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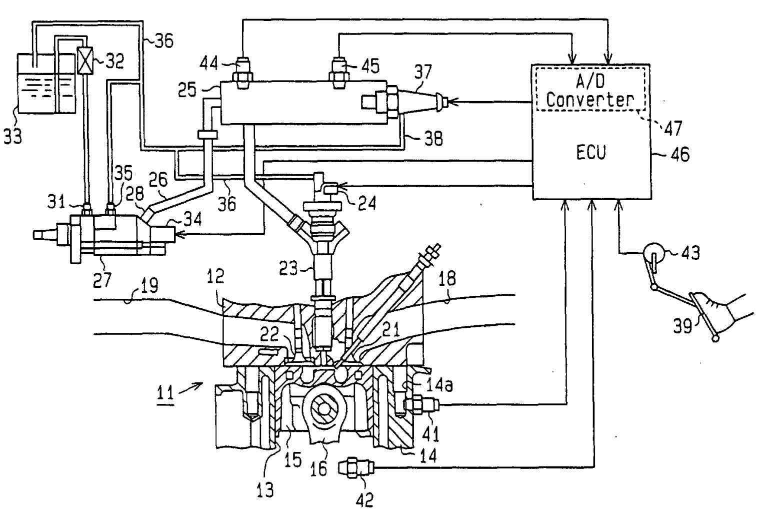
(54) FUEL INJECTION CONTROLLER

(57) A fuel injection control device is provided with a plurality of pressure sensors 44 and 45 that individually detect pressures of fuel in a common rail 25 and an electronic control unit (ECU) 46. When respective detected values of two fuel pressure sensors 44 and 45 are in a normally-possible range and when the deviation of the two detected values is smaller than a given determination value, the ECU 46 sets the higher detected value as the fuel pressure. The ECU 46 obtains an injection period based upon a fuel injection amount that is set in accordance with an operating state of an engine 11 and the fuel pressure, and controls fuel injection valves 23 so as to inject the fuel during the injection period.

Fig.1



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Description

Technical Field

[0001] The present invention relates to a fuel injection control device which is installed in an engine in which pressurized fuel is distributed to a plurality of fuel injection valves through fuel distribution pipes and injected therefrom, and which detects pressures of fuel in the fuel distribution pipes by a plurality of fuel pressure sensors so that at least either of the injection amount or injection pressure of the fuel is controlled based upon the detected values.

Background Art

[0002] Diesel engines in which fuel is compressed by a fuel pump to have a high pressure have been known. In such a diesel engine, the fuel is distributed by fuel distribution pipes, that is, common rails, to fuel injection valves of individual cylinders so that the fuel is injected by opening the fuel injection valves. One of the engine fuel injection control techniques has an arrangement in which the pressure of the fuel in the common rails is detected by a single fuel pressure sensor so that the injection amount and injection pressure of the fuel from the fuel injection valves are controlled based upon the detected value.

[0003] In the above-mentioned fuel injection control, when the detected value of the fuel pressure sensor is out of a normally-possible range, it is possible to know that the fuel pressure sensor is abnormal. Therefore, in this case, it is possible to carry out an appropriate fail treatment in the injection amount control and injection pressure control of the fuel. However, in the event of a characteristic abnormality in the fuel pressure sensor, it is difficult to detect this fact and deal with the abnormality. The characteristic abnormality refers to a phenomenon in which, although the detected value of the fuel pressure sensor is within the normally-possible range, it is different from the normal output characteristic. For example, in the case of a fuel pressure sensor that outputs a voltage that is in proportion to the pressure, it refers to a phenomenon in which, although the gradient of the characteristic is the same as the gradient at the normal time, it deviates therefrom, or a phenomenon in which the gradient of the characteristic is different from the gradient at the normal time. In this case, it is difficult to discriminate a characteristic abnormality from the normal state.

[0004] Therefore, conventionally, a technique in which the pressures of fuel in the common rails are detected by a plurality of fuel pressure sensors, and a characteristic abnormality of the fuel pressure sensor is detected by using these detected values (for example, see Japanese Unexamined Patent Publication No. Hei 8-61133) has been known. In this technique, based upon the fact that when all the fuel pressure sensors are normal, the detected values (fuel pressures) of these are approximately the same, when, with respect to predetermined two fuel pressure sensors, the deviation of these detected values (fuel pressures) is greater than a given determination value, either of the fuel pressure sensors is determined to be abnormal in characteristic.

[0005] However, even when the individual fuel pressure sensors are normal, there are some variations in these output characteristics. For this reason, unless the above-mentioned determining process is carried out by using a determination value in which the variations have been taken into consideration, the deviation of the fuel pressures becomes greater than the determination value, causing that a normal fuel pressure sensor is erroneously detected as abnormal in character. Therefore, in order to prevent this erroneous detection due to variations, the determination value is set to be a greater value to a certain degree. With this arrangement, when the deviation of the detected values is particularly great, by determining that either of the fuel pressure sensors is clearly abnormal in characteristic, it is possible to detect the abnormality.

[0006] However, a small deviation does not necessarily show that all the fuel pressure sensors are normal. Although not clearly determined, there still remains a possibility that one of the fuel pressure sensors is abnormal in characteristic. In this case, the deviation becomes smaller than the determination value, and there might be a failure in detecting abnormality in characteristic. In this manner, when the deviation is smaller than the determination value, since it is not clear whether or not there is an abnormality in characteristic, the resulting problem is that it is difficult to carry out an appropriate fail-safe treatment on the injection amount control and injection pressure control of fuel.

[0007] The present invention has been devised so as to solve the above-mentioned problems, and its objective is to provide a fuel injection control device which can carry out a fail-safe treatment appropriately even when fuel pressures detected by a plurality of fuel pressure sensors are in a normally-possible range, and when the deviation of fuel pressures detected by the predetermined two fuel pressure sensors is smaller than a given determination value.

Disclosure of the Invention

[0008] The following description will discuss means for achieving the above-mentioned objective and the operation thereof.

[0009] In one aspect of the present invention, a fuel injection control device is provided with a plurality of fuel pressure sensors that are installed in fuel distribution pipes that distribute pressurized fuel to a plurality of fuel injection valves of an engine, and individually detect pressures of the fuel in the fuel distribution pipes, fuel pressure setting means which sets a fuel pressure to be used as a controlling parameter based upon the detected value of each of the fuel pressure sensors, and fuel injection control means which obtains an injection period based upon a fuel injection amount set in accordance with an operating state of the engine and the fuel pressure set by the fuel pressure setting means, and controls the above-mentioned fuel injection valves so as to inject the fuel during the injection period, wherein, when detected values of the predetermined two fuel pressure sensors are each in a normally-possible range and when the deviation of the two detected values is smaller than a given determination value, the above-mentioned fuel pressure setting means sets the higher detected value as the above-mentioned fuel pressure used for calculating the above-mentioned injection period by the above-mentioned fuel injection control means.

[0010] With the above-mentioned arrangement, the pressures of fuel in the fuel distribution pipes are individually detected by a plurality of fuel pressure sensors. When both of the predetermined two fuel pressure sensors are normal, the detected values therefrom are supposed to be approximately the same value. The fuel pressure setting means sets a fuel pressure based upon the detected value from each of the fuel pressure sensors. The fuel injection control means obtains an injection period based upon a fuel injection amount in accordance with an operating state of the engine and the fuel pressure. The injection period becomes shorter as the fuel pressure becomes higher when the fuel injection amount is the same. Moreover, the fuel injection control means controls the fuel injection valves so as to inject fuel during the injection period.

[0011] Supposing that, of the detected values of two fuel pressure sensors, the higher detected value is correct and the lower detected value is incorrect, and that the latter detected value is set as the fuel pressure by the fuel pressure setting means, the injection period, which is determined by the fuel injection amount and fuel pressure, becomes longer than the injection period that should be determined. For this reason, when fuel is injected during the set period, an amount of fuel greater than the fuel that should be injected is injected.

[0012] In contrast, supposing that the higher detected value is incorrect and the lower detected value is correct, and that the former detected value is set as the fuel pressure by the fuel pressure setting means, the injection period, which is determined by the fuel injection amount and fuel pressure, becomes shorter than the injection period that should be determined. For this reason, when fuel is injected during the set period, an amount of fuel smaller than that should be injected is injected.

[0013] However, in one aspect of the present invention, when individually detected values of predetermined two fuel pressure sensors are in a normally-possible range and when the deviation of the two detected values is smaller than a given determination value, since there still remains a possibility that either of the fuel pressure sensors might be abnormal in characteristic although it is not clearly determined in comparison with the case where the deviation is greater than the determination value, the higher detected value is set as the fuel pressure. Therefore, it is possible to prevent an excessive amount of fuel from being injected by carrying out an appropriate fail-safe treatment using the fuel pressure that has been set in this manner to control the fuel injection valves, and consequently.

[0014] In another aspect of the present invention, a fuel injection control device is provided with a plurality of fuel pressure sensors that are installed in fuel distribution pipes that distribute pressurized fuel supplied from a fuel pump to a plurality of fuel injection valves of an engine, and individually detect pressures of the fuel in the fuel distribution pipes, a fuel pressure setting means which sets a fuel pressure to be used as a controlling parameter based upon the detected value of each of the fuel pressure sensors, and a fuel injection control means which controls the fuel pump so that the fuel pressure set by the fuel pressure setting means is converged to a target pressure set in accordance with an operating state of the engine, wherein, when individually detected values of predetermined two fuel pressure sensors are in a normally-possible range and when the deviation of the two detected values is smaller than a given determination value, the above-mentioned fuel pressure setting means sets the higher detected value as the above-mentioned fuel pressure to be used by the fuel injection control means to control the fuel pump.

[0015] With the above-mentioned arrangement, the pressures of fuel in the fuel distribution pipes supplied from the fuel pump are individually detected by a plurality of fuel pressure sensors. When both of the predetermined two fuel pressure sensors are normal, the detected values therefrom are supposed to be approximately the same value. In the fuel pressure setting means, the fuel pressure is set based upon the detected value from each of the fuel pressure sensors. The fuel injection control means controls the fuel pump so that the fuel pressure set by the fuel pressure setting means is converged to a target pressure set in accordance with an operating state of the engine.

[0016] Supposing that, of the detected values of two fuel pressure sensors, the higher detected value is correct and the lower detected value is incorrect, and that the latter detected value is set as the fuel pressure by the fuel pressure setting means, the deviation between the target pressure and the fuel pressure becomes greater than the deviation that should be determined, resulting in that the amount of control required for causing the fuel pressure to be converged on the target pressure becomes greater than the amount of control that should be determined (that is, an amount of control required for the case where the former detected value is set as the fuel pressure). For this reason, the pressure of fuel to be supplied from the fuel pump and further to the fuel pressure in the fuel distribution pipes becomes higher than a value that should be determined.

[0017] In contrast, supposing that the higher detected value is incorrect and the lower detected value is correct, and that the former detected value is set as the fuel pressure by the fuel pressure setting means, the deviation between the target pressure and the fuel pressure becomes smaller than the deviation that should be determined, resulting in that the amount of control required for causing the fuel pressure to be converged on the target pressure becomes smaller than an amount of control that should be determined (that is, an amount of control required for the case where the latter detected value is set as the fuel pressure). For this reason, the pressure of fuel in the fuel distribution pipes becomes lower than a value that should be determined.

[0018] However, in another aspect of the present invention, when individually detected values of predetermined two fuel pressure sensors are in a normally-possible range and when the deviation of the two detected values is smaller than a given determination value, since there still remains a possibility that either of the fuel pressure sensors might be abnormal in characteristic although it is not clearly determined in comparison with the case in which the deviation is greater than the determination value, the higher detected value is set as the fuel pressure. Therefore, it is possible to prevent the pressure of fuel in the fuel distribution pipes from increasing excessively by carrying out an appropriate failsafe treatment using the fuel pressure that has been set in this manner so as to control the fuel pump, and consequently.

[0019] When only one of the detected values of predetermined two fuel pressure sensors is out of the above-mentioned range, it is desirable that the above-mentioned fuel pressure setting means sets the other detected value of the fuel pressure sensors as the above-mentioned fuel pressure.

[0020] When one of the detected values of the fuel pressure sensors is out of the normally-possible range, it is clear that the detected value is abnormal. When the other detected value of the fuel pressure sensors is in the range, the detected value is not clearly abnormal. In addition, there is a very little possibility that both of the two fuel pressure sensors fails to operate properly at the same time. Based upon these facts, the latter (the other) detected value is considered to be normal.

[0021] As described above, in the fuel pressure setting means, when one of the detected values of the fuel pressure sensors is out of a normally-possible range, while the other detected value of the fuel pressure sensors is in the range, the latter (the other) detected value of the fuel pressure sensors is set as a fuel pressure so as to be used in the controlling operation in the fuel injection control means. Therefore, it is possible to prevent a failure caused by using the former (one) detected value of the fuel pressure sensor which is considered to be clearly abnormal. The latter (the other) detected value considered to be normal is used so that the controlling process is carried out appropriately.

[0022] When both of the detected values of the predetermined two fuel pressure sensors are out of the above-mentioned range, it is desirable that the fuel pressure setting means sets a value in accordance with an operating state of the engine as the above-mentioned fuel pressure.

[0023] In accordance with the above-mentioned arrangement, when both of the detection values of the fuel pressure sensors are out of a normally-possible range, it is clear that both detected values are abnormal. Therefore, instead of the detected values of the two fuel pressure sensors, the fuel pressure setting means sets a value determined in accordance with an operating state of the engine at that time as the fuel pressure, and this value is used in the controlling operation by the fuel injection control means.

[0024] Therefore, it is possible to prevent a failure caused by using the detected values of both of the fuel pressure sensors that are considered to be clearly abnormal in the above-mentioned controlling operation. Thus, it is possible to appropriately continue the controlling operation by using a value set in accordance with an operating state of the engine at that time.

[0025] When both of the detected values of the predetermined two fuel pressure sensors are in the above-mentioned range, and when the deviation of the two detected values is equal to or greater than the above-mentioned determination value, it is desirable that the fuel pressure setting means sets the value determined based upon an operating state of the engine as the fuel pressure.

[0026] In accordance with the above-mentioned arrangement, when both detected values of the two fuel pressure sensors are in the normally-possible range, and when the deviation of the two detected values is equal to or greater than a given determination value, either of the fuel pressure sensors is considered to be clearly abnormal in characteristic. However, it is unclear which is abnormal in characteristic. Therefore, instead of the detected values of the two fuel pressure sensors, the fuel pressure setting means sets a value determined in accordance with an operating state of the engine at that time as the fuel pressure, and this value is used in the controlling operation by the fuel injection control means.

[0027] Therefore, it is possible to prevent the detected value of a fuel pressure sensor that is suspected of being abnormal from being used in the above-mentioned controlling operation, causing an excessive amount of fuel to be injected from the fuel injection valves as well as causing the pressure of fuel in the fuel distribution pipes to rise excessively. Thus, it is possible to appropriately continue the controlling operation by using a value set in accordance with an operating state of the engine at that time.

[0028] In still another aspect of the present invention, a fuel injection control method is provided. The method includes the steps of: detecting pressures of fuel in fuel distribution pipes that distribute pressurized fuel to a plurality of fuel injection valves of an engine by using a plurality of fuel pressure sensors, setting a fuel pressure to be used as a controlling parameter based upon the detected value of each of the fuel pressure sensors, and obtaining an injection period based upon a fuel injection amount in accordance with an operating state of the engine and the fuel pressure set in the fuel pressure setting step and controlling the fuel injection valves so as to inject the fuel during the injection period. In particular, in the fuel pressure setting step, when detected values of predetermined two fuel pressure sensors are each in a normally-possible range and when the deviation of the two detected values is smaller than a given determination value, the higher detected value is set as a fuel pressure used for calculating the injection period. Therefore, in the same manner as the aspect with respect to the device, it is possible to carry out an appropriate fail-safe treatment, and consequently to prevent an excessive amount of fuel from being injected.

Brief Description of the Drawings

[0029]

Fig. 1 is a schematic drawing that shows a structure of one embodiment in which a fuel injection control device of the present invention is embodied in a diesel engine;
Fig. 2 is a graph that shows an output characteristic of a fuel pressure sensor;
Fig. 3 is a flowchart that shows a sequence in which fuel pressure is set;
Fig. 4 is a flowchart that also shows a sequence in which fuel pressure is set;
Fig. 5 is a flowchart that shows a sequence in which an injection period is set in an injection amount controlling process;
Fig. 6 is a schematic drawing that shows a control map used for setting the injection period; and
Fig. 7 is a flowchart that shows a sequence in which injection pressure is controlled.

Best Mode for Carrying out the Invention

[0030] Referring to the drawings, the following description will discuss one embodiment of a fuel injection control device of the present invention.

[0031] As shown in Fig. 1, a vehicle is provided with an accumulator diesel engine 11 (hereinafter, referred to simply as engine). The engine 11 is provided with a cylinder block 14 having a cylinder head 12 and a plurality of cylinders 13. Each cylinder 13 has a piston 15 housed therein such that the piston can reciprocate. Each piston 15 is connected to a crankshaft (not shown) that is an output shaft of the engine 11 via a connecting rod 16. The reciprocating movement of each piston 15 is converted to a rotary movement by the connecting rod 16, and then transmitted to the crankshaft.

[0032] An intake passage 18 is connected to a combustion chamber formed in each cylinder 13 so that external air of the engine 11 is taken into the combustion chamber through the intake passage 18. Moreover, an exhaust passage 19 is connected to the combustion chamber. In the cylinder head 12, an intake valve 21 and an exhaust valve 22 are provided in each of the cylinders 13. These intake valve 21 and exhaust valve 22 are reciprocated in cooperation with the rotation of the crankshaft so that the connecting portions of the intake passage 18 and the exhaust passage 19 to the combustion chamber are each opened and closed.

[0033] A fuel injection valve (injector) 23 for injecting fuel into the combustion chamber of each of the cylinders 13 is provided in the cylinder head 12. The fuel injection from each fuel injection valve 23 to the corresponding combustion chamber is controlled by an electromagnetic valve 24. The fuel injection valve 23 is connected to fuel distribution pipes, that is, a common rail 25 so that, while the electromagnetic valve 24 is open, fuel inside the common rail 25 is injected to the corresponding combustion chamber from the fuel injection valve 23. A comparatively high pressure, which corresponds to a fuel injection pressure, is accumulated in the common rail 25. In order to realize this pressure accumulation, the common rail 25 is connected to a discharge port 28 of a supply pump 27 through a supply pipe 26.

[0034] A suction port 31 of the supply pump 27 is connected to a fuel tank 33 through a filter 32. The supply pump 27 intakes fuel from the fuel tank 33 through the filter 32. Moreover, the supply pump 27 allows a plunger to reciprocate by a cam, not shown, that is synchronous to the rotation of the engine 11 so that the fuel is allowed to have a predetermined pressure, and be supplied to the common rail 25.

[0035] A pressure control valve 34, which controls the pressure of fuel to be discharged from the discharge port 28 to the common rail 25, and consequently controls the amount of discharge, is placed in the vicinity of the discharge port 28 of the supply pump 27. Excessive fuel, which is not discharged from the discharge port 28, is returned to the fuel tank 33 through a return pipe 36 from a return port 35 of the supply pump 27 by opening the pressure control valve 34.

[0036] A relief valve 37, which is opened when predetermined conditions are satisfied, is placed in the common rail 25. When this relief valve 37 is opened, high-pressure fuel in the common rail 25 is returned to the fuel tank 33 through the return pipe 38 so that the pressure inside the common rail 25 is lowered.

[0037] Then, from the fuel injection valve 23, fuel is injected to high-temperature, and high-pressure suction air that has been introduced into the cylinder 13 through the intake passage 18, and compressed by the piston 15. This injected fuel is self-ignited, and burned. The piston 15 is reciprocated by combustion gas generated at this time so that the crankshaft is rotated to provide a driving force (output torque) of the engine 11. The combustion gas is externally discharged from the engine 11 through the exhaust passage 19.

[0038] In order to detect an operating state of the engine 11, various sensors, such as a coolant temperature sensor 41, a rotation speed sensor 42, an acceleration pedal sensor 43 and a plurality of fuel pressure sensors, are used. The coolant temperature sensor 41 is attached to the cylinder block 14 so that the temperature of cooling water which flows through a water jacket 14a, that is, the cooling water temperature, is detected. A rotation speed sensor 42 is placed in the vicinity of the crankshaft so that the number of revolution of the crankshaft per unit time, that is, the engine rotation speed, is detected. The acceleration pedal sensor 43 detects the acceleration depression amount by the driver, of an acceleration pedal 39, that is, the acceleration opening.

[0039] A plurality of fuel pressure sensors are attached to the common rail 25 to detect the pressure of fuel inside the common rail 25. In the present embodiment, a first fuel pressure sensor 44 and a second fuel pressure sensor 45 are used as a plurality of fuel pressure sensors. Each of the two fuel pressure sensors 44 and 45 outputs a voltage (analog value) that is proportional to the pressure of the fuel.

[0040] Fig. 2 shows characteristics of the voltage VPC output from the two fuel pressure sensors 44 and 45. In the drawing, a first area indicated by a broken line, which is lower than a lower-limit value VMIN, and a second area also indicated by a broken line, which is higher than a higher-limit value VMAX, are areas in which values of the fuel pressure sensors 44 and 45 would never belong to if they are normal. When the voltage VPC is in the first area (VPC<VMIN), it is highly possible that fuel pressure sensors 44 and 45 are disconnected. Moreover, when the voltage VPC is in the second area (VPC>VMAX), it is highly possible that fuel pressure sensors 44 and 45 are short-circuited. In other words, the area indicated by VMIN≤VPC≤VMAX is an area in which values of normal fuel pressure sensors 44 and 45 usually belong.

[0041] A first character line L1, indicated by a solid line, shows a characteristic of a voltage output from a normal first fuel pressure sensor 44, and a second character line L2, indicated by a solid line, shows a characteristic of a voltage output from a normal second fuel pressure sensor 45. The two characteristic lines L1 and L2 show that the voltage increases in proportion to the rise of the pressure (fuel pressure) within the above-mentioned normally-possible range. Here, the two characteristic lines L1, L2 are not coincident with each other, and different from each other by a predetermined amount of voltage ΔV with respect to the same pressure.

[0042] In Fig. 2, an area surrounded by two dashed lines shows a first range R1 in which a voltage, output from a normal first fuel pressure sensor 44, disperses around the above-mentioned characteristic line L1 as its center. In the same manner, an area surrounded by two chain double-dashed lines shows a second range R2 in which a voltage, output from a normal second fuel pressure sensor 45, disperses around the above-mentioned characteristic line L2 over the whole range of pressure as its center.

[0043] In the event of an abnormality in characteristic in the first fuel pressure sensor 44, the voltage output from the sensor 44 deviates from the first range R1. Moreover, in the event of an abnormality in characteristic in the second fuel pressure sensor 45, the voltage output from the sensor 45 deviates from the second range R2.

[0044] As shown in Fig. 1, in order to control respective parts of an engine 11 based upon the above-mentioned detected values of the various sensors 41 to 45, a vehicle is provided with an electronic control unit (ECU) 46. The ECU 46 is formed with a microcomputer as its center so that a central processing unit (CPU) carries out calculating processes in accordance with a control program, initial data and control maps, etc. that are stored in a read-only memory (ROM), and executes various controlling processes based upon the results of calculations. The results of calculations by the CPU are temporarily stored in a random access memory (RAM). Moreover, the ECU 46 is provided with an A/D converter 47 which converts a voltage (analog value) output from the individual fuel pressure sensors 44 and 45 to a digital value. The above-mentioned various controlling processes include setting of a fuel pressure, controlling of the amount of injection of fuel and controlling of the injection pressure.

[0045] In setting the above-mentioned fuel pressure, the ECU 46 executes a "fuel pressure setting routine" shown in Figs. 3 and 4 repeatedly, for example, every predetermined period of time in predetermined timing.

[0046] In step S100, the ECU 46 first A/D converts the output voltage of the first fuel pressure sensor 44 to obtain an A/D conversion value VPC1. In step S105, it A/D converts the output voltage of the second fuel pressure sensor 45 to obtain an A/D conversion value VPC2.

[0047] Next, in step S110, it calculates a first fuel pressure PCR1 in accordance with the following equation 1, and also calculates a second fuel pressure PCR2 in accordance with the following equation 2. Equation 1 is a converting equation used for converting the A/D conversion value VPC1 to the first fuel pressure PCR1, and equation 2 is a converting equation used for converting the A/D conversion value VPC2 to the second fuel pressure PCR2. A and B in equation 1 and C and D in equation 2 are constant values. In accordance with equation 1 and equation 2, when both fuel pressure sensors 44 and 45 are normal, fuel pressures PCR1 and PCR2 are determined to be approximately the same value.

$$PCR1 = VPC1 \cdot A + B \qquad \text{Equation 1}$$

PCR2 = VPC2•C+D Equation 2

[0048] Subsequently, in step S115, it is determined whether or not only the first fuel pressure PCR1 is abnormal. More specifically, it is determined whether or not both of the conditions that the first fuel pressure PCR1 is out of the normally-possible range (MIN1 to MAX1) and the second fuel pressure PCR2 belongs to the normally-possible range (MIN2 to MAX2) are satisfied. In this case, the lower-limit values MIN1, MIN2 correspond to the lower-limit value VMIN of Fig. 2, and the upper-limit values MAX1, MAX2 correspond to the upper-limit value VMAX of Fig. 2.

[0049] When the determination conditions in the step S115 are satisfied, since the first fuel pressure PCR1 is out of the above-mentioned normal range (MIN1 to MAX1), it is clear that it (the first fuel pressure sensor) is abnormal. Moreover, since the second fuel pressure PCR2 belongs to the normal range (MIN2 to MAX2), it (the second fuel pressure sensor) is not considered to be clearly abnormal. In addition, there is a very little possibility that both of the two fuel pressure sensors 44 and 45 fail to function properly at the same time. Based upon these facts, the second fuel pressure PCR2 is considered to be normal. Therefore, in step S120, the second fuel pressure PCR2 is set as the final fuel pressure PCR, and this routine is then completed.

[0050] When the determination conditions in the above-mentioned step S115 are not satisfied, it is determined in step S125 whether or not only the second fuel pressure PCR2 is abnormal. More specifically, it is determined whether or not both of the conditions that the first fuel pressure PCR1 belongs to the normally-possible range (MIN1 to MAX1) and the second fuel pressure PCR2 is out of the normally-possible range (MIN2 to MAX2) are satisfied.

[0051] When the determination conditions in the step S125 are satisfied, since the second fuel pressure PCR2 is out of the above-mentioned normal range (MIN2 to MAX2), it is clear that it (the second fuel pressure sensor) is abnormal. Moreover, since the first fuel pressure PCR1 belongs to the normal range (MINI to MAX1), it (the first fuel pressure sensor) is not considered to be clearly abnormal. In addition, there is a very little possibility that both of the two fuel pressure sensors 44 and 45 fail to function properly at the same time. Based upon these facts, the first fuel pressure PCR1 is considered to be normal. Therefore, in step S130, the first fuel pressure PCR1 is set as the final fuel pressure PCR, and this routine is then completed.

[0052] When the determination conditions in the above-mentioned step S125 are not satisfied, it is determined in step S135 of Fig. 4 whether or not both of the first fuel pressure PCR1 and the second fuel pressure PCR2 are abnormal. More specifically, it is determined whether or not both of the condition that the first fuel pressure PCR1 is out of the normal range (MIN1 to MAX1) and the condition that the second fuel pressure PCR2 is out of the normal range (MIN2 to MAX2) are satisfied.

[0053] When the determination conditions in step S135 are satisfied, it is clear that both of the first and second fuel pressures PCR1 and PCR2 are abnormal. Based upon this fact, in step S140, in place of the two fuel pressures PCR1 and PCR2, a target pressure, which is determined based upon an operating state of the engine 11 at that time, is set as the final fuel pressure PCR, and this routine is then completed. When the determination conditions in step S135 are not satisfied, it is determined in step S145 whether or not the absolute value of the deviation ΔPCR of the two fuel pressures PCR1 and PCR2 is equal to or greater than a given determination value X. This determination value X is set by taking the above-mentioned variation of the first fuel pressure PCR1 and variation of the second fuel pressure PCR2, that is, the first and second ranges R1 and R2, into consideration.

[0054] The process in step S145 is applied to a case where either of the two fuel pressure sensors 44 and 45 is abnormal in characteristic, and used for determining the degree of its abnormality. In other words, when the first fuel pressure PCR1 and the second fuel pressure PCR2 are greatly different from each other, it is considered to be clear that either of the fuel pressure sensors 44 (or 45) is abnormal in characteristic. In contrast, when the fuel pressures PCR1 and PCR2 are close to each other, although it is not as clear as the above-mentioned case, there still remains a possibility that either of the fuel pressure sensors 44 (or 45) is abnormal in characteristic.

[0055] Therefore, it is determined whether or not the absolute value of the deviation ΔPCR is equal to or greater than the determination value X; and when it is equal to or greater than the determination value, either of them is determined to be clearly abnormal, and when it is smaller than the determination value, it is determined that although it is not so clearly determined, there is still a possibility that either of them is abnormal in characteristic.

[0056] When the determination conditions in step S145 are satisfied, this routine is completed after the processes in the above-mentioned step S140. In contrast, when the determination conditions in step S145 are not satisfied, in step S150, the higher value of the two fuel pressures PCR1 and PCR2 is set as the final fuel pressure PCR, and this routine is then completed.

[0057] The final fuel pressure PCR, thus set based upon the detected values of the fuel pressure sensors 44 and 45 as described above, is used for calculating the amount of injection of fuel and the injection pressure as a controlling parameter. Next, referring to Figs. 5 and 7, the following description will discuss "injection amount control routines" and "injection pressure control routines" that are executed by the ECU 46.

[0058] Fig. 5 shows a routine for setting the injection period among the injection amount control routines. In this injection period setting routine, the ECU 46 first reads an injection amount Q in step S200. The injection amount Q is calculated based upon an operating state of the engine 11 through an injection amount calculation routine that has been prepared separately. In this injection amount calculation routine, for example, a predetermined control map is referred to so that a reference fuel injection amount (reference fuel injection time) that corresponds to the engine rotation speed and the acceleration opening is obtained. The reference fuel injection amount is corrected based upon a cooling water temperature, etc. so that the final injection amount Q is determined.

[0059] Next, the ECU 46 reads the final fuel pressure PCR in step S205. At this time, it reads the final fuel pressure PCR that has been set in the above-mentioned fuel pressure setting routine. In step S210, referring to the control map shown in Fig. 6, the ECU 46 calculates the injection period TQ of fuel.

[0060] In this control map, the injection period TQ is specified based upon the injection amount Q and the final fuel pressure PCR. In this control map, supposing that the injection amount Q is constant, the injection period TQ becomes shorter as the final fuel pressure PCR increases. Moreover, supposing that the final fuel pressure PCR is constant, the injection period TQ becomes longer as the injection amount Q increases. Then, in the above-mentioned step S210 of Fig. 5, the ECU 46 reads the injection period TQ that corresponds to the above-mentioned injection amount Q and final fuel pressure PCR from the control map.

[0061] In step S215, the above-mentioned injection period TQ is stored in a RAM, and this routine is then completed. The injection period TQ is used as an energization period of time when the electromagnetic valve 24 of the fuel injection valve 23 is energization-controlled in another routine. As a result, the fuel injection valve 23 is opened during the injection period TQ so that a desired amount (injection amount Q) of fuel is injected.

[0062] In the injection pressure control routine of Fig. 7, in step S300, the ECU 46 adds a leak amount and an estimated amount of target pressure variation to the injection amount Q, and sets the result of addition as an estimated discharging amount QBASE of the supply pump 27. The injection amount is an amount of fuel to be injected from the fuel injection valve 23, and the leak amount is an amount of fuel that leaks from the fuel injection valve 23, etc. The value, obtained by adding the leak amount to the injection amount Q, forms an amount of fuel that is required for maintaining the fuel pressure. Moreover, the estimated amount of target pressure variation is an amount of fuel (estimated amount) which, when the target value of the fuel pressure, set in accordance with an operating state of the engine 11, varies, that is, when the target pressure PCRTRG varies, is required for making the actual fuel pressure coincident with the target pressure PCRTRG.

[0063] Next, in step S305, the final fuel pressure PCR is subtracted from the target pressure PCRTRG and the result of subtraction is set as the pressure deviation PCRDL. In this case, the final fuel pressure PCR, which has been set in the above-mentioned fuel setting routine, is used as the final fuel pressure PCR in the above-mentioned step S305. Based upon this pressure deviation PCRDL, a feedback (F/B) proportional term QFBP and an F/B integral term GFBI are obtained in steps S310 and S315. More specifically, in step S310, the pressure deviation PCRDL is multiplied by a predetermined value K, and the result of multiplication is set as the F/B proportional term QFBP. In step S315, the product of the above-mentioned pressure deviation PCRDL and a predetermined value M is added to the F/B integral term QFBI in the previous controlling cycle, and the result of addition is set as a new F/B integral term QFBI.

[0064] In step S320, the above-mentioned F/B proportional term QFBP and the above-mentioned F/B integral term QFBI are added to the above-mentioned estimated discharging amount QBASE, and the result of the addition is set as a final discharging amount QPF.

[0065] In step S325, based upon the above-mentioned final discharging amount QPF and engine rotation speed, the ECU 46 obtains the current passing the pump in accordance with a predetermined control map or a predetermined arithmetic expression. In step S330, the ECU 46 energization-controls the pressure control valve 34 of the supply pump 27 by using the above-mentioned current passing the pump, and this routine is then completed. In this manner, in the injection pressure control routine, the supply pump 27 is controlled so that the final fuel pressure PCR is converged on the target pressure PCRTRG that corresponds to an operating state of the engine 11.

[0066] In accordance with the present embodiment that has been discussed in detail, the following effects are obtained.

(1) If, under a circumstance in which, of the two fuel pressures PCR1 and PCR2, the higher value is correct and the lower value is incorrect, the latter lower value is set as the final fuel pressure PCR, the injection period TQ, which is determined based upon the injection amount Q and the final fuel pressure PCR, becomes longer than the injection period that should be set. For this reason, when fuel is injected during the period thus set, an amount of fuel that is greater than the amount that should be injected is injected.

In contrast, if, under a circumstance in which the higher value is incorrect and the lower value is correct, the former higher value is set as the final fuel pressure PCR, the injection period TQ becomes shorter than the injection period that should be set. For this reason, when fuel is injected during the period thus set, an amount of fuel that is smaller than the amount that should be injected is injected.

In the present embodiment, when the first fuel pressure PCR1 and second fuel pressure PCR2 are each within normally-possible ranges and when the deviation ΔPCR of the two fuel pressures PCR1 and PCR2 is smaller than a determination value X, the higher value is set as the final fuel pressure PCR (steps S135, S145 and S150) so as to be reflected to the fuel injection amount control (step S205). Therefore, by conducting an appropriate fail-safe treatment, which uses the higher value as the final fuel pressure PCR to carry out the injection amount control, it becomes possible to prevent an excessive amount of fuel being injected, and further to prevent an excessive rise (overrun) in the engine rotation speed due to an increase in the injection amount.

(2) If, under a circumstance in which, of the two fuel pressures PCR1 and PCR2, the higher value is correct and the lower value is incorrect, the latter lower value is set as the final fuel pressure PCR, a control amount (F/B proportional term QFBP, F/B integral term QFBI), which is necessary to converge the final fuel pressure PCR on the target pressure PCRTRG, becomes greater than the control amount that should be set (the F/B proportional term QFBP and F/B integral term QFBI that are required when the former higher value is set as the final fuel pressure PCR). For this reason, the pressure of fuel to be supplied from the supply pump 27, that is, the pressure of fuel within the common rail 25, becomes higher than the pressure of fuel that should be set.

In contrast, if, under a circumstance in which the higher value is incorrect and the lower value is correct, the former higher value is set as the final fuel pressure PCR, a control amount, which is required to converge the final fuel pressure PCR on the target pressure PCRTRG, becomes smaller than the control amount that should be set (the F/B proportional term QFBP and F/B integral term QFBI that are required when the latter lower value is set as the final fuel pressure PCR). For this reason, the pressure of fuel to be supplied from the supply pump 27, that is, the pressure of fuel within the common rail 25, becomes lower than the pressure of fuel that should be set.

In the present embodiment, when the fuel pressures PCR1 and PCR2 are each within normally-possible ranges and when the deviation ΔPCR is smaller than the determination value X, the higher value is set as the final fuel pressure PCR (steps S135, S145 and S150) to be reflected to the fuel injection amount control (step S305). Therefore, by conducting an appropriate fail-safe treatment, which uses the higher value as the final fuel pressure PCR to carry out the injection amount control, it becomes possible to prevent an excessive rise in the fuel pressure in the common rail 25.

(3) When one of the fuel pressures PCR1 (or PCR2) is out of the normally-possible range while the other fuel pressure PCR2 (or PCR1) belongs to the normally-possible range, the latter value is set as the final fuel pressure PCR (steps S115, S120, S125 and S130). In other words, the fuel pressure PCR2 (or PCR1) that is considered to be normal is set as the final fuel pressure PCR to be used for controlling the injection amount of fuel and for controlling the injection pressure (steps S205 and S305).

Therefore, it is possible to prevent a problem in which the fuel pressure PCR1 (or PCR2) that is considered to be clearly abnormal is used in the above-mentioned controlling process from occurring. It is possible to carry out the controlling process appropriately by using the fuel pressure PCR2 (or PCR1) that is considered to be normal as the final fuel pressure PCR.

(4) When both fuel pressures PCR1 and PCR2 are out of the normally-possible ranges, it is clear that both of the first and second fuel pressures PCR1 and PCR2 are abnormal. In the present embodiment, in such a case, in place of the two fuel pressures PCR1 and PCR2, a value (target pressure), which is determined based upon an operating state of the engine 11 at that time, is set as the final fuel pressure PCR (steps S135 and S140), and this value is used for controlling the injection amount of fuel and for controlling the injection pressure (steps S205 and S305).

Therefore, it is possible to prevent a failure caused by using both fuel pressures PCR1 and PCR2 that are considered to be clearly abnormal in the above-mentioned controlling operation. It is possible to appropriately continue the controlling operation by utilizing the target value as the final fuel pressure PCR.

(5) When both fuel pressures PCR1 and PCR2 are in normally-possible ranges and when the deviation ΔPCR is greater than a determination value X, either of the fuel pressure sensors 44 (or 45) is considered to be clearly abnormal in characteristic. However, it is unclear which one of the fuel pressure sensors 44 (or 45) is abnormal in characteristic. Therefore, in the present embodiment, in place of the two fuel pressures PCR1 and PCR2, a value (target pressure), which is suitable for an operating state of the engine 11 at that time, is set as the final fuel pressure PCR (steps S135, S145 and S140), and this value is used for controlling the injection amount of fuel and for controlling the injection pressure (steps S205 and S305).

[0067] Therefore, it is possible to prevent a problem in which the fuel pressure PCR1 (or PCR2) that is suspected of being abnormal in characteristic is used for controlling operation causing an excessive amount of a fuel injection or an excessive increase in the fuel pressure. It is possible to appropriately continue the controlling operation by using the target value as the final fuel pressure PCR.

[0068] Moreover, the present invention may be embodied in the following other embodiments.

[0069] The present invention may be applied to a system in which three fuel pressure sensors or more are used and the detected values thereof are used as controlling parameters to carry out controlling operations. In this case, when, for example, fuel pressures, set by predetermined two fuel pressure sensors, are each in normally-possible ranges, and when the deviation ΔPCR is smaller than the determination value X, the higher fuel pressure is set as the final fuel pressure PCR.

[0070] Not limited to diesel engines, the present invention is applicable to engines in which the injection amount and injection pressure of fuel are controlled based upon a fuel pressure inside a fuel distribution pipe, for example, gasoline engines of a direct-injection type in which fuel is directly injected into a combustion chamber.

[0071] The present invention may be applied to a fuel injection control device in which detected values from a plurality of fuel pressure sensors are used for controlling only the fuel injection amount, or for controlling only the fuel pressure.

[0072] In the above-mentioned embodiment, fuel pressure sensors 44 and 45, which output voltages that are different from each other by a predetermined amount ΔV with respect to the same pressure are used. Therefore, when both fuel pressure sensors 44 and 45 are normal, a constant deviation is supposed to occur between the two voltages. Based on this fact, the deviation between A/D-converted values VPC1 and VPC2 is obtained, and when the deviation is smaller than a predetermined value, the A/D converter 47 may be determined to be abnormal. With this arrangement, it is possible to detect if there is any abnormality in the A/D converter 47.

[0073] The fuel pressure sensors 44 and 45 may be replaced by fuel pressure sensors that output the same voltage when the same pressure is applied.

Claims

1. A fuel injection control device comprising:

a plurality of fuel pressure sensors, wherein the fuel pressure sensors are installed in fuel distribution pipes that distribute pressurized fuel to a plurality of fuel injection valves of an engine, and individually detect pressures of the fuel in the fuel distribution pipes;

fuel pressure setting means which sets a fuel pressure to be used as a controlling parameter based upon the detected value of each of the fuel pressure sensors; and

fuel injection control means which obtains an injection period based upon a fuel injection amount that is set in accordance with an operating state of the engine and the fuel pressure set by the fuel pressure setting means, and wherein the fuel injection control means controls the fuel injection valves so as to inject the fuel during the injection period,

wherein, when detected values of predetermined two fuel pressure sensors are each in a normally-possible range and when the deviation of the two detected values is smaller than a given determination value, the fuel pressure setting means sets the higher detected value as the fuel pressure used for calculating the injection period by the fuel injection control means.

2. A fuel injection control device comprising:

a plurality of fuel pressure sensors, wherein the fuel pressure sensors are installed in fuel distribution pipes that distribute pressurized fuel supplied from a fuel pump to a plurality of fuel injection valves of an engine, and individually detect pressures of the fuel in the fuel distribution pipes;

fuel pressure setting means which sets a fuel pressure to be used as a controlling parameter based upon the detected value of each of the fuel pressure sensors; and

fuel injection control means which controls the fuel pump so that the fuel pressure set by the fuel pressure setting means is converged to a target pressure that is set in accordance with an operating state of the engine,

wherein, when respective detected values of predetermined two fuel pressure sensors are each in a normally-possible range and when the deviation of the two detected values is smaller than a given determination value, the fuel pressure setting means sets the higher detected value as the fuel pressure to be used by the fuel injection control means to control the fuel pump.

3. The fuel injection control device according to Claim 1 or 2, wherein, when only one of the detected values of predetermined two fuel pressure sensors is out of the range, the fuel pressure setting means sets the other detected value of the fuel pressure sensors as the fuel pressure.

4. The fuel injection control device according to Claim 1 or 2, wherein, when both detected values of the predetermined two fuel pressure sensors are out of the range, the fuel pressure setting means sets a value in accordance with an operating state of the engine as the fuel pressure.

5. The fuel injection control device according to Claim 1 or 2, wherein, when both detected values of the predetermined two fuel pressure sensors are in the range, and when the deviation of the two detected values is equal to or greater than the determination value, the fuel pressure setting means sets a value determined in accordance with an operating state of the engine as the fuel pressure.

6. A fuel injection control method comprising the steps of:

detecting pressures of fuel in fuel distribution pipes that distribute pressurized fuel to a plurality of fuel injection valves of an engine by using a plurality of fuel pressure sensors;
setting a fuel pressure to be used as a controlling parameter based upon the detected value of each of the fuel pressure sensors; and
obtaining an injection period based upon a fuel injection amount set in accordance with an operating state of the engine and the fuel pressure set in the fuel pressure setting step and controlling the fuel injection valves so as to inject the fuel during the injection period,

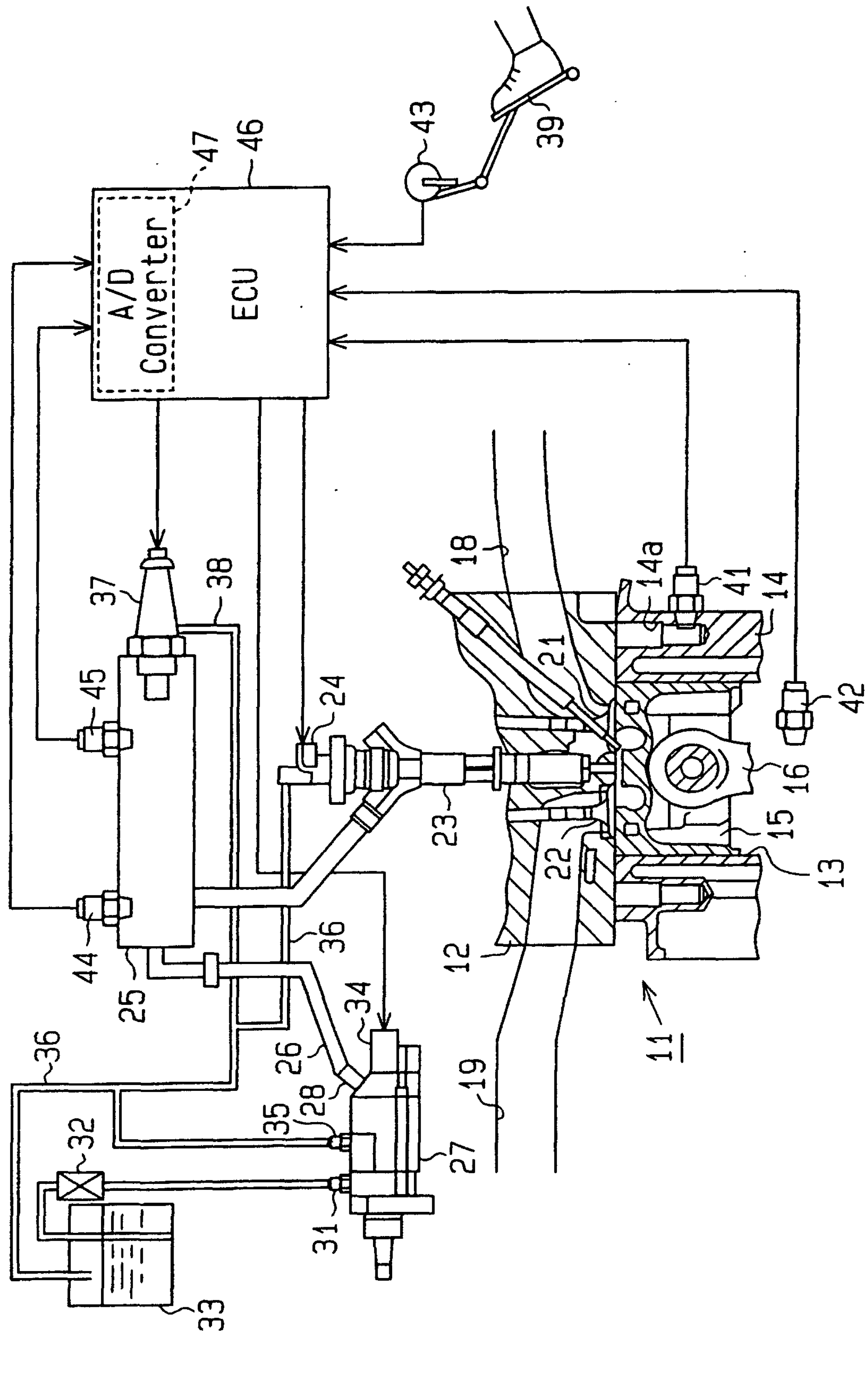
wherein in the fuel pressure setting step, when detected values of predetermined two fuel pressure sensors are each in a normally-possible range and when the deviation of the two detected values is smaller than a given determination value, the higher detected value is set as a fuel pressure used for calculating the injection period.

7. The fuel injection control method according to Claim 6, wherein, when only one of the detected values of predetermined two fuel pressure sensors is out of the range, the other detected value of the fuel pressure sensors is set as the fuel pressure in the fuel pressure setting step.

8. The fuel injection control method according to Claim 6, wherein, when both detected values of the predetermined two fuel pressure sensors are out of the range, a value determined in accordance with an operating state of the engine is set as the fuel pressure in the fuel pressure setting step.

9. The fuel injection control method according to Claim 6, wherein, when both detected values of predetermined two fuel pressure sensors are in the range, and when the deviation of the two detected values is equal to or greater than the determination value, a value determined in accordance with an operating state of the engine is set as the fuel pressure in the fuel pressure setting step.

10. The fuel injection control method according to Claim 6, wherein the pressure of fuel in each fuel distribution pipe is detected by two fuel pressure sensors.


A/D Converter
ECU
11
12
13
14
14a
15
16
18
19
21
22
23
24
25
26
27
28
31
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46
47

Fig.1

Fig.2

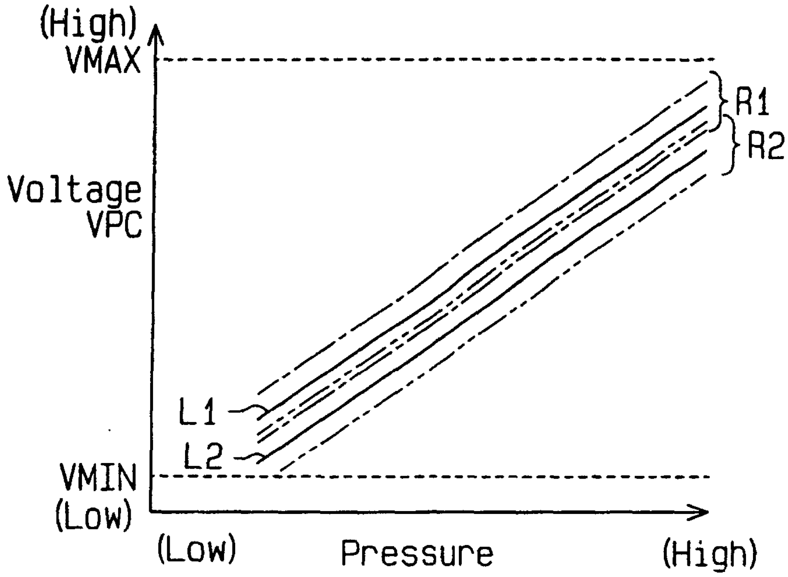

(High)
VMAX
Voltage
VPC
VMIN
(Low)
L1
L2
R1
R2
(Low)
Pressure
(High)

Fig.3

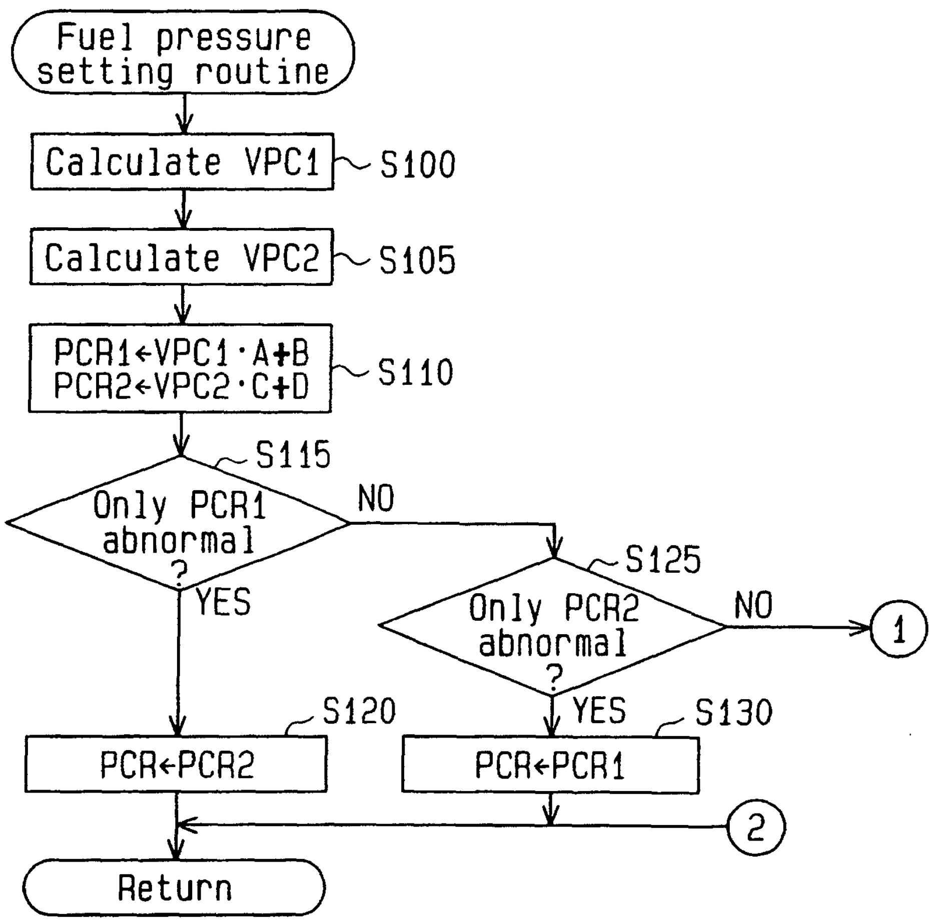

Fuel pressure setting routine
Calculate VPC1
S100
Calculate VPC2
S105
PCR1←VPC1·A+B
PCR2←VPC2·C+D
S110
S115
Only PCR1 abnormal ?
NO
YES
S125
Only PCR2 abnormal ?
NO
1
YES
S120
S130
PCR←PCR2
PCR←PCR1
2
Return

Fig.4

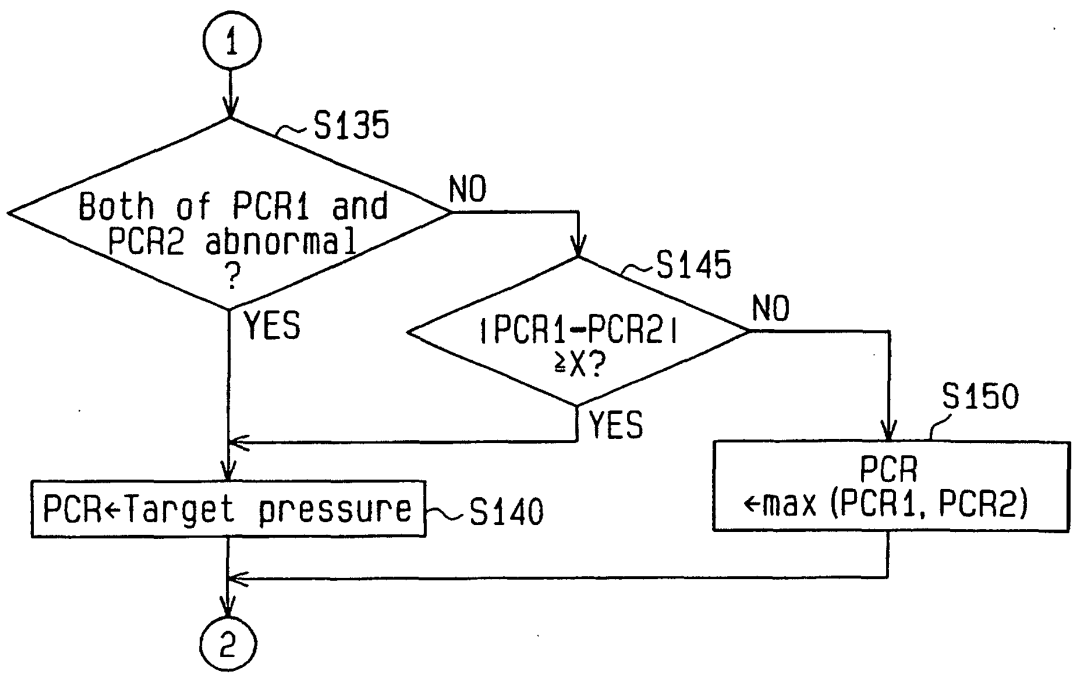

1
S135
Both of PCR1 and PCR2 abnormal ?
NO
YES
S145
|PCR1-PCR2| ≥X?
NO
YES
S150
PCR ←max (PCR1, PCR2)
PCR←Target pressure
S140
2

Fig.5

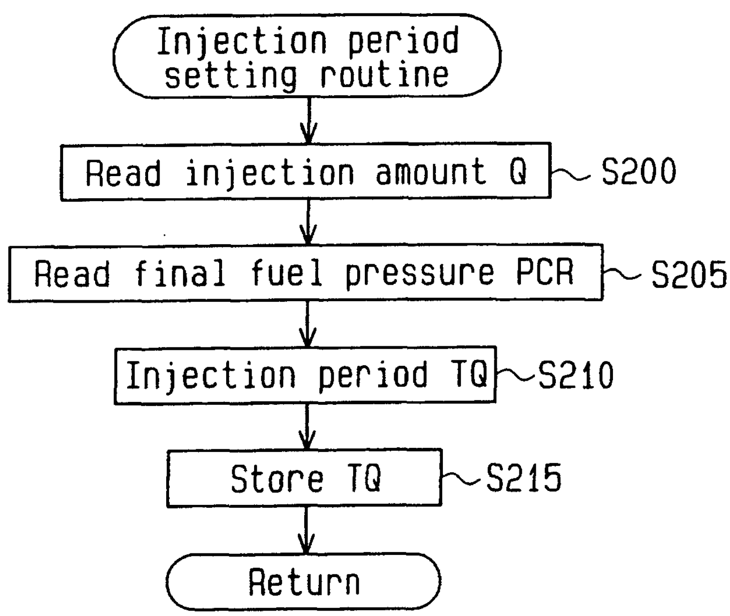

Injection period setting routine
Read injection amount Q
S200
Read final fuel pressure PCR
S205
Injection period TQ
S210
Store TQ
S215
Return

Fig.6

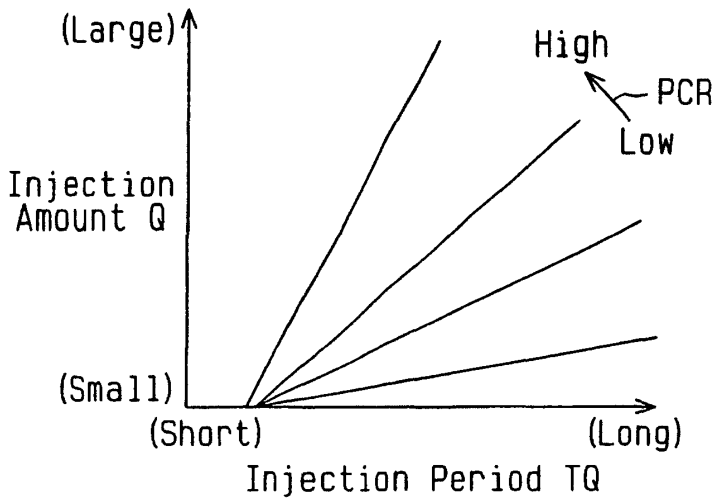
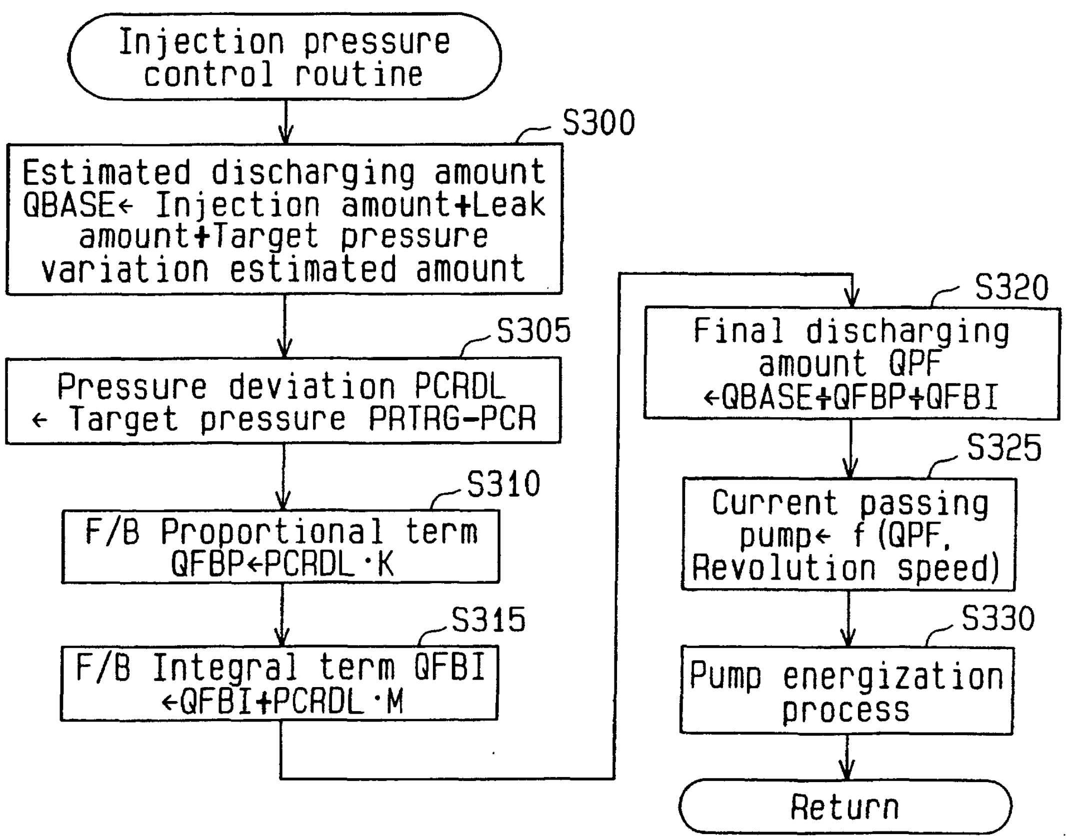

(Large)
Injection
Amount Q
(Small)
High
PCR
Low
(Short)
(Long)
Injection Period TQ

Fig.7


Injection pressure control routine
S300
Estimated discharging amount QBASE← Injection amount+Leak amount+Target pressure variation estimated amount
S305
Pressure deviation PCRDL ← Target pressure PRTRG-PCR
S310
F/B Proportional term QFBP←PCRDL·K
S315
F/B Integral term QFBI ←QFBI+PCRDL·M
S320
Final discharging amount QPF ←QBASE+QFBP+QFBI
S325
Current passing pump← f (QPF, Revolution speed)
S330
Pump energization process
Return

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/01075

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^{7} F02D41/38, F02D41/22, F02D45/00, F02M63/02

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^{7} F02D41/00-45/00, F02M63/02

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Toroku Jitsuyo Shinan Koho	1994-2002

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.
A	JP, 11-2148, A (Toyota Motor Corp.), 06 January, 1999 (06.01.99), Full text; Figs. 1 to 10 (Family: none)	1-10
A	JP, 10-54317, A (Toyota Motor Corp.), 24 February, 1998 (24.02.98), Full text; Figs. 1 to 6 (Family: none)	1-10
A	JP, 4-272445, A (Nippondenso Co., Ltd.), 29 September, 1992 (29.09.92), Full text; Figs. 1 to 16 (Family: none)	1-10
A	JP, 8-61133, A (Isuzu Motors Ltd.), 05 March, 1996 (05.03.96), Full text; Figs. 1 to 12 (Family: none)	1-10

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
06 March, 2002 (06.03.02)	19 March, 2002 (19.03.02)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/01075

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 8-284722, A (Mitsubishi Motors Corp.), 29 October, 1996 (29.10.96), Full text; Figs. 1 to 2 (Family: none)	1-10
A	JP, 11-210532, A (Toyota Motor Corp.), 03 August, 1999 (03.08.99), Full text; Figs. 1 to 7 (Family: none)	1-10
A	US, 6012438, A (Robert Bosch GmbH), 11 January, 2000 (11.01.00), Full text; Figs. 1 to 4 & JP 10-325352 A & DE 19721176 A & FR 2763650 A	1-10

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