a cross-sectional view showing construction of a common rail pressure sensor according to a second embodiment; and

FIG. 7 is a cross-sectional view showing construction of a common rail pressure sensor according to a third embodiment.

Detailed Description of the Preferred Embodiments

(First Embodiment)

[0013] FIGS. 1 to 3 show the first embodiment of the present invention. FIG. 1 is a diagram showing the construction of a common rail type fuel injection system having two common rail pressure sensors. FIG. 2 is a view showing construction of the common rail pressure sensor.

[0014] A common rail type fuel injection system according to the embodiment has a common rail 1, a plurality of injectors 2, a supply pump 3, and an electronic control unit (ECU) 10. The common rail 1 is an accumulator vessel that accumulates high-pressure fuel under a pressure corresponding to an injection pressure. The injectors 2 are fuel injection valves of the present invention. The injectors 2 are connected to the common rail 1 and inject fuel into respective cylinders of a four-cylinder engine such as a multi-cylinder diesel engine. There are four injectors 2 in the embodiment shown. The supply pump 3 is rotationally driven by the engine. The ECU 10 is a controller that electronically controls the injectors 2 and the supply pump 3. In FIG. 1, only one injector 2 corresponding to one cylinder of the four-cylinder engine is shown, and the other injectors 2 are not shown.

[0015] The common rail 1 needs to continuously accumulate a high pressure corresponding to the fuel injection pressure. Therefore, the supply pump 3 supplies the high-pressure fuel through a high-pressure passage 11 to the common rail 1, and the fuel is accumulated in the common rail 1. The injector 2 is an electromagnetic valve that comprises a fuel injection nozzle, an electromagnetic actuator, a biasing means such as a spring, and the like. The fuel injection nozzle is connected with a lower end of each of the high-pressure passages 12 branching from the common rail 1 and injects the fuel into the cylinder of the engine. The electromagnetic actuator drives a nozzle needle disposed in the fuel injection nozzle in a direction to open the valve. The biasing means biases the nozzle needle in a direction to close the valve. The fuel injection from each injector 2 to the engine is electronically controlled by turning on and off the current supply to an injection controlling electromagnetic valve 4. The injection controlling electromagnetic valve 4 operates as an electromagnetic actuator for controlling back pressure of the nozzle needles of the fuel injection nozzles. More specifically, high-pressure fuel accumulated in the common rail 1 is supplied to each cylinder of the engine by injection while the injection controlling electromagnetic valve 4 of the injector 2 of each cylinder is open.

[0016] The supply pump 3 comprises a known feed pump, a plunger and a pressurizing chamber. The feed pump is a low-pressure supply pump that draws low-pressure fuel from a fuel tank 5 by rotation of a pump-driving shaft that rotates with a crankshaft of the engine. The plunger is driven by the pump-driving shaft. The pressurizing chamber is a plunger chamber that pressurizes the fuel by reciprocation of the plunger. The supply pump 3 is a fuel supply pump,

that is, a high-pressure supply pump, that pressurize the low-pressure fuel drawn by the feed pump from the fuel tank 5 through a filter 6 and supplies the fuel to the common rail 1 under pressure through the high-pressure passage 11. A suction control valve (SCV) is disposed in an inlet passage of the pressurizing chamber of the supply pump 3. The suction control valve (SCV) operates as an electromagnetic actuator that changes the quantity of the fuel supply from the supply pump 3 to the common rail 1 by opening and closing the inlet passage.

[0017] The fuel that leaks from the injector 2 and the supply pump 3 is returned to the fuel tank 5 through the low-pressure passages 13, 14 and the low-pressure passage 15. A pressure limiter 7 disposed in the high-pressure passage 11 operates as a pressure relief valve that prevents a common rail pressure, that is, pressure in the common rail, from rising to an extraordinary level. Specifically, when the common rail pressure surpasses a predetermined pressure limit, the pressure limiter 7 releases the fuel into the low-pressure passage 15 by opening a valve member 16 against the biasing force of a spring 17 and reduces the fuel pressure under the limit pressure.

[0018] The ECU 10 has a microcomputer with a known construction. The microcomputer functions as a CPU that performs control transactions and calculation transactions. The microcomputer also has a ROM that stores various programs and data, a RAM, an input circuit, an output circuit, a power supply circuit, a pump driving circuit and the like. Sensor signals output by the various sensors are input to the microcomputer after the signals are converted from analog signals to digital signals by an A/D converter.

[0019] The ECU 10 has a common rail pressure controlling means that calculates a target common rail pressure that corresponds to an optimum fuel injection pressure suitable for operating conditions of the engine and controls the common rail pressure by regulating pump-driving signals that are transmitted to the suction control valve (SCV) of the supply pump 3. The common rail pressure controlling means has a target common rail pressure determining means, a pump driving means, and an SCV controlling means. The target common rail pressure determining means determines a target common rail pressure based on the engine rotation speed detected by a rotation speed sensor 21 and information on the operations of the engine. Operations include items such as the opening of the accelerator detected by an accelerator opening detection sensor 22 and adding a modification made with the temperature of the engine cooling water to the determination. The temperature of engine cooling water is detected by a cooling water temperature sensor 23. The pump driving means controls the common rail pressure by outputting the pump-driving signals to the suction control valve (SCV) of the supply pump 3 in order to attain the target common rail pressure.

[0020] More preferably, the pump-driving signals, driving current, to the suction control valve (SCV) of the supply pump 3 should be controlled in a feedback control so that an actual common rail pressure P_c , which is a common rail pressure detected by a common rail pressure detecting means (explained later), is generally equal to the target common rail pressure P_t , which is determined based on the operating conditions of the engine. Preferably, the control of the driving current to the suction control valve (SCV) should be controlled in a duty cycle control. Precise digital control is realized by employing the duty cycle control in which opening of the suction control valve (SCV) is changed by regulating an on-off ratio of the pump-driving signals per unit time, that is, the current supply ratio or the duty ratio.

[0021] The ECU 10 further comprises an injection quantity and timing controlling means that controls the quantity and timing of fuel injection of the injectors 2 of the respective cylinders. The injection quantity and timing controlling means is made up of an injection quantity and timing determining means, an injection pulse duration determining means, and an injector driving means or an INJ controlling means. The injection quantity and timing determining means determines optimum timing of the fuel injection, or timing to start the fuel injection, and target injection quantity, or injection period, in correspondence with the operating conditions of the engine. The injection pulse duration determining means calculates the injection pulse duration, or width of the pulse, corresponding to the operating conditions of the engine and the target injection quantity. The injector driving means applies injector (INJ) injection pulses to the injection controlling electromagnetic valves 4 of the respective cylinders through an injector driving circuit (EDU) 24.

[0022] The ECU 10 calculates the target injection quantity (Q) based on the engine rotation speed detected by the engine rotation speed sensor 21 and information on the operating conditions of the engine, such as accelerator opening (ACCP) detected by the accelerator opening sensor 22, with the modification made with the temperature of engine cooling water (THW) detected by the cooling water temperature sensor 23 added to the calculation. The engine rotation speed is referred to as an engine rotation number NE, hereafter. The ECU 10 applies injector (INJ) injection pulses to the injection controlling electromagnetic valves 4 of the injectors 2 of the respective cylinders in accordance with the injection pulse duration T_q calculated from the actual common rail pressure P_c detected by the common rail pressure detecting means (explained later) and the target injection quantity Q.

[0023] In the embodiment, the target injection quantity Q, the injection timing T, and the target common rail pressure P_t are calculated using the rotation speed sensor 21, the accelerator opening detection sensor 22 and the cooling water temperature sensor 23 as operating condition detecting means that detect the operating conditions of the engine. The target injection quantity Q, the injection timing T, and the target common rail pressure P_t may be modified by detection signals, or information on the operation of the engine, output from other kinds of sensors as the operating condition detecting means, such as a suction temperature sensor, a fuel temperature sensor, a suction pressure sensor, a cylinder determination sensor and an injection timing sensor.

[0024] The ECU 10 comprises the common rail detecting means that detects the actual common rail pressure P_c corresponding to the pressure of the fuel injected from the injectors 2 of the respective cylinders to the engine. The common rail pressure detecting means is a common rail pressure calculating circuit that averages electric signals of pressure, that is, sensor output values V_{c1} , V_{c2} output by first and second common rail pressure sensors S1 S2. The common rail pressure sensors S1, S2 are mounted in the common rail type fuel injection system, or in the right end of the common rail 1 as shown in FIG. 1. The common rail pressure detecting means calculates the actual common rail pressure P_c from the average value $(V_{c1}+V_{c2})/2$.

[0025] The first and second common rail pressure sensors S1 and S2 correspond to the fuel pressure sensors of the present invention. As shown in FIG. 2, a semiconductor pressure sensor in which a sensor detection part 31, such as a piezoresistance element, is formed on a silicon substrate (not shown), or a circuit substrate, is used as the common rail pressure sensor S1 or S2. The sensor detection part 31 is a main body of the common rail pressure sensor. The sensor detection part 31 is housed in a housing 33 formed with a male screw part 32 that is screwed to a female screw part in an attaching joint of the common rail 1. Thus, in the embodiment, each housing 33 includes each common rail pressure sensor.

[0026] The housing 33 has a concave part in its upper end and in the concave part is a sensor pressure detection part 34 as shown in FIG. 2. Also in the housing 33 is a high pressure introduction passage 35 which interconnects with an inside of an accumulator chamber formed in the common rail 1. Preferably, the sensor detection part 31 should be disposed on a metallic diaphragm because high-pressure fuel flows into the high pressure introduction passage 35. The semiconductor pressure sensor is a pressure sensor made by forming a diaphragm by manufacturing silicon single crystal and forming a strain gage resistor on the surface of the diaphragm by a diffusion process or an ion implantation process, among pressure sensors using piezo-resistance effect of semiconductor single crystal.

[0027] Characteristics of the common rail type fuel injection system according to the first embodiment will be explained below based on FIGS. 1 to 3. FIG. 3 is an explanatory diagram showing an example in which a standard characteristics range, or a range of tolerance, of a conventional common rail type pressure sensor is divided into two parts, wherein the common rail type pressure sensor is sufficient for shipping as a product. FIG. 3 shows a normal distribution, a Gaussian distribution, of outputs of "N" test pieces of the common rail pressure sensors, wherein "N" is more than 200, for instance. Table 1 shows variation in averaged tolerance in a case in which the common rail pressure sensor S1 in the range of the standard characteristics range A and the common rail pressure sensor S2 in the range of the standard characteristics range B are disposed in the common rail type fuel injection system. Table 1 also shows variation in averaged tolerance in a case in which the common rail pressure sensor S1 in the standard characteristics range B and the common rail pressure sensor S2 in the standard characteristics range A are disposed in the common rail type fuel injection system.

[0028] The common rail pressure sensor in the standard characteristics range A is a common rail pressure sensor that has such characteristics that an output voltage value V_c , corresponding to the fuel pressure when the fuel pressure is equal to the atmospheric pressure, and output voltage values V_c , corresponding to the minimum and maximum fuel pressures in a range of normal use of the fuel pressure as the common rail pressures, invariably fall in a range below a basic characteristic output of the common rail pressure sensor, more specifically, in a range from $-a$ to 0.

[0029] The common rail pressure sensor in the standard characteristics range B is a common rail pressure sensor that has such characteristics that an output voltage value V_c , corresponding to the fuel pressure when the fuel pressure is equal to the atmospheric pressure, and output voltage values V_c , corresponding to the minimum and maximum fuel pressures in the range of normal use of the fuel pressure as the common rail pressure, invariably fall in a range above a basic characteristic output of the common rail pressure sensor, more specifically, in a range from 0 to $+\alpha$.

[Table 1]

Pairing		1	2
Sensor			
S1		A	B
S2		B	A
Variation after averaging		± 0.5	± 0.5
Formula for Averaging: $(V_{c1}+V_{c2})/2$			

[0030] In the embodiment, a pair of the common rail pressure sensor S1 in the characteristics standard A and the common rail pressure sensor S2 in the characteristics standard B, or a pair of the common rail pressure sensor S1 in the characteristics standard B and the common rail pressure sensor S2 in the characteristics standard A are disposed in the common rail type fuel injection system. The actual common rail pressure P_c is calculated in the ECU 10 by averaging

the electric signals output by the common rail pressure sensors S1 and S2, that is, sensor output values V_{c1} and V_{c2} . Therefore, when the standard characteristics range of the conventional common rail pressure sensor is ± 1 , the range of the tolerance variation in the averaged actual common rail pressure P_c is ± 0.5 , which is half of the conventional value.

[0031] FIG. 4 is an explanatory diagram showing an example, not according to the invention, in which a characteristics standard, or a range of tolerance, of a conventional common rail type pressure sensor is divided into three parts, wherein the common rail type pressure sensor is good enough for shipping as a product. FIG. 4 shows a normal distribution, a Gaussian distribution, of outputs of test pieces of "N" pieces of the common rail pressure sensors, wherein "N" is more than 200, for instance.

[0032] Table 2 shows variation in averaged tolerance in a case in which the common rail pressure sensor S1 in the range of characteristics standard A and the common rail pressure sensor S2 in the range of characteristics standard C are disposed in the common rail type fuel injection system. Table 2 also shows variation in averaged tolerance in a case in which the common rail pressure sensor S1 in the range of characteristics standard C and the common rail pressure sensor S2 in the range of characteristics standard A are disposed in the common rail type fuel injection system. Table 2 also shows variation in averaged tolerance in a case in which the common rail pressure sensor S1 in the range of characteristics standard B and the common rail pressure sensor S2 in the range of characteristics standard B are disposed in the common rail type fuel injection system.

[0033] The common rail pressure sensor in the standard characteristics range A is a common rail pressure sensor that has such characteristics that an output voltage value V_c , corresponding to the fuel pressure when the fuel pressure is equal to the atmospheric pressure, and output voltage values V_c , corresponding to the minimum and maximum fuel pressures in a range of normal use of the fuel pressure as the common rail pressure, invariably fall in a range below a basic characteristic output of the common rail pressure sensor, more specifically, in a range from $-\alpha$ to $-\alpha/3$.

[0034] The common rail pressure sensor in the standard characteristics range B is a common rail pressure sensor that has such characteristics that an output voltage value V_c , corresponding to the fuel pressure when the fuel pressure is equal to the atmospheric pressure, and output voltage values V_c , corresponding to the minimum and maximum fuel pressures in a range of normal use of the fuel pressure as the common rail pressure, invariably fall in a range near a basic characteristic output of the common rail pressure sensor, more specifically, in a range from $-\alpha/3$ to $+\alpha/3$.

[0035] The common rail pressure sensor in the standard characteristics range C is a common rail pressure sensor that has such characteristics that an output voltage value V_c , corresponding to the fuel pressure when the fuel pressure is equal to the atmospheric pressure, and output voltage values V_c , corresponding to the minimum and maximum fuel pressures in a range of normal use of the fuel pressure as the common rail pressure, invariably fall in a range above a basic characteristic output of the common rail pressure sensor, more specifically, in a range from $+\alpha/3$ to $+\alpha$.

[Table 2]

Pairing	1	2	3
Sensor			
S1	A	C	B
S2	C	A	B
Variation after averaging	± 0.33	± 0.33	± 0.33
Formula for Averaging: $(V_{c1}+V_{c2})/2$			

[0036] In the embodiment, a pair of the common rail pressure sensors, S1 in the characteristics standard A and the common rail pressure sensor S2 in the characteristics standard C, or a pair of the common rail pressure sensors, S1 in the characteristics standard C and the common rail pressure sensor S2 in the characteristics standard A, or a pair of the common rail pressure sensors, S1 in the characteristics standard B and the common rail pressure sensor S2 in the characteristics standard B, are disposed in the common rail type fuel injection system. The actual common rail pressure P_c is calculated in the ECU 10 by averaging the electric signals output by the common rail pressure sensors S1 and S2, that is, the sensor output values V_{c1} and V_{c2} . Therefore, when the standard characteristics range of the conventional common rail pressure sensor is ± 1 , the range of the tolerance variation in the averaged actual common rail pressure P_c is ± 0.33 , which is one third of the conventional value. In this case, it is appropriate to dispose a common rail pressure sensor in the characteristics standard A, a common rail pressure sensor in the characteristics standard B, and a common rail pressure sensor in the characteristics standard C in the common rail 1 or in the high-pressure passages.

[0037] FIG. 5 is an explanatory diagram showing an example, not according to the invention, in which a characteristics standard, or a range of tolerance, of a conventional common rail type pressure sensor is divided into four parts, wherein the common rail type pressure sensor is of a quality suitable for shipping as a product. FIG. 5 shows a normal distribution, a Gaussian distribution, of outputs of test pieces of "N" pieces of the common rail pressure sensors, wherein "N" is more

than 200, for instance. Table 3 shows variation in averaged tolerance in a case in which the common rail pressure sensor S1 in the range of characteristics standard A and the common rail pressure sensor S2 in the range of characteristics standard D are disposed in the common rail type fuel injection system. Table 3 also shows variation in averaged tolerance in a case in which the common rail pressure sensor S1 in the range of characteristics standard D and the common rail pressure sensor S2 in the range of characteristics standard A are disposed in the common rail type fuel injection system. Additionally, Table 3 shows variation in averaged tolerance in a case in which the common rail pressure sensor S1 in the range of characteristics standard B and the common rail pressure sensor S2 in the range of characteristics standard C are disposed in the common rail type fuel injection system. Table 3 also shows variation in averaged tolerance in a case in which the common rail pressure sensor S1 in the range of characteristics standard C and the common rail pressure sensor S2 in the range of characteristics standard B are disposed in the common rail type fuel injection system.

[0038] The common rail pressure sensor in the standard characteristics range A is a common rail pressure sensor that has such characteristics that an output voltage value V_c , corresponding to the fuel pressure when the fuel pressure is equal to the atmospheric pressure, and output voltage values V_c , corresponding to the minimum and maximum fuel pressures in a range of normal use of the fuel pressure as the common rail pressure, invariably falls in a range below a basic characteristic output of the common rail pressure sensor, more specifically, in a range from $-\alpha$ to $-\alpha/2$.

[0039] The common rail pressure sensor in the standard characteristics range B is a common rail pressure sensor that has such characteristics that an output voltage value V_c , corresponding to the fuel pressure when the fuel pressure is equal to the atmospheric pressure, and output voltage values V_c , corresponding to the minimum and maximum fuel pressures in a range of normal use of the fuel pressure as the common rail pressure, invariably fall in a range below a basic characteristic output of the common rail pressure sensor, more specifically, in a range from $-\alpha/2$ to 0.

[0040] The common rail pressure sensor in the standard characteristics range C is a common rail pressure sensor that has such characteristics that an output voltage value V_c , corresponding to the fuel pressure when the fuel pressure is equal to the atmospheric pressure, and output voltage values V_c , corresponding to the minimum and maximum fuel pressures in a range of normal use of the fuel pressure as the common rail pressure, invariably fall in a range above a basic characteristic output of the common rail pressure sensor, more specifically, in a range from 0 to $+\alpha/2$.

[0041] The common rail pressure sensor in the standard characteristics range D is a common rail pressure sensor that has such characteristics that an output voltage value V_c , corresponding to the fuel pressure when the fuel pressure is equal to the atmospheric pressure, and output voltage values V_c , corresponding to the minimum and maximum fuel pressures in a range of normal use of the fuel pressure as the common rail pressure, invariably fall in a range above a basic characteristic output of the common rail pressure sensor, more specifically, in a range from $+\alpha/2$ to $+\alpha$.

[Table 3]

Pairing	1	2	3	4
Sensor				
S1	A	D	B	C
S2	D	A	C	B
Variation after averaging	± 0.25	± 0.25	± 0.25	± 0.25
Formula for Averaging: $(V_{c1}+V_{c2})/2$				

[0042] In the embodiment, a pair of the common rail pressure sensors, S1 in the characteristics standard A and the common rail pressure sensor S2 in the characteristics standard D, or a pair of the common rail pressure sensors, S1 in the characteristics standard D and the common rail pressure sensor S2 in the characteristics standard A, or a pair of the common rail pressure sensors, S1 in the characteristics standard B and the common rail pressure sensor S2 in the characteristics standard C, or a pair of the common rail pressure sensors, S1 in the characteristics standard C and the common rail pressure sensor S2 in the characteristics standard B, are disposed in the common rail type fuel injection system.

[0043] The actual common rail pressure P_c is calculated in the ECU 10 by averaging the electric signals output by the common rail pressure sensors S1 and S2, that is, the sensor output values V_{c1} and V_{c2} . Therefore, when the characteristics standard of the conventional common rail pressure sensor is ± 1 , the range of the tolerance variation in the averaged actual common rail pressure P_c is ± 0.25 , which is one fourth of the conventional value. In this case, it is appropriate to dispose a common rail pressure sensor in the characteristics standard A, a common rail pressure sensor in the characteristics standard B, a common rail pressure sensor in the characteristics standard C and a common rail pressure sensor in the characteristics standard D in the common rail 1 or in the high-pressure passages. In the above explanation, examples of dividing the characteristics standard of the sensor into two, three, or 4 parts are described. Thresholds of the characteristics standards of the sensor may be changed in compliance with the desired characteristics

of the sensor.

[0044] As explained above, the common rail type fuel injection system, according to the embodiment, possesses a plurality of common rail pressure sensors, that is, two common rail pressure sensors S1 and S2, as described in the embodiment. The characteristics standards of the common rail pressure sensors S1 and S2 are divided into two parts or more, respectively. The ECU 10 calculates the actual common rail pressure P_c corresponding to the fuel injection pressure by averaging the electric signals output by the common rail pressure sensors S1 and S2 that are within the respective characteristics standards, which are divided into two or more parts.

[0045] The detection accuracy of the common rail sensors S1 and S2 improves as the dividing number of the characteristics standard and the range of tolerance of the conventional common rail pressure sensor is raised. Thus, the detection accuracy of the actual common rail pressure P_c is improved without increasing the extraction (failure) rate of the common rail sensors S1 and S2. Therefore, the injection pulse duration T_q , which is calculated based on the target injection quantity set in accordance with the actual common rail pressure P_c and the operating conditions of the engine, is set to an optimum value corresponding to the actual common rail pressure P_c . Accordingly, the variation in the quantity of the fuel injected from the injectors 2 is reduced and the fuel injection accuracy is improved without requiring substantial alterations in the conventional common rail type fuel injection system.

[0046] The detection accuracy of the actual common rail pressure P_c is improved without increasing the extraction (failure) rate of the common rail sensors S1 and S2. Therefore, the on-off ratio of the pump driving signal to the suction control valve (SCV) of the supply pump 3, that is, the ratio of the current supply duration or the duty ratio, is set to an optimum value. The pump driving signal is calculated based on the pressure difference between the actual common rail pressure P_c and the target common rail pressure P_t set in accordance with the operating conditions of the engine. As a result, any variation in the quantity of the fuel supplied by the supply pump 3 is reduced and the accuracy of the fuel supply, or the accuracy of the fuel supply under pressure, is improved without requiring substantial alterations in the conventional common rail type fuel injection system. In addition, since the extraction (failure) rate of the common rail pressure sensors S1 and S2 is not raised, productivity of the common rail pressure sensor is improved and manufacturing costs are reduced.

(Second Embodiment)

[0047] FIG. 6 shows construction of a common rail pressure sensor according to the second embodiment of the present invention. In the embodiment, a semiconductor pressure sensor is used as the common rail pressure sensor. The pressure sensor exhibits a sensor chip 42, which is a main body of a common rail pressure sensor, such as a piezoresistance element, and a transaction circuit 43 formed on a silicon substructure 41 as a circuit substructure. The common rail pressure sensor is housed in a housing 45, which is usually a steel case, that is formed with a male screw part 44 that screws into a female screw part 19, as an attaching joint, of a common rail 1.

[0048] The housing 45 is formed with a sensor pressure detection part 46 in the housing upper end as shown in FIG. 6. In the sensor pressure detection part 46, a screw 48 that holds a metallic diaphragm 47 in the center of the sensor pressure detection part 46 is screwed and fastened to a female screw part 49. The sensor chip 42 is disposed on the diaphragm 47. The housing 45 is formed with a high pressure introduction passage 50 that connects with an interior accumulator chamber formed in the lower portion of the common rail 1 as shown in FIG. 6.

[0049] Moreover, the diaphragm 47 is formed with an interconnecting passage 51 that interconnects with the high pressure introduction passage 50. In the common rail pressure sensors S1 and S2, the lower end surface of the housing 45 in FIG. 6 and a seating surface 20 of the common rail 1 seal by the contact of the metal surfaces. Likewise, the lower end surface of the metal diaphragm 47 in FIG. 6 and a seating surface 52 of the housing 45 also seal by contact. A connector 53 is made of electrical insulating plastic and is fastened to the upper end of the housing 45 in FIG. 6 by press-fitting and the like. A terminal 54 electrically connects the ECU 10 and the sensor chip 42 through a wiring harness (W/H).

(Third Embodiment)

[0050] FIG. 7 shows construction of a common rail pressure sensor according to the third embodiment of the present invention. In the embodiment, a semiconductor pressure sensor in which two sensor detection parts 61, 62, which are main bodies of a common rail pressure sensor such as piezoresistance elements, are formed on a silicon substructure as a circuit substructure, is used as the common rail pressure sensor. The common rail pressure sensors are housed in a housing 64, commonly a steel case, that is formed with a male screw part 63 that is screwed to a female screw part in an attaching joint of a common rail 1. The upper portion of the housing 64 has a sensor pressure detection part 65 as shown in FIG. 7. The housing 64 is formed with two high pressure introduction passages 66, 67 that interconnect with an inside of an accumulator chamber formed in the common rail 1 in the lower portion of the housing 64 as shown in FIG. 7. More specifically, a plurality of common rail pressure sensors is integrated by disposing the plurality, two

common rail pressure sensors in the embodiment, in one housing 64. Therefore, space for installation, labor hours for assembling, and the number of parts are reduced.

(Modified Examples)

[0051] In the embodiments, examples in which two common rail pressure sensors are disposed in the common rail type fuel injection system, especially in the common rail 1, are explained. Alternatively, not according to the invention three or more common rail pressure sensors may be disposed in the common rail type fuel injection system.

[0052] In the embodiments, the common rail pressure sensors S1 and S2 are disposed directly in the common rail 1 and output electric signals corresponding to the actual common rail pressure P_c suitable for the fuel injection pressure. Alternatively, a construction is possible in which fuel pressure sensors are disposed in a fuel pipe and the like between the plunger chamber, which is the pressurizing chamber, of the supply pump 3 and fuel passages in the injectors 2. The fuel pressure sensors output electric signals that correspond to the pressure value of the fuel discharged from the pressurizing chamber of the supply pump 3 or the fuel injection pressure of the fuel injected from the injectors 2.

[0053] In the embodiments, examples in which the semiconductor pressure sensor is used as the common rail pressure sensor or the fuel pressure sensor are explained. Alternatively, a pressure sensor in which a first conversion element that generates a displacement or strain proportional to fuel pressure and a second conversion element that converts the displacement or the strain into electric signals are combined may be applied as the common pressure sensor or the fuel pressure sensor. Such a pressure sensor is a differential transformer pressure sensor, a strain gage pressure sensor, or an electric capacitance pressure sensor, for instances. In the semiconductor pressure sensor, the first conversion element and the second conversion element are integrated. Therefore, an adhesive layer and a base film layer are not formed differently from the strain gage pressure sensor. In addition, the semiconductor pressure sensor has no or little hysteresis because the first conversion elastic body thereof is a covalent crystal having a diamond structure.

Claims

1. A common rail fuel injection system that accumulates high-pressure fuel in a common rail (1) under a pressure corresponding to fuel injection pressure and delivers the high-pressure fuel accumulated in the common rail (1) to a plurality of fuel injection valves (4) mounted in respective cylinders of an engine, and that supplies the high-pressure fuel from the plurality of fuel injection valves (4) to the respective cylinders of the engine by injection, the common rail fuel injection system comprising:

a common rail pressure detecting means that includes two fuel pressure sensors (S1, S2) disposed in the common rail fuel injection system,

characterized in that

the common rail pressure detecting means is adapted to detect a common rail pressure corresponding to the fuel injection pressure by averaging two fuel pressure signals respectively output by the two fuel pressure sensors (S1, S2), wherein the two fuel pressure sensors (S1, S2) include two characteristics standards (A, B) or ranges of tolerance that are divided by a basic characteristic output of the fuel pressure sensor and different from each other.

2. The common rail fuel injection system set forth in claim 1, further comprising:

a fuel injection quantity controlling means that controls a fuel injection quantity to the respective cylinders of the engine by determining an injection period based on a target injection quantity set in correspondence with operating conditions of the engine and the common rail pressure detected by the common rail pressure detecting means and by outputting driving signals corresponding to the determined injection period to the plurality of fuel injection valves (4),

characterized in that the fuel injection valves (4) are injectors that have fuel injection nozzles (2) for injecting fuel into the respective cylinders of the engine and actuators for driving the fuel injection nozzles to opening directions.

3. The common rail type fuel injection system set forth in claim 2, further comprising:

a fuel supply pump (3) that pressurizes the fuel to a high pressure and supplies the fuel to the common rail (1) under pressure; and
a common rail pressure controlling means that controls the common rail pressure by determining the fuel quantity

to supply to the common rail (1) by the fuel supply pump (3) based on the common rail pressure detected by the common rail pressure detecting means and by outputting driving signals corresponding to the fuel quantity to the fuel supply pump (3).

4. The common rail fuel injection system set forth in any one of claims 1 to 3, wherein the two fuel sensors (S1, S2) are disposed integrally in a housing mounted in the common rail (1).

Patentansprüche

1. Common Rail Kraftstoffeinspritzsystem, das mit Hochdruck beaufschlagten Kraftstoff in einer Common Rail (1) unter einem Druck korrespondierend zu einem Kraftstoffeinspritzdruck ansammelt und den mit Hochdruck beaufschlagten Kraftstoff, der in der Common Rail (1) angesammelt ist, zu einer Vielzahl von Kraftstoffeinspritzventilen (4) liefert, die in entsprechenden Zylindern eines Motors montiert sind, und das den mit Hochdruck beaufschlagten Kraftstoff von der Vielzahl von Kraftstoffeinspritzventilen (4) zu den entsprechenden Zylindern des Motors durch Einspritzung zuführt, wobei das Common Rail Kraftstoffeinspritzsystem:

eine Common Rail Druckerfassungseinrichtung hat, die zwei Kraftstoffdrucksensoren (S1, S2) hat, die in dem Common Rail Kraftstoffeinspritzsystem angeordnet sind,

dadurch gekennzeichnet, dass

die Common Rail Druckerfassungseinrichtung angepasst ist, um einen Common Rail Druck korrespondierend zu dem Kraftstoffeinspritzdruck durch Mitteln zweier Kraftstoffdrucksignale, die jeweils durch die zwei Kraftstoffdrucksensoren (S1, S2) ausgegeben werden, zu erfassen, wobei die zwei Kraftstoffdrucksensoren (S1, S2) zwei Eigenschaftensstandards (A, B) oder Toleranzbereiche haben, die durch einen Grundeigenschaftsausgang des Kraftstoffdrucksensors geteilt sind und voneinander unterschiedlich sind.

2. Common Rail Kraftstoffeinspritzsystem nach Anspruch 1, ferner mit:

einer Kraftstoffeinspritzmengesteuereinrichtung, die eine Kraftstoffeinspritzmenge zu den jeweiligen Zylindern des Motors durch Bestimmen eines Einspritzzeitraums auf der Grundlage einer Solleinspritzmenge, die korrespondierend zu Betriebsbedingungen des Motors und des Common Rail Drucks gesetzt ist, der durch die Common Rail Druckerfassungseinrichtung erfasst wird, und durch Ausgeben von Antriebssignalen korrespondierend zu dem bestimmten Einspritzzeitraum zu der Vielzahl von Kraftstoffeinspritzventilen (4) steuert,

dadurch gekennzeichnet, dass die

Kraftstoffeinspritzventile (4) Injektoren sind, die Kraftstoffeinspritzdüsen (2) zum Einspritzen von Kraftstoff in die jeweiligen Zylinder des Motors und Stellglieder zum Antreiben der Kraftstoffeinspritzdüsen in Öffnungsrichtungen haben.

3. Common Rail Kraftstoffeinspritzsystem nach Anspruch 2, ferner mit:

einer Kraftstoffzufuhrpumpe (3), die den Kraftstoff auf einen hohen Druck mit Druck beaufschlagt und den Kraftstoff zu der Common Rail (1) unter Druck zuführt; und
einer Common Rail Drucksteuereinrichtung, die den Common Rail Druck durch Bestimmen der Kraftstoffmenge, die durch die Kraftstoffzufuhrpumpe (3) zu der Common Rail (1) zugeführt wird, auf der Grundlage des Common Rail Drucks, der durch die Common Rail Druckerfassungseinrichtung erfasst wird, und durch Ausgeben von Antriebssignalen korrespondierend zu der Kraftstoffmenge zu der Kraftstoffzufuhrpumpe (3) steuert.

4. Common Rail Kraftstoffeinspritzsystem nach einem der Ansprüche 1 bis 3, wobei die zwei Kraftstoffsensoren (S1, S2) integral in einem Gehäuse angeordnet sind, das in der Common Rail (1) montiert ist.

Revendications

1. Un système d'injection de carburant à rampe commune qui accumule du carburant à haute pression dans une rampe commune (1) sous une pression correspondant à une pression d'injection de carburant, et distribue le carburant à haute pression accumulé dans la rampe commune (1) à une multiplicité de soupapes d'injection de carburant

(4) montées dans des cylindres respectifs d'un moteur, et qui fournit aux cylindres respectifs du moteur, par injection, le carburant à haute pression provenant de la multiplicité de soupapes d'injection de carburant (4), le système d'injection de carburant à rampe commune comprenant :

5 un moyen de détection de pression de rampe commune qui comprend deux capteurs de pression de carburant (S1, S2) disposés dans le système d'injection de carburant à rampe commune,

caractérisé en ce que

10 le moyen de détection de pression de rampe commune est adapté pour détecter une pression de rampe commune correspondant à la pression de carburant en faisant la moyenne de deux signaux de pression de carburant qui sont respectivement émis par les deux capteurs de pression de carburant (S1, S2), les deux capteurs de pression de carburant (S1, S2) incluant deux catégories de caractéristiques (A, B) ou plages de tolérance, qui sont séparées par une caractéristique de sortie de base du capteur de pression de carburant et sont mutuellement différentes.

15 **2.** Le système d'injection de carburant à rampe commune selon la revendication 1, comprenant en outre :

un moyen de commande de quantité d'injection de carburant qui commande une quantité d'injection de carburant pour les cylindres respectifs du moteur en déterminant une période d'injection sur la base d'une quantité d'injection de carburant cible fixée en correspondance avec des conditions de fonctionnement du moteur, et de la pression de rampe commune détectée par le moyen de détection de pression de rampe commune, et en émettant vers la multiplicité de soupapes d'injection de carburant (4) des signaux d'attaque correspondant à la période d'injection déterminée,

25 **caractérisé en ce que** les soupapes d'injection de carburant (4) sont des injecteurs qui ont des buses d'injection de carburant (2) pour injecter du carburant dans les cylindres respectifs du moteur, et des actionneurs pour déplacer les buses d'injection de carburant dans des directions d'ouverture.

3. Le système d'injection de carburant du type à rampe commune selon la revendication 2, comprenant en outre :

30 une pompe d'alimentation en carburant (3) qui pressurise le carburant à une pression élevée et fournit le carburant sous pression à la rampe commune (1); et
un moyen de commande de pression de rampe commune qui commande la pression de rampe commune en déterminant la quantité de carburant à fournir à la rampe commune (1) par la pompe d'alimentation en carburant (3), sur la base de la pression de rampe commune détectée par le moyen de détection de pression de rampe commune et en émettant vers la pompe d'alimentation en carburant (3) des signaux d'activation correspondant à la quantité de carburant.

40 **4.** Le système d'injection de carburant à rampe commune selon l'une quelconque des revendications 1 à 3, dans lequel les deux capteurs de carburant (S1, S2) sont disposés de manière intégrée dans un boîtier monté dans la rampe commune (1).

FIG. 1

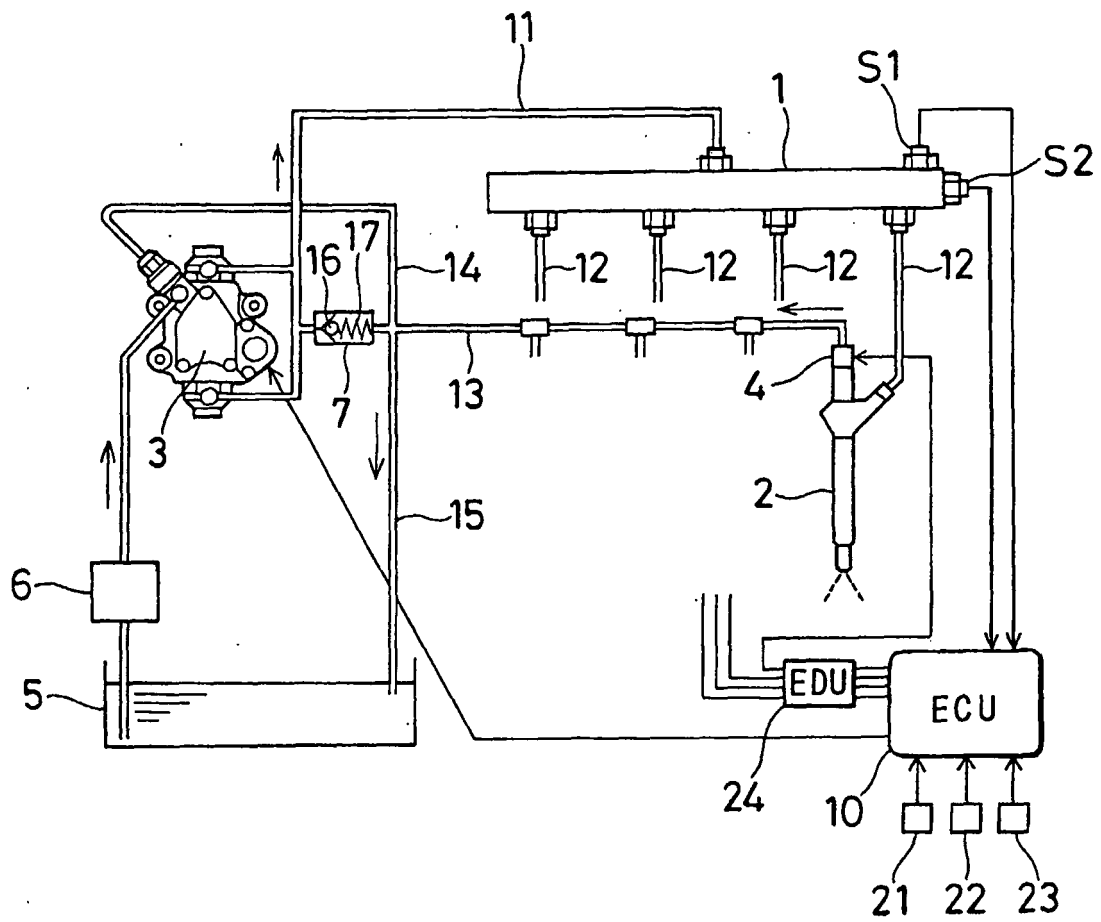


FIG. 2

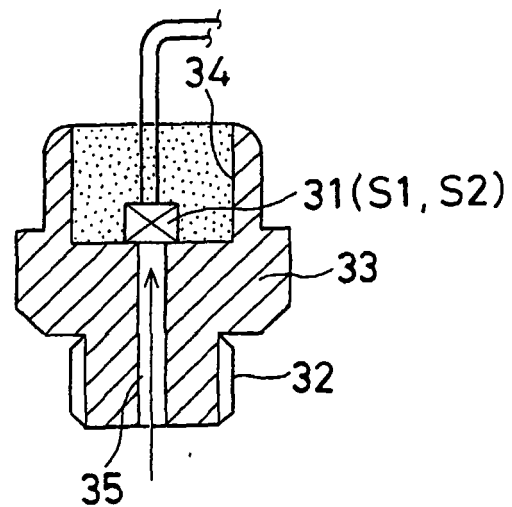


FIG. 3

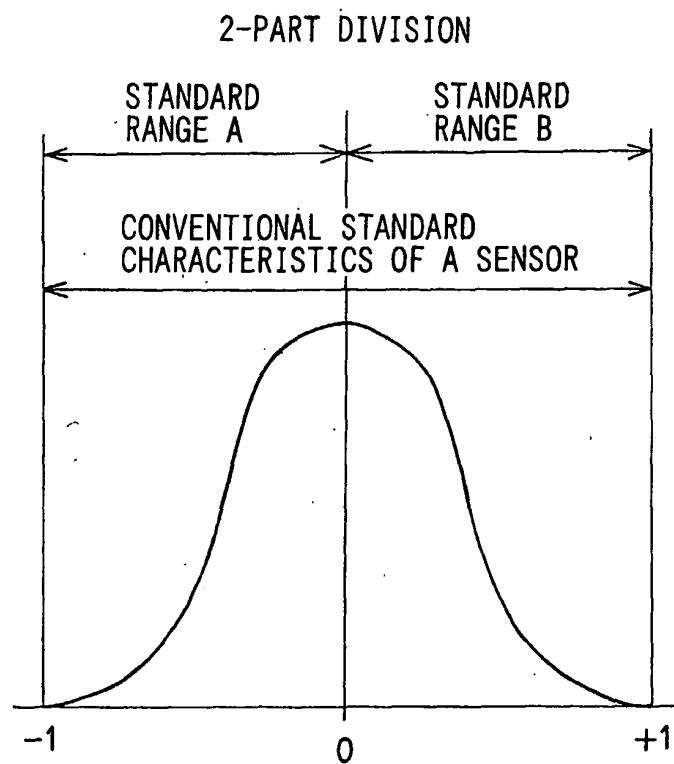


FIG. 4

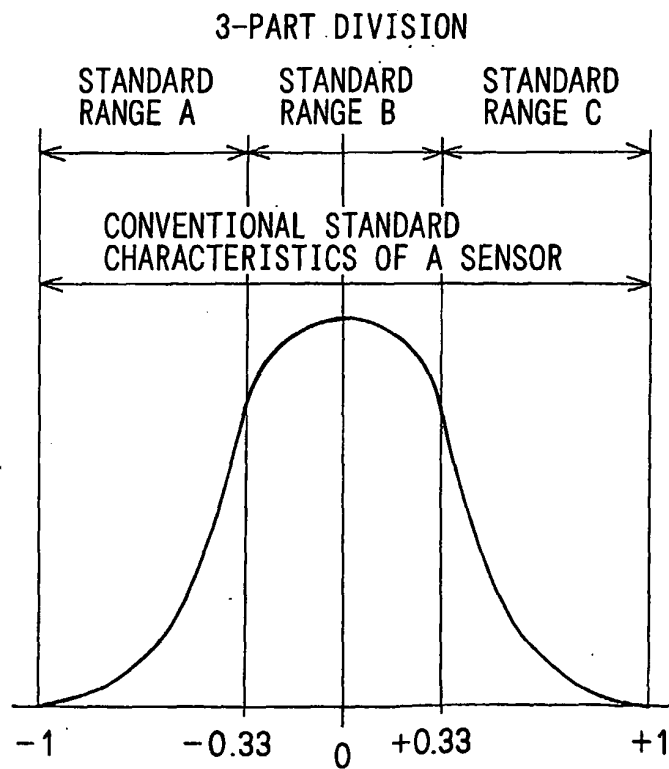


FIG. 5

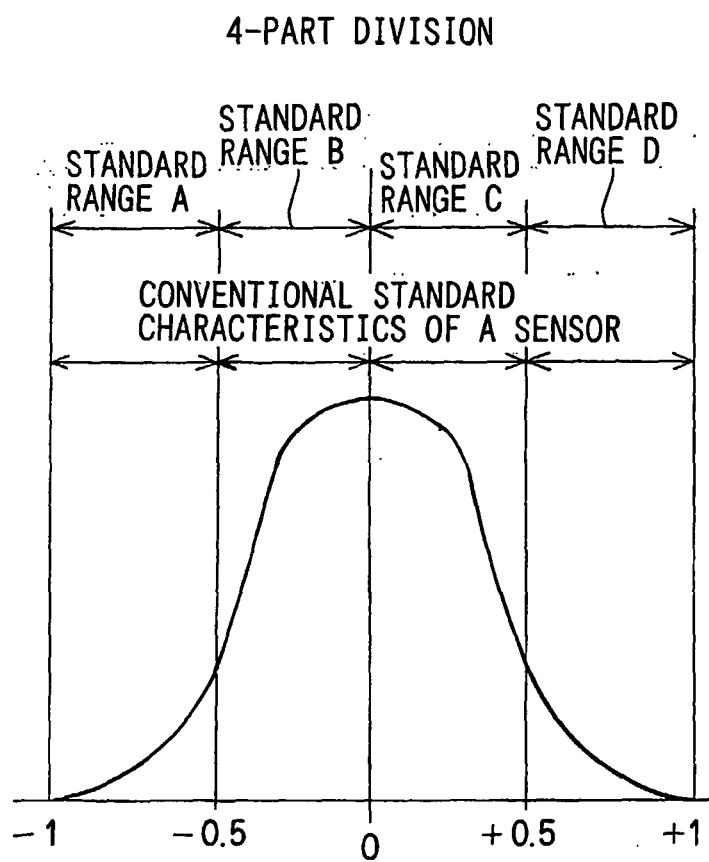


FIG. 6

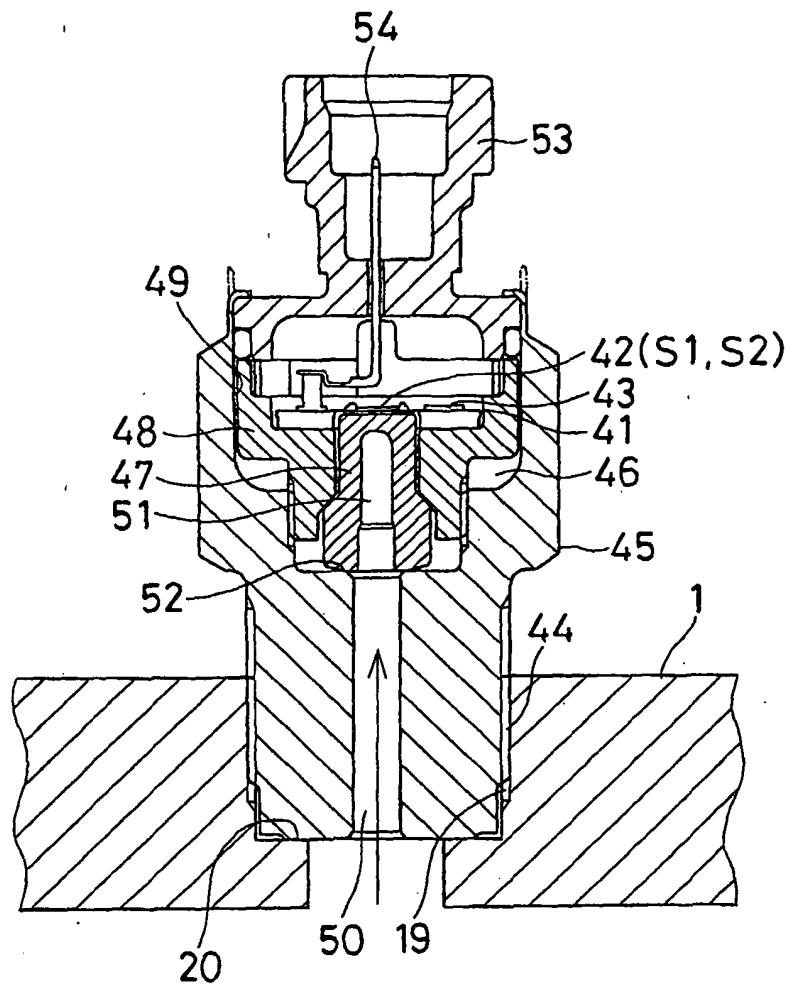


FIG. 7

