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(54) **Pressure accumulation type fuel injection system**

Druckspeicherkraftstoffeinspritzsystem

Système d’injection de carburant du type à accumulation de pression

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Description

[0001] The present invention relates to a pressure accumulation type fuel injection system for accumulating high-pressure fuel, which is pressurized and pressure-fed by a fuel supply pump driven by an engine, in a common rail and for injecting and supplying the high-pressure fuel accumulated in the common rail into respective cylinders of the engine through fuel injection valves. Specifically, the invention relates to a pressure accumulation type fuel injection system having a pressure limiter, which opens when the fuel pressure in the common rail exceeds a limit set pressure in order to limit the fuel pressure in the common rail to the limit set pressure or under.

[0002] A pressure accumulation type fuel injection system for accumulating high-pressure fuel, which is pressurized and pressure-fed by a fuel supply pump driven by an engine, in a common rail, and for supplying the accumulated high-pressure fuel into respective cylinders of the engine through injection with a plurality of fuel injection valves mounted on the respective cylinders is publicly known as disclosed in Japanese Patent Application Unexamined Publication No. 2001-295685 (pp. 1 to 7 and Figs. 1 to 6), for instance. A suction control valve (SCV) is disposed in a fuel supply passage leading to a pressurizing chamber of the fuel supply pump. The SCV changes a discharging quantity of the high-pressure fuel discharged from the pressurizing chamber of the fuel supply pump into the common rail by regulating a drawing quantity of the fuel drawn into the pressurizing chamber of the fuel supply pump from a fuel tank through a feed pump. Generally, a normally open type electromagnetic valve, which opens fully when energization is stopped, is employed as the SCV.

[0003] When a fully opening abnormality failure is generated in the SCV because of breakage failure of a wire harness for transmitting a pump driving signal for driving the SCV, the fuel supply pump pressure-feeds the high-pressure fuel excessively into the common rail. In this case, there is a possibility that the fuel pressure in a high-pressure piping passage (system) leading from the pressurizing chamber of the fuel supply pump to high-pressure sealing portions of the injectors of the respective cylinders through the common rail, specifically, the fuel pressure in the common rail, may exceed the limit set pressure (an abnormally high pressure beyond a supposed pressure for the system). Considering the case in which the abnormally high pressure beyond the supposed pressure for the system is generated, a pressure limiter is disposed at the end of the common rail. If an abnormally high pressure is generated in the system, the pressure limiter quickly opens in a mechanical manner in order to avoid the abnormally high-pressure state in the common rail. Thus, the reliability of the pressure accumulation type fuel injection system is warranted.

[0004] In the case where the pressure accumulation type fuel injection system employs the suction control type fuel supply pump and the normally open type SCV, the fuel supply pump is brought to a full capacity discharging state if the fully opening abnormality failure is generated in the SCV because of the breakage of the wire harness for transmitting the pump driving signal to drive the SCV.

[0005] In this case, the SCV loses its circuit conductivity and cannot be controlled any more by an engine control unit (ECU). Therefore, the abnormally high-pressure state caused in the common rail by the breakage of the wire harness cannot be avoided or the safety and reliability of the pressure accumulation type fuel injection system cannot be ensured without employing the pressure limiter capable of mechanically opening. The abnormally high-pressure state in the common rail can be avoided and the safety of the system can be ensured by employing a pressure control valve or a pressure relief valve, which can be electrically operated based on the command of the ECU, instead of the pressure limiter. However, this replacement causes a problem that a system cost is increased.

[0006] In recent years, demands for size reduction to improve mounting performance and for an increase in an injection pressure, which is required under the intensified exhaust gas regulations, are increasing year by year. Therefore, the quantity of the fuel discharged from the pressurizing chamber of the fuel supply pump tends to decrease in accordance with the size reduction of the fuel supply pump. Meanwhile, an injector leak quantity tends to increase and a valve-opening set pressure of the pressure limiter tends to rise in accordance with the increase in the fuel injection pressure. Conventionally, the fuel discharging quantity has been larger than the injector leak quantity when a failure that causes the abnormally high-pressure state in the common rail occurs. Therefore, the pressure limiter quickly opens and the abnormally high-pressure state in the common rail can be avoided quickly. However, nowadays, the possibility that the pressure limiter takes a long time to open should be considered.

[0007] Moreover, in the pressure accumulation type fuel injection system, the fuel supply pump is driven by the rotational force in synchronization with the engine rotation speed. Therefore, specifically in an operation area such as a low engine rotation speed operation area where the fuel discharging quantity cannot be ensured sufficiently, the fuel discharging quantity substantially coincides with the injector leak quantity when the fuel pressure is lower than the valve-opening set pressure of the pressure limiter. Therefore, the possibility that the common rail pressure cannot be increased to the valve-opening set pressure of the pressure limiter should be considered. More specifically, in order to avoid the abnormally high-pressure state in the common rail, an additional abnormality diagnosis device is required in addition to the pressure limiter.

[0008] It is therefore an object of the present invention to provide a pressure accumulation type fuel injection system capable of highly precisely detecting an abnormally high-pressure state in which a pressure safety valve takes a long time to open or cannot open when the abnormally high-pressure state continues and of quickly avoiding the abnormally high-pressure state without increasing a system cost. It is another object of the present invention to provide a pressure accumulation type fuel injection system capable of highly precisely detecting deterioration in reliability of a fuel supply pump and of urging a user to replace the fuel supply pump, whose reliability is deteriorated, with a normal fuel supply pump at appropriate timing.

[0009] According to an aspect of the present invention, a pressure accumulation type fuel injection system can highly precisely detect an abnormally high-pressure state, in which a fuel pressure in a common rail sensed by fuel pressure sensing means exceeds a pump usage allowable area that affects deterioration of reliability of a fuel supply pump or an injector usage allowance area that affects deterioration of reliability of an injector, when the abnormally high-pressure state continues for a predetermined period. Then, the fuel injection system controls an engine so as to avoid the abnormally high-pressure state. The abnormally high-pressure state is caused when a pressure safety valve, which is a key component of safety designing of the accumulation type fuel injection system, cannot open because of an increase in a fuel leak quantity caused by functional degradation of the injector or the fuel supply pump, a decrease in a fuel discharging quantity due to size reduction of the fuel supply pump, or an increase in the fuel leak quantity due to an increase in an injection pressure. In order to prevent performance degradation of the fuel supply pump (functional degradation such as deterioration of fuel lubrication of a sliding portion of the fuel supply pump) due to continuation of a low-speed and high-pressure state or a high-speed and high-pressure state, an emergency operation (a fail-safe operation) is performed, for instance. Thus, the abnormally high-pressure state can be quickly avoided and the safety and reliability of the pressure accumulation type fuel injection system can be ensured without increasing a system cost.

[0010] Features and advantages of an embodiment will be appreciated, as well as methods of operation and the function of the related parts, from a study of the following detailed description, the appended claims, and the drawings, all of which form a part of this application. In the drawings:

Fig. 1 is schematic diagram showing a common rail type fuel injection system according to an embodiment of the present invention;
Fig. 2 is a flowchart showing a pump and injector abnormality diagnosing method according to the present embodiment;
Fig. 3 is a graph showing a pressure limiter opening pressure, a pump usage allowable area, a first threshold and a second threshold according to the present embodiment;
Fig. 4 is a flowchart showing a pump allowance determination control according to the present embodiment;
Fig. 5 is a flowchart showing the pump allowance determination control according to the present embodiment;
Fig. 6 is a flowchart showing the pump allowance determination control according to the present embodiment;
Fig. 7 is a graph showing the pressure limiter opening pressure, an injector usage allowable area and an injector allowance determination threshold according to the present embodiment;
Fig. 8 is a flowchart showing injector allowance determination control according to the present embodiment;
Fig. 9 is a table showing relationships between detected abnormalities and demanded levels of a fail-safe operation according to the present embodiment;
Fig. 10 is a flowchart showing fail-safe operation control according to the present embodiment; and
Fig. 11 is a flowchart showing the fail-safe operation control according to the present embodiment.

[0011] Referring to Fig. 1, a common rail type fuel injection system of an embodiment of the present invention is illustrated.

[0012] The common rail type fuel injection system of the present embodiment has a common rail 2, a plurality of (four in the present embodiment) injectors 3, a fuel supply pump 4 and an engine control unit (ECU) 10. The common rail 2 functions as a pressure accumulation vessel for accumulating fuel at a high pressure corresponding to an injection pressure of the fuel injected and supplied into combustion chambers of respective cylinders of an internal combustion engine (an engine, hereafter) 1 such as a multi-cylinder diesel engine. The plurality of injectors 3 is mounted in the respective cylinders of the engine 1. The fuel supply pump 4 pressurizes the fuel drawn into a pressuring chamber through a suction control value (an SCV, hereafter) 5 and pressure-feeds the high-pressure fuel into the common rail 2. The ECU 10 electronically controls actuators of the injectors 3 and an actuator of the SCV 5.

[0013] The common rail 2 is required to continuously accumulate the fuel at the high pressure corresponding to the fuel injection pressure. Therefore, the common rail 2 is connected to a discharge port of the fuel supply pump 4, which discharges the high-pressure fuel, through a fuel passage (a high-pressure passage) 11. Leak fuel from the injectors 3 and the fuel supply pump 4 is returned to a fuel tank 6 through leak pipes (fuel return passages) 12, 13, 14. A pressure limiter 16 is disposed in a return pipe (a fuel return passage) 15 leading from the common rail 2 to the fuel tank 6. The pressure limiter 16 is a pressure safety valve, which opens when the fuel pressure in the common rail 2 exceeds a limit set pressure (a pressure limiter opening set value: a pressure limiter opening pressure, a P/L opening pressure, hereafter). Thus, the pressure limiter 16 limits the fuel pressure in the common rail 2 to the P/L opening pressure or under.

[0014] The injector 3 is an electromagnetic fuel injection valve mounted in each cylinder of the engine 1. The injector 3 has a fuel injection nozzle, an electromagnetic actuator, needle biasing means and the like. The fuel injection nozzle is connected to a downstream end of one of a plurality of branching pipes 17 branching from the common rail 2 and supplies the high-pressure fuel accumulated in the common rail 2 into the combustion chamber of the cylinder through injection. The electromagnetic actuator drives a nozzle needle accommodated in the fuel injection nozzle in a valve-opening direction. The needle biasing means biases the nozzle needle in a valve-closing direction. The fuel injection from the injector 3 of each cylinder into the combustion chamber of the cylinder is electronically controlled by turning on and off energization to an injection control electromagnetic valve as the electromagnetic actuator connected to the downstream end of each branching pipe 17. More specifically, the high-pressure fuel accumulated in the common rail 2 is injected and supplied into the combustion chamber of the cylinder of the engine 1 while the injection control electromagnetic valve of the injector 3 of the cylinder is open.

[0015] The fuel supply pump 4 has a publicly known feed pump, a plunger and a pressurizing chamber (a plunger chamber). The feed pump draws the fuel from the fuel tank 6 when a pump drive shaft 22 rotates in accordance with rotation of a crankshaft 21 of the engine 1. The plunger is driven by the pump drive shaft 22. The pressurizing chamber pressurizes the fuel with the reciprocating movement of the plunger. The fuel supply pump 4 pressurizes the fuel drawn by the feed pump through a fuel pipe 19 and discharges the high-pressure fuel from the discharge port to the common rail 2. The SCV 5 is disposed in a fuel suction passage for supplying the fuel from the feed pump to the pressurizing chamber of the fuel supply pump 4. The SCV 5 changes an opening area of the fuel suction passage.

[0016] The SCV 5 is a pump flow control valve (a drawing quantity control electromagnetic valve) electronically controlled with a pump driving signal provided by the ECU 10 through a pump driving circuit. Thus, the SCV 5 controls the drawing quantity of the fuel drawn from the feed pump into the pressurizing chamber of the fuel supply pump 4 through the fuel suction passage. Thus, the SCV 5 changes the injection pressure of the fuel injected from the respective injectors 3 into the engine 1, or the fuel pressure (the common rail pressure) in the common rail 2. The SCV 5 includes a valve member for changing the opening area of the fuel suction passage and a solenoid coil for regulating a valve opening degree (an opening area of a valve port, a lifting degree of the valve) in accordance with the pump driving signal. The SCV 5 is a normally open type electromagnetic valve, which fully opens when energization to the solenoid coil is stopped.

[0017] The ECU 10 includes a microcomputer having known structure including functions of a CPU for performing control processing and calculation processing, a memory (ROM, RAM) for storing various programs and data, an input circuit, an output circuit, a power supply circuit, an injector driving circuit (EDU), the pump driving circuit and the like. If an ignition switch is turned on (IG·ON), the ECU 10 receives ECU power supply and electronically controls the actuators of respective control parts such as the injectors 3 or the fuel supply pump 4 based on the control programs stored in the memory. If the ignition switch is turned off (IG·OFF) and the supply of the ECU power is stopped, the above control based on the control programs stored in the memory is ended compulsorily.

[0018] The sensor signals from the various sensors are converted from analog signals into digital signals by an A/D converter and are inputted to the microcomputer included in the ECU 10. The microcomputer is connected with operating condition detecting means for detecting the operating state or the operating condition of the engine 1, such as a rotation speed sensor 31 for sensing engine rotation speed NE, an accelerator position sensor 32 for sensing an accelerator position ACCP, a cooling water temperature sensor 33 for sensing engine cooling water temperature THW, a fuel temperature sensor 34 for sensing the temperature THF of the fuel on the pump suction side, or the fuel drawn into the fuel supply pump 4, and the like.

[0019] The ECU 10 includes basic injection quantity determining means, command injection quantity determining means, injection timing determining means, injection period determining means, and injector driving means. The basic injection quantity determining means calculates an optimum basic injection quantity QBASE in accordance with the engine rotation speed NE and the accelerator position ACCP based on a characteristic map made in advance by measurement through experimentation and the like. The command injection quantity determining means calculates a command injection quantity QFIN by adding an injection quantity correction value to the basic injection quantity QBASE. The injection quantity correction value corresponds to the operating conditions such as the engine cooling water temperature THW or the fuel temperature THF on the pump suction side. The injection timing determining means calculates command injection timing T in accordance with the engine rotation speed NE and the command injection quantity QFIN. The injection period determining means calculates an energization period (injection pulse length, injection pulse width, a command injection period) of the injection control electromagnetic valve of the injector 3 in accordance with the common rail pressure PC and the command injection quantity QFIN, based on a characteristic map made in advance by measurement through experimentation and the like. The injector driving means applies a pulse-shaped injector driving current (an INJ driving current, an injector injection pulse) to the injection control electromagnetic valve of the injector 3 of each cylinder through the injector driving circuit EDU.

[0020] Moreover, the ECU 10 includes discharging quantity controlling means for calculating the optimum common rail pressure for the operating conditions of the engine 1 and for driving the SCV 5 of the fuel supply pump 4 through the pump driving circuit. More specifically, the ECU 10 calculates the target common rail pressure Pt in accordance with engine operation information such as the engine rotation speed NE sensed by the rotation speed sensor 31 and the accelerator position ACCP sensed by the accelerator position sensor 32, and correction values corresponding to the engine cooling water temperature THW sensed by the cooling water temperature sensor 33 and the fuel temperature THF on the pump suction side sensed by the fuel temperature sensor 34. The ECU 10 controls the pressure-feeding quantity (the pump discharging quantity) of the fuel discharged from the fuel supply pump 4 by regulating the pump driving signal (SCV driving current) applied to the SCV 5 of the fuel supply pump 4, so as to achieve the target common rail pressure Pt.

[0021] More preferably, a common rail pressure sensor 35 should be attached to the common rail 2, and the pump driving signal (the SCV driving current) applied to the solenoid coil of the SCV 5 of the fuel supply pump 4 should be feedback-controlled so that the common rail pressure PC sensed by the common rail pressure sensor 35 substantially coincides with the target common rail pressure Pt determined in accordance with the operating condition or the operating state of the engine 1. The driving current applied to the solenoid coil of the SCV 5 should preferably be controlled through duty cycle control. Highly precise digital control can be achieved by employing the duty cycle control in which the opening degree of the valve of the SCV 5 is controlled by regulating an on/off ratio of the pump driving signal per unit time (an energization period ratio, a duty ratio) in accordance with a pressure deviation ΔP between the common rail pressure PC and the target common rail pressure Pt, for instance.

[0022] The common rail pressure sensor 35 outputs an electric signal corresponding to the fuel pressure (the common rail pressure, the actual fuel pressure) in the common rail 2 corresponding to the injection pressure of the fuel injected into the combustion chambers of the respective cylinders of the engine 1.

[0023] In the present embodiment, a strain gauge type pressure sensor is employed as the common rail pressure sensor 35. Therefore, the ECU 10 has fuel pressure sensing means for calculating the common rail pressure (the actual fuel pressure) PC from the electric signal (a voltage signal, a pressure signal) outputted from the common rail pressure sensor 35. If the electric signal outputted from the common rail pressure sensor 35 is equal to or greater than an upper limit value (for instance, 5 V), the ECU 10 determines that a sensor abnormality is generated and does not perform a pump and injector abnormality diagnosis. In this case, the ECU 10 stops the feedback control by replacing the output of the common rail pressure sensor 35 with the target common rail pressure Pt, for instance. Then, the ECU 10 performs a fail-safe operation (a limp home operation) with an open loop. Alternatively, the ECU 10 outputs an engine stop demand instantly. The normally used voltage of the electric signal outputted from the common rail pressure sensor 35 is in a range from 0.5 V to 4.5 V, for instance.

[0024] Next, an abnormality diagnosing method of the fuel supply pump 4 and the injectors 3 of the embodiment will be explained based on Figs. 1 to 10. Fig. 2 is a flowchart showing a pump and injector abnormality diagnosing method. The main routine shown in Fig. 2 is executed at a predetermined time interval (100 ms, for instance).

[0025] The flowchart of the present embodiment corresponds to the control program stored in the memory. The flowchart shown in Fig. 2 is started when the ignition switch is switched from the off state (OFF) to the on state (ON) and the main relay is turned on to supply the ECU power from the battery to the ECU 10, and is repeatedly executed at the predetermined time interval. When the ignition switch is switched from the on state (ON) to the off state (OFF) so that the main relay is turned off and the ECU power supply to the ECU 10 is stopped, the execution of the flowchart is compulsorily ended.

[0026] If the main routine shown in Fig. 2 starts, the common rail pressure PC corresponding to the electric signal outputted from the common rail pressure sensor 35 is inputted in Step S1. Then, it is determined whether or not the common rail pressure sensor 35 is normal in Step S2. The determination of the normality of the common rail pressure sensor 35 is performed through a publicly known method of examining whether or not the electric signal (the output voltage) outputted from the common rail pressure sensor 35 is within a predetermined range (the normally used voltage range from 0.5 V to 4.5 V, for instance).

[0027] If the result of the determination in Step S2 is "NO", the main routine shown in Fig. 2 is ended without executing the abnormality diagnosis of the fuel supply pump 4 and the injector 3. If the result of the determination in Step S2 is "YES", the engine rotation speed NE sensed by the rotation speed sensor 31 is calculated in Step S3.

[0028] A crank angle sensor is employed as the rotation speed sensor 31. The rotation speed sensor 31 includes a signal rotor, a multiplicity of crank angle detection teeth and an electromagnetic pickup coil. The signal rotor rotates in accordance with the rotation of the crankshaft 21 of the engine 1. The signal rotor rotates once while the crankshaft 21 rotates once, for instance. The multiplicity of crank angle detection teeth is formed on the outer circumference of the signal rotor. The electromagnetic pickup coil generates NE signal pulses in accordance with approach and separation between the electromagnetic pickup coil and the crank angle detection teeth. The electromagnetic pickup coil outputs a plurality of NE signal pulses while the signal rotor rotates once (or while the crankshaft 21 rotates once). The ECU 10 can sense the engine rotation speed NE by measuring the time intervals of the NE signal pulses.

[0029] Then, in Step S4, pump allowance determination control shown in a graph of Fig. 3 and a subroutine of Figs. 4 to 6 is performed. Then, injector allowance determination control shown in a graph of Fig. 7 and a subroutine of Fig. 8 is performed in Step S5. Then, a fail-safe operation control shown in a table of Fig. 9 and a subroutine of Figs. 10 and 11 is performed in Step S6.

[0030] Next, the pump allowance determination control in Step S2 of the flowchart shown in Fig. 2 will be explained based on Figs. 3 to 6. Usually, the fuel supply pump 4 is designed on the premise that the fuel supply pump 4 is used in a pump usage allowable area "A" in Fig. 3. However, the common rail pressure PC may exceed a first threshold PCTH1 and may be brought into an area "B" if the common rail pressure PC is increased by some failures (for instance, an abnormality failure that the fuel discharging quantity increases and the ECU 10 cannot control the SCV 5). In this case, the common rail pressure PC should preferably be quickly dropped by a method of stopping the engine 1, for instance, in order to retain the reliability of the fuel supply pump 4. In Fig. 3, NEMAX represents a maximum value (6000 rpm, for instance) of the permissible rotation speed NE of the engine 1 for the fuel supply pump 4 and PLIMIT is the limit set pressure (the P/L opening pressure) of the common rail type fuel injection system. The limit set pressure PLIMIT is 250 MPa, for instance.

[0031] Generally, the fuel supply pump 4 of the common rail type fuel injection system has a structure for ensuring lubrication of a pumping mechanism with diesel oil as the fuel. Therefore, in an area where the engine rotation speed NE is very low (as shown by an area "C" in Fig. 3) or is very high (as shown by an area "D" in Fig. 3), the influence on the reliability becomes great. In the areas "C", "D" in Fig. 3, the fuel temperature excessively rises and the injector temperature or the injector leak temperature rises to a high value. Therefore, there is a possibility that heat resistance reliability of an insulating film of a rubber seal or a solenoid coil in the injector 3 and the like may be degraded.

[0032] There is a possibility that the performance of the fuel supply pump 4 may be degraded if a low-speed and high-pressure state shown by the area "C" in Fig. 3 or a high-speed and high-pressure state shown by the area "D" in Fig. 3 continues for a long time. The low-speed and high-pressure state is the state in which the engine rotation speed NE is equal to or lower than a predetermined value (1000 rpm, for instance) and the common rail pressure PC is high. The high-speed and high-pressure state is the state in which the engine rotation speed NE is equal to or higher than a predetermined value (5000 rpm, for instance) and the common rail pressure PC is high. It is because an oil lubrication film is hardly formed between a sliding contact portion of the camshaft and a sliding contact portion of the plunger of the fuel supply pump 4 in the low-speed and high-pressure state, although the oil lubrication film is formed in an usual state.

[0033] In the high-speed and high-pressure state, the oil lubrication film is easily cut, so the wear of the sliding portions or the seizing of the sliding portions due to heat generation can be caused easily. As a result, the performance degradation of the fuel supply pump 4 will proceed. Therefore, a second threshold PCTH2 is set in order to indicate the area where it may be difficult to ensure the fuel lubrication. The pressure limiter 16 of the present embodiment mechanically opens when the fuel pressure in the common rail 2 exceeds the P/L opening pressure PLIMIT (250 Mpa, in the present embodiment as shown in Fig. 3).

[0034] Next, the pump allowance determination control in Step S4 of the flowchart shown in Fig. 2 will be explained based on a flowchart shown in Figs. 4 to 6. The flowchart shown in Figs. 4 to 6 is a subroutine for detecting the stay of the operating state in the area exceeding the pump usage allowable area "A" shown in Fig. 3 without erroneous diagnosis.

[0035] First, the first threshold PCTH1 corresponding to the pump usage allowable area is calculated in Step S11 of the flowchart shown in Fig. 4. Then, it is determined whether or not the common rail pressure PC sensed by the common rail pressure sensor 35 is higher than the first threshold PCTH1 in Step S12. If the result of the determination in Step S12 is "YES", a counter CPMP1B is incremented in Step S13.

[0036] If the result of the determination in Step S12 is "NO", the counter CPMP1B is reset to zero in Step S14.

[0037] Then, it is determined whether or not a predetermined period has passed after the common rail pressure PC exceeds the first threshold PCTH1 in Step S15. More specifically, it is determined whether or not the counter CPMP1B is greater than a determination value KCPMP1B in Step S15. If the result of the determination in Step S15 is "YES", a flag XCPMP1B is raised, or the flag XCPMP1B is set to one (XCPMP1B = 1) in Step S16. The flag XCPMP1B is raised when the abnormally high-pressure state in the common rail type fuel injection system (specifically, in the common rail 2) is maintained continuously.

[0038] If the result of the determination in Step S15 is "NO", the flag XCPMP1B is reset (XCPMP1B = 0) in Step S17.

[0039] Then, in Step S18, it is determined whether or not the flag XCPMP1B is raised (XCPMP1B = 1). If the result of the determination in Step S18 is "NO", the processing proceeds directly to Step S22.

[0040] If the result of the determination in Step S18 is "YES", it is determined whether or not the previous value of the flag XCPMP1B is zero in Step S19. More specifically, it is determined whether or not XCPMP1B is incremented from zero to one in Step S19. If the result of the determination in Step S19 is "YES", a counter CPMP1 is incremented by an increment masking period KCPMP1B in Step S20.

[0041] If the result of the determination in Step S19 is "NO", the counter CPMP1 is incremented by one in Step S21.

[0042] The counter CPMP1B, which is incremented when the common rail pressure PC exceeds the first threshold PCTH1, functions as a masking for prohibiting the increment of the counter CPMP1 and is very important for excluding the following causes of the erroneous diagnosis.

[0043] The determination of whether or not the counter CPMP1B is greater than the increment masking period KCPMP1B is necessary in order to prohibit the increment of the counter CPMP1. Thus, causes of the erroneous diagnosis such as the noises instantaneously superposed on the electric signal (for instance, the pressure signal corresponding to the fuel pressure in the common rail 2) outputted from the common rail pressure sensor 35 can be excluded.

[0044] In the case where the abnormally high-pressure state caused by some abnormalities in the common rail 2 is quickly avoided by opening the pressure limiter 16, it is unnecessary to consider the influence on the reliability of the fuel supply pump 4. Therefore, in order to exclude such a situation, it should be determined whether or not the counter CPMP1B is greater than the increment masking period KCPMP1B.

[0045] For instance, when the engine is started in a state in which the fuel is empty, controllability of the common rail pressure is deteriorated for a predetermined period after the fuel supply is resumed because of excessive updating of an integral term in proportional integral control (PI control) or proportional integral and differential control (PID control), which is generally used as the common rail pressure control of the common rail type fuel injection system. However, such a situation is eliminated within a very short period. Therefore, in order to prevent the increment of the counter CPMP1B in such a situation, it should be determined whether or not the counter CPMP1B is greater than the increment masking period KCPMP1B.

[0046] Following steps from Step S22 to Step S31 and Step S32 are basically similar to the steps from Step S11 to Step S20 and Step S21, but it is determined whether or not the common rail pressure PC exceeds the second threshold PCTH2 in the steps from Step S22 to Step S31 and Step S32.

[0047] In Step S22, the second threshold PCTH2 is calculated. Then, in Step S23, it is determined whether or not the common rail pressure PC sensed by the common rail pressure sensor 35 is higher than the second threshold PCTH2. If the result of the determination in Step S23 is "YES", a counter CPMP2B is incremented in Step S24.

[0048] If the result of the determination in Step S23 is "NO", the counter CPMP2B is reset to zero in Step S25.

[0049] Then, in Step S26, it is determined whether or not a predetermined period has passed after the common rail pressure PC exceeds the second threshold PCTH2. More specifically, it is determined whether or not the counter CPMP2B is greater than a determination value KCPMP2B in Step S26. If the result of the determination in Step S26 is "YES", a flag XCPMP2B is raised, or the flag XCPMP2B is set to one (XCPMP2B = 1), in Step S27. The flag XCPMP2B is set to one when the abnormally high-pressure state in the common rail 2 is maintained continuously.

[0050] If the result of the determination in Step S26 is "NO", the flag XCPMP2B is lowered, or the flag XCPMP2B is reset to zero (XCPMP2B = 0), in Step S28.

[0051] Then, it is determined whether or not the flag XCPMP2B is raised, or the flag XCPMP2B is set to one (XCPMP2B = 1), in Step S29. If the result of the determination in Step S29 is "NO", the processing proceeds directly to Step S33.

[0052] If the result of the determination in Step S29 is "YES", it is determined whether or not the previous value of the flag XCPMP2B is zero in Step S30. More specifically, it is determined whether or not the flag XCPMP2B has been incremented from zero to one in Step S30. If the result of the determination in Step S30 is "YES", a counter CPMP2 is incremented by a value provided by multiplying an increment masking period KCPMP2B by a weight KWEIGHT in Step S31.

[0053] If the result of the determination in Step S30 is "NO", or if the flag XCPMP2B has not changed from zero to one but has remained one, the counter CPMP2 is incremented by the weight KWEIGHT in Step S32. The influence on the reliability of the fuel supply pump 4 generated in the case where the common rail pressure PC exceeds the first threshold PCTH1 differs from the influence in the case where the common rail pressure PC exceeds the second threshold PCTH2. Therefore, the counter CPMP2 is incremented by using the weight KWEIGHT, as shown in Step S31 and Step S32. The weight KWEIGHT takes a value (five, for instance) larger than one.

[0054] Then, the maximum value between the counter CPMP1, which is calculated in Step S20 or Step S21, and the counter CPMP2, which is calculated in Step S31 or Step S32, is selected as a counter CPMP in Step S33. Then, it is determined whether or not the counter CPMP is greater than a determination value KCPMP in Step S34. If the result of the determination in Step S34 is "YES", it is determined that a fail-safe operation for decreasing the common rail pressure PC is necessary in order to retain the reliability of the fuel supply pump 4. It is because the operating state is in the abnormally high-pressure state in which the pressure limiter 16 cannot open or takes a long time to open, if the counter CPMP is greater than the determination value KCPMP. Subsequently, a diagnosis flag XDGCPMP1 is set to one (XDGCPMP1 = 1) in Step S35.

[0055] If the result of the determination in Step S34 is "NO", the diagnosis flag XDGCPMP1 is reset (XDGCPMP1 = 0) in Step S36.

[0056] Steps from Step S37 to Step S43 are executed in the case where the common rail pressure PC higher than the second threshold PCTH2 is sensed, in particular when the engine 1 is started. First, in Step S37, it is determined whether or not the common rail pressure PC sensed by the common rail pressure sensor 35 is higher than the second threshold PCTH2. If the result of the determination in Step S37 is "YES", it is determined whether or not the engine rotation speed NE sensed by the rotation speed sensor 31 is higher than a determination value KNECPMP3 in Step S38.

[0057] If the result of the determination in Step S37 is "YES" and the result of the determination in Step S38 is "YES", a counter CPMP3 is incremented in Step S39. If the result of the determination in Step S37 or the result of the determination in Step S38 is "NO", the counter CPMP3 is reset (CPMP3 = 0) in Step S40.

[0058] When the engine 1 is in the situation where the pressure in the system (the common rail pressure PC) is increased to an abnormally high pressure because of generation of a failure, the situation of the abnormally high pressure may continue for a long time so long as the user turns the starter to start the engine 1. In this case, if an engine stopping operation is executed in the form of control through a fail-safe operation (explained after) while the engine 1 is being cranked, the user will repeat the cranking operation until the engine actually starts. As a result, the situation of the abnormally high pressure will continue for a long time, so as to generate a disadvantage for the reliability of the fuel supply pump 4. In this case, the damage to the reliability of the fuel supply pump 4, which is caused by unnecessary repetition of the cranking operation of the engine 1, can be reduced by allowing the engine start once and by performing the engine stop operation after determining whether or not the common rail pressure PC is higher than the second threshold PCTH2. More specifically, the operations in steps from Step S37 to Step S43 aim at providing a scheme for classifying the fail-safe operations by dividing the diagnosis flags XDGCPMP1, XDGCPMP3, which are used when the common rail pressure PC is higher than the second threshold PCTH2.

[0059] Then, it is determined whether or not the counter CPMP3 is greater than a determination value KCPMP3 in Step S41. If the result of the determination in Step S41 is "YES", a diagnosis flag XDGCPMP3 is set to one (XDGCPMP3 = 1) in Step S42. If the result of the determination in Step S41 is "NO", the diagnosis flag XDGCPMP3 is reset (XDGCPMP3 = 0) in Step S43. Then, the processing leaves the operation of Step S4 of the flowchart shown in Fig. 2.

[0060] Next, the injector allowance determination control of Step S5 of the flowchart shown in Fig. 2 will be explained based on Figs. 7 and 8. The influence on the reliability of the injector 3 is given by the common rail pressure PC, not by the engine rotation speed NE. Therefore, the injector allowance determination threshold is set to a fixed value KINJ (MPa), as shown in Fig. 7.

[0061] Next, the injector allowance determination control performed in Step S5 of the flowchart shown in Fig. 2 will be explained based on a flowchart shown in Fig. 8. The injector allowance determination control is performed in order to detect the stay of the operating state in the pressure area exceeding the injector usage allowable area "A'" shown in Fig. 7. First, in Step S51, it is determined whether or not the common rail pressure PC sensed by the common rail pressure sensor 35 is higher than the injector allowance determination threshold KINJ. If the result of the determination in Step S51 is "YES", a counter CINJ is incremented in Step S52. If the result of the determination in Step S51 is "NO", the counter CINJ is reset (CINJ = 0) in Step S53.

[0062] Then, in Step S54, it is determined whether or not the counter CINJ is greater than a predetermined allowance value KCINJ. If the result of the determination in Step S54 is "YES", a diagnosis flag XDGINJ is set to 1 (XDGINJ = 1) in Step S55. If the result of the determination in Step S54 is "NO", the diagnosis flag XDGINJ is reset (XDGINJ = 0) in Step S56.

[0063] The allowance value KCINJ is set to a permissible period for continuously applying the abnormally high pressure to the injector 3. Thus, an opening motion of the pressure limiter 16 in a short period, which does not affect the reliability of the injector 3, can be excluded from the factors that sets the diagnosis flag XDGINJ to one (XDGINJ = 1). Likewise, another effect of excluding instantaneous noises, which are superposed on the electric signal (the pressure signal corresponding to the fuel pressure in the common rail 2) outputted from the common rail pressure sensor 35, is also exerted.

[0064] Next, the fail-safe operation control performed in Step S6 of the flowchart shown in Fig. 2 will be explained based on Figs. 9 to 11.

[0065] A table shown in Fig. 9 enumerates relationships between three diagnosis flags XDGCPMP1, XDGCPMP3, XDGINJ and demanded fail-safe levels XFSENG1, XFSENG2, XFSQ, IDLE-UP. If the flag XDGCPMP3 is set to one (XDGCPMP3 = 1), the engine stop is demanded immediately (XFSENG1) because of the serious influence on the reliability of the fuel supply pump 4. If the flag XDGCPMP1 is set to one (XDGCPMP1 = 1), limp home traveling (refuge traveling) to a safer place is allowed by limiting the engine output (XFSQ) for a predetermined period, and the engine stop is demanded (XFSENG2) when the predetermined period passes after the limp hole traveling is started. If the flag XDGINJ is set to one (XDGINJ = 1), the engine stopping operation is not performed, but the limitation of the engine output is demanded (XFSQ). In the case where the flag XDGCPMP1 is set to one (XDGCPMP1 = 1), an idle-up operation for increasing idling rotation speed may be demanded (for instance, the idling rotation speed may be increased from 850 rpm to 1000 rpm). The advantage of not stopping the engine 1 immediately when the flag XDGCPMP1 is set to one is explained above (in the explanation of the steps from Step S37 to Step S43).

[0066] Next, the fail-safe operation control performed in Step S6 of the flowchart shown in Fig. 2 will be explained based on a flowchart shown in Figs. 10 and 11. The flowchart shown in Figs. 10 and 11 is a subroutine for realizing the demanded fail-safe level enumerated in the table shown in Fig. 9. First, in Step S61, it is determined whether or not the diagnosis flag XDGCP-MP3 has been set to one (XDGCPMP3 = 1). If the result of the determination in Step S61 is "YES", an immediate engine stop demanding flag XFSENG1 is set to one (XFSENG1 = 1) in Step S62.

[0067] If the result of the determination in Step S61 is "NO", the immediate engine stop demanding flag XFSENG1 is withdrawn (XFSENG1 = 0) in Step S63.

[0068] Then, in Step S64, it is determined whether or not the diagnosis flag XDGCPMP1 has been set to one (XDGCPMP1 = 1). If the result of the determination in Step S64 is "YES", a predetermined period later engine stop demanding flag XFSENG2 and an engine output limit demanding flag XFSQ for limiting the engine output for a predetermined period until the engine stops are set to one (XFSENG2 = 1, XFSQ = 1), respectively. Instead of setting the flag XFSQ to one, an idle-up ON flag may be set to one in Step S65.

[0069] If the result of the determination in Step S64 is "NO", the predetermined period later engine stop demanding flag XFSENG2 is withdrawn (XFSENG2 = 0) and the engine output limit demanding flag XFSQ is withdrawn (XFSQ = 0) in Step S66. Instead of setting the flag XFSQ to zero, an idle-up OFF flag may be set to one in Step S66.

[0070] Then, in Step S67, it is determined whether or not the diagnosis flag XDGINJ has been set to one (XDG-INJ = 1). If the result of the determination in Step S67 is "YES", the engine output limit demanding flag XFSQ is set to one (XFSQ = 1) in Step S68.

[0071] If the result of the determination in Step S67 is "NO", the processing proceeds to Step S69. In Step S69, it is determined whether or not the engine output limit demanding flag XFSQ has been set to one by setting the diagnosis flag XDGCPMP to one (XDGCPMP = 1) in Step S64. If the result of the determination in Step S69 is "YES", the diagnosis flag XDGCPMP has already been set to one (XDGCPMP = 1). Therefore, the processing proceeds directly to a determination operation in Step S71.

[0072] If the result of the determination in Step S69 is "NO", no diagnosis flag demands the setting of the engine output limit demanding flag XFSQ. Therefore, the engine output limit demanding flag XFSQ is withdrawn (XFSQ = 0) in Step S70.

[0073] Then, in Step S71, it is determined whether or not the immediate engine stop demanding flag XFSENG1 has been set to one (XFSENG1 = 1). If the result of the determination in Step S71 is "YES", an engine stop counter CFSENG is set to a predetermined value KCFSENG so as to stop the engine immediately in Step S72.

[0074] If the result of the determination in Step S71 is "NO", it is determined whether or not the predetermined period later engine stop demanding flag XFSENG2 has been set to one (XFSENG2 = 1) in Step S73. If the result of the determination in Step S73 is "YES", the engine stop counter CFSENG is incremented in Step S74.

[0075] If the result of the determination in Step S73 is "NO", the engine stop is not demanded. Therefore, the engine stop counter CFSENG is reset (CFSENG = 0) in Step S75.

[0076] Then, in Step S76, it is determined whether the engine stop counter CFSENG is "equal to or larger than" the predetermined value KCFSENG or not. If the result of the determination in Step S76 is "YES", an injection quantity limit value QLIMIT is set to 0 mm^3/st (QLIMIT = 0 mm^3/st) so as to stop the engine 1.

[0077] If the result of the determination in Step S76 is "NO", it is determined whether or not the engine output limit demanding flag XFSQ has been set to one (XFSQ = 1) in Step S78. If the result of the determination in Step S78 is "YES", the injection quantity limit value QLIMIT is calculated based on a one-dimensional map of the engine rotation speed NE in Step S79.

[0078] If the result of the determination in Step S78 is "NO", the injection quantity limit value QLIMIT is set to 100 mm^3/st (QLIMIT = 100 mm^3/st). The value of 100 mm^3/st is an example. Actually, in this case, the injection quantity limit value is set to a value greater than the maximum injection quantity of the engine 1, so that the actual injection quantity is not limited by the injection quantity limit value.

[0079] Then, in Step S81, the final injection quantity, or the command injection quantity QFIN, is set to the minimum value between the injection quantity limit value QLIMIT and the basic injection quantity QBASE. Then, the present routine is ended. The basic injection quantity QBASE is calculated through a well-known method based on the engine rotation speed NE, the accelerator position ACCP and a characteristic map made in advance by measurement through experiments and the like.

[0080] Then, the ECU 10 calculates the energization period (the command injection period) of the injection control electromagnetic valve of the injector 3 in accordance with the common rail pressure PC and the command injection quantity QFIN, based on a characteristic map made in advance by measurement through experiments and the like. At the command injection timing, the ECU 10 applies the pulse-shaped injector driving current to the injection control electromagnetic valve of the injector 3 of each cylinder through the injector driving circuit EDU for the command injection period. Thus, the nozzle needle of the injector 3 is opened so that the fuel injection quantity corresponding to the command injection quantity QFIN is injected into the combustion chamber of each cylinder of the engine 1. Thus, the rotation speed of the engine 1 is controlled.

[0081] As explained above, the first threshold PCTH1 corresponds to the upper limit pressure of the pump usage allowable area, which is important for retaining the reliability of the fuel supply pump 4. The second threshold PCTH2 avoids the performance degradation damage (for instance, the seizing of the sliding portion due to the deterioration in the fuel lubrication) of the fuel supply pump 4. The injector allowance determination threshold KINJ corresponds to the upper limit pressure of the injector usage allowable area, which is important for retaining the reliability of the injector 3. As shown in Figs. 3 and 7, the first threshold PCTH1, the second threshold PCTH2 and the injector allowance determination threshold KINJ are calculated based on the two-dimensional map of the common rail pressure PC and the engine rotation speed NE or the one-dimensional map of the engine rotation speed NE.

[0082] In the case where the abnormally high-pressure state, in which the common rail pressure PC exceeds the first threshold PCTH1 or the second threshold PCTH2, continues for a long time, it is determined that the abnormally high-pressure state due to the abnormality failure of the fuel supply pump 4 is formed. More specifically, the situation of the prolonged continuation of the abnormally high-pressure state in the common rail 2 where the pressure limiter 16 takes a long time to open or cannot open can be detected highly precisely. In order to prevent the seizing or the like of the fuel supply pump 4, the emergency operation (the fail-safe operation) is performed. In accordance with the level of the abnormality, the engine is stopped immediately when such a situation is detected or when a predetermined period passes after the situation is detected. Thus, the abnormally high-pressure state in the common rail 2 can be avoided quickly and the seizing and the like of the fuel supply pump 4 can be prevented without raising the system cost. Thus, the reliability and the safety of the common rail type fuel injection system can be ensured.

[0083] In the case where the abnormally high-pressure state, in which the common rail pressure PC exceeds the injector allowance determination threshold KINJ, continues for a long time, it is determined that the abnormality failure of the injector 3 is generated and it is determined that the abnormally high-pressure state due to the abnormality failure is generated. More specifically, the situation of the prolonged abnormally high-pressure state in the common rail 2 where the pressure limiter 16 takes a long time to open or cannot open can be detected highly precisely. In order to avoid the abnormally high-pressure state in the common rail 2, the injection quantity of the fuel injected into the combustion chamber of each cylinder of the engine 1 is limited to decrease the engine rotation speed to the predetermined value or under, or the injection quantity in the idling operation is increased to a predetermined value or over in order to perform the idle-up operation. Thus, the abnormally high-pressure state in the common rail 2 can be avoided quickly. As a result, the reliability and the safety of the common rail type fuel injection system can be ensured.

[0084] When one of the diagnosis flags XDGCPMP1, XDGCPMP3 enumerated in the table shown in Fig. 9 is detected, or when one of the diagnosis flags XDGCPMP1, XDGCPMP3 is set to one, it can be determined that the abnormality failures including the functional degradation or the performance degradation of the SCV 5 due to the degradation with time caused by extraneous matters stuck into the valve hole of the SCV 5, or the fully opening abnormality of the SCV 5 due to a characteristic abnormality, breakage in the pump driving signal transmitting wire harness or the control abnormality of the ECU 10 are generated in the fuel supply pump 4. Therefore, when one of the diagnosis flags XDGCPMP1, XDGCPMP3 is detected, visual displaying means such as an abnormality warning lamp (an indicator lamp) or aural displaying means such as voice and the like may be used to urge the vehicle driver to replace the fuel supply pump 4. Thus, the deterioration in the reliability of the fuel supply pump 4 and the SCV 5 can be detected highly precisely, and the user can be urged at suitable timing to replace the fuel supply pump 4 or the SCV 5, whose reliability is degraded, with the normal fuel supply pump 4 or the normal SCV 5.

[0085] When the diagnosis flag XDGINJ enumerated in the table shown in Fig. 9 is detected, or when the diagnosis flag XDGINJ is set to one (XDGINJ = 1), it can be determined that the abnormality failures including the functional degradation (the performance degradation or the reliability deterioration) of the injector 3 due to degradation with time caused by extraneous matters stuck into the high-pressure sealing portion of the injector 3 or the abnormality such as the fully opening abnormality, fully closing abnormality or no injection abnormality of the injector 3 due to the breakage in the injector driving signal transmitting wire harness or due to the control abnormality of the ECU 10 are generated in the injector 3. Therefore, when the diagnosis flag XDGINJ is detected, visual displaying means such as an abnormality warning lamp (an indicator lamp), or aural displaying means such as voice may be used to urge the driver to replace the injector 3. Thus, the deterioration in the reliability of the injector 3 can be detected highly precisely, and the user can be urged to replace the injector 3, whose reliability is degraded, with the normal injector 3 at suitable timing.

(Modifications)

[0086] In the present embodiment, the common rail pressure sensor 35 is attached directly to the common rail 2 to detect the fuel pressure (the common rail pressure, the actual fuel pressure) in the common rail 2. Alternatively, the common rail pressure sensor 35 may be attached to the fuel pipe and the like leading from the plunger chamber (the pressurizing chamber) of the fuel supply pump 4 to the fuel passage in the injector 3 to detect the discharge pressure of the fuel discharged from the pressurizing chamber of the fuel supply pump 4, or the injection pressure of the fuel injected into the combustion chamber of each cylinder of the engine 1.

[0087] In the present embodiment, the SCV (the drawing quantity control electromagnetic valve) 5 for changing (controlling) the drawing quantity of the fuel drawn into the plunger chamber (the pressurizing chamber) of the fuel supply pump 4 is employed. Alternatively, a discharging quantity control electromagnetic valve for changing (controlling) the discharging quantity of the fuel discharged from the plunger chamber (the pressurizing chamber) of the fuel supply pump 4 to the common rail 2 may be employed. In the present embodiment, the SCV 5 of the normally open type electromagnetic valve, which opens fully when the energization to the electromagnetic valve is stopped, is employed. Alternatively, a normally open type discharging quantity control electromagnetic valve, which opens fully when the energization to the electromagnetic valve is stopped, may be employed. A normally close type discharging quantity control electromagnetic valve or a normally close type drawing quantity control electromagnetic valve, which fully opens when energized, may also be used.

[0088] In the present embodiment, the command injection quantity QFIN, the command injection timing T and the target common rail pressure Pt are calculated by using the rotation speed sensor 31, the accelerator position sensor 32, the cooling water temperature sensor 33 and the fuel temperature sensor 34 as the operating condition detecting means for detecting the operating conditions of the engine 1. The command injection quantity QFIN, the command injection timing T and the target common rail pressure Pt may be corrected by considering the detection signals (the engine operating information) outputted from other sensors as the operating condition detecting means such as an intake temperature sensor, an intake pressure sensor, a cylinder determination sensor or an injection timing sensor.

[0089] In the present embodiment, the ECU 10 stops the operation of the engine 1 when the state in which the common rail pressure PC is higher than the first threshold PCTH1 or the second threshold PCTH2 continues for a predetermined period. Alternatively, the ECU 10 may stop the operation of the engine 1 if a state in which the common rail pressure PC is higher than the first threshold PCTH1 and is lower than the second threshold PCTH2 continues for a predetermined period. Alternatively, the ECU 10 may stop the operation of the engine 1 if the common rail pressure PC exceeds the second threshold PCTH2. Thus, the reliability of the fuel supply pump 4 can be improved further.

[0090] The present invention should not be limited to the disclosed embodiment, but may be implemented in many other ways without departing from the scope of the claims.

Claims

1. A pressure accumulation type fuel injection system for accumulating high-pressure fuel, which is pressurized and pressure-fed by a fuel supply pump (4) driven by an engine (1), in a common rail (2) and for injecting the high-pressure fuel accumulated in the common rail (2) into a cylinder of the engine (1) through an injector (3), the pressure accumulation type fuel injection system including a pressure safety valve (16) that opens when the fuel pressure in the common rail (2) exceeds a limit set pressure in order to limit the fuel pressure in the common rail (2) to the limit set pressure or under, comprising:

   fuel pressure sensing means (35) for sensing the fuel pressure in the common rail (2); and
   an engine control unit (10) for controlling the engine (1) to avoid further continuation of an abnormally high-pressure state, in which the fuel pressure in the common rail (2) sensed by the fuel pressure sensing means (35) exceeds at least one of a pump usage allowable area, the fuel pressure in the common rail above which adversely affects reliability of the fuel supply pump (4), and an injector usage allowable area, the fuel pressure in the common rail above which adversely affects reliability of the injector (3), when the abnormally high-pressure state continues for a predetermined period;
   wherein the engine control unit (10) includes abnormality diagnosing means (S5) for detecting an abnormality failure of the injector (3) when an abnormally high-pressure state, in which the fuel pressure in the common rail (2) sensed by the fuel pressure sensing means (35) exceeds a determination value corresponding to the injector usage allowable area, continues for a predetermined period; and
   the engine control unit (10) demands limitation of an engine output of the engine (1) or an idle-up operation for increasing idling rotation speed of the engine (1) when the abnormality failure of the injector (3) is detected by the abnormality diagnosing means (S5), wherein
   the engine control unit (10) includes rotation speed sensing means (S3) for sensing engine rotation speed; **characterized in that**
   the determination value corresponding to the injector usage allowable area is calculated in accordance with the engine rotation speed sensed by the rotation speed sensing means (S3).

2. The pressure accumulation type fuel injection system as in claim 1, further **characterized in that** the engine control unit (10) includes abnormality diagnosing means (S4, S5) for detecting an abnormality failure of the fuel supply pump (4) or the injector (3) and visual or aural displaying means for urging replacement of the fuel supply pump (4) or the injector (3) when the abnormality failure of the fuel supply

pump (4) or the injector (3) is detected by the abnormality diagnosing means (S4, S5).

3. The pressure accumulation type fuel injection system as in claim 1, further **characterized in that** the engine control unit (10) includes first abnormality diagnosing means (S2) for detecting an abnormality failure of the fuel pressure sensing means (35) and second abnormality diagnosing means (S4, S5) for detecting an abnormality failure of the fuel supply pump (4) or the injector (3), and
the engine control unit (10) prohibits the detection of the abnormality failure of the fuel supply pump (4) or the injector (3) with the second abnormality diagnosing means (S4, S5) if the abnormality failure of the fuel pressure sensing means (35) is detected by the first abnormality diagnosing means (S2).

4. The pressure accumulation type fuel injection system as in claim 1, further **characterized in that** the fuel supply pump (4) includes a pressurizing chamber for pressurizing the fuel drawn through a fuel suction passage and includes a suction control valve (5) for regulating the fuel pressure in the common rail (2) by changing a discharging quantity of the fuel discharged from the pressurizing chamber into the common rail (2) in accordance with an opening area of the fuel suction passage or a lifting degree of a valve member; and
the suction control valve (5) is a normally open type electromagnetic valve, which opens fully when energization thereto is stopped.

5. The pressure accumulation type fuel injection system as in claim 1, further **characterized in that** the engine control unit (10) sets a first weight added to a first elapsed time of a state in which the fuel pressure in the common rail (2) continuously exceeds the first determination value and a second weight added to a second elapsed time of a state in which the fuel pressure in the common rail (2) continuously exceeds the second determination value so that the second weight is greater than the first weight, and
the engine control unit (10) stops the operation of the engine (1) when the sum of the first elapsed time and the first weight or the sum of the second elapsed time and the second weight exceeds a predetermined value.

6. The pressure accumulation type fuel injection system as in claim 1, further **characterized in that** the engine control unit (10) stops the operation of the engine (1) when a state in which the fuel pressure in the common rail (2) is higher than the first determination valve and is lower than the second determination value continues for a predetermined period.

7. The pressure accumulation type fuel injection system as in claim 1, further **characterized in that** the engine control unit (10) stops the operation of the engine (1) when the fuel pressure in the common rail (2) exceeds the second determination value.

Patentansprüche

1. Kraftstoffeinspritzsystem der Druckspeicherbauart zum Speichern von Hochdruckkraftstoff, der durch eine von einer Kraftmaschine (1) ange-triebenen Kraftstoffzuführpumpe (4) mit Druck beaufschlagt und unter Druck zugeführt wird, in einer Common-Rail (2), und zum Einspritzen des in der Common-Rail (2) gespeicherten Hochdruckkraftstoffs in einen Zylinder der Kraftmaschine (1) durch einen Injektor (3), wobei das Kraftstoffeinspritzsystem der Druckspeicherbauart ein Drucksicherheitsventil (16) aufweist, das dann öffnet, wenn der Kraftstoffdruck in der Common-Rail (2) einen Grenzeinstelldruck überschreitet, um den Kraftstoffdruck in der Common-Rail (2) auf den Grenzeinstelldruck oder darunter zu begrenzen, mit:

   einem Kraftstoffdruckerfassungsmittel (35) zum Erfassen des Kraftstoffdrucks in der Common-Rail (2); und
   eine Kraftmaschinensteuereinheit (10) zum Steuern der Kraftmaschine (1), um ein weiteres Andauern eines anormalen Hochdruckzustands zu vermeiden, in welchem der durch das Kraftstoffdruckerfassungsmittel (35) erfasste Kraftstoffdruck in der Common-Rail (2) zumindest eines von einem Pumpenverwendungszulässigkeitsbereich, über dem der Kraftstoffdruck in der Common-Rail die Zuverlässigkeit der Kraftstoffzuführpumpe (4) nachteilig beeinträchtigt, und einen Injektorverwendungszulässigkeitsbereich, über dem der Kraftstoffdruck in der Common-Rail die Zuverlässigkeit des Injektors (3) nachteilig beeinträchtigt, überschreitet, wenn der anormale Hochdruckzustand für eine vorbestimmte Zeitspanne andauert;
   wobei die Kraftmaschinensteuereinheit (10) ein Anormalitätsdiagnosemittel (S5) zum Erfassen eines Anormalitätsfehlers des Injektors (3), wenn ein anormaler Hochdruckzustand, in dem der durch das Kraftstoffdruckerfassungsmittel (35) erfasste Kraftstoffdruck in der Common-Rail (2) einen dem Injektorverwendungszulässigkeitsbereich entsprechenden Bestimmungswert überschreitet, für eine vorbestimmte Zeitspanne andauert; und
   die Kraftmaschinensteuereinheit (10) die Begrenzung einer Kraftmaschinenabgabe der Kraftmaschine (1) oder einen Leerlaufbetrieb zum Erhöhen der Leerlaufdrehzahl der Kraftma-

schine (1) nachfragt, wenn der Anormalitätsfehler des Injektors (3) durch das Anormalitätsdiagnosemittel (S5) erfasst wird, wobei
die Kraftmaschinensteuereinheit (10) ein Drehzahlerfassungsmittel (S3) zum Erfassen der Kraftmaschinendrehzahl aufweist, **dadurch gekennzeichnet, dass**
der dem Injektorverwendungszulässigkeitsbereich entsprechende Bestimmungswert in Übereinstimmung mit der durch das Drehzahlerfassungsmittel (S3) erfassten Kraftmaschinendrehzahl berechnet wird.

2. Kraftstoffeinspritzsystem der Druckspeicherbauart gemäß Anspruch 1, ferner **dadurch gekennzeichnet, dass**
die Kraftmaschinensteuereinheit (10) Anormalitätsdiagnosemittel (S4, S5) zum Erfassen eines Anormalitätsfehlers der Kraftstoffzuführpumpe (4) oder des Injektors (3) und ein visuelles oder auditives Anzeigemittel zum Zwingen des Austauschs der Kraftstoffzuführpumpe (4) oder des Injektors (3) aufweist, wenn der Anormalitätsfehler der Kraftstoffzuführpumpe (4) oder des Injektors (3) durch das Anormalitätsdiagnosemittel (S4, S5) erfasst wird.

3. Kraftstoffeinspritzsystem der Druckspeicherbauart gemäß Anspruch 1, ferner **dadurch gekennzeichnet, dass**
die Kraftmaschinensteuereinheit (10) ein erstes Anormalitätsdiagnosemittel (S2) zum Erfassen eines Anormalitätsfehlers des Kraftstoffdruckerfassungsmittels (35) und ein zweites Anormalitätsdiagnosemittel (S4, S5) zum Erfassen eines Anormalitätsfehlers der Kraftstoffzuführpumpe (4) oder des Injektors (3) aufweist, und
die Kraftmaschinensteuereinheit (10) das Erfassen des Anormalitätsfehlers der Kraftstoffzuführpumpe (4) oder des Injektors (3) mit dem zweiten Anormalitätsdiagnosemittel (S4, S5) verhindert, falls der Anormalitätsfehler des Kraftstoffdruckerfassungsmittels (35) durch das erste Anormalitätsdiagnosemittel (S2) erfasst wird.

4. Kraftstoffeinspritzsystem der Druckspeicherbauart gemäß Anspruch 1, ferner **dadurch gekennzeichnet, dass**
die Kraftstoffzuführpumpe (4) eine Druckbeaufschlagungskammer zum Druckbeaufschlagen des durch einen Kraftstoffansaugdurchlass angesaugten Kraftstoffs aufweist und ein Ansaugsteuerventil (5) zum Regeln des Kraftstoffdrucks in der Common-Rail (2) durch Ändern einer Abgabemenge des von der Druckbeaufschlagungskammer in die Common-Rail (2) abgegebenen Kraftstoffs in Übereinstimmung mit einer Öffnungsfläche des Kraftstoffansaugdurchlasses oder eines Anhubgrads des Ventilelements aufweist; und
das Ansaugsteuerventil (5) ein elektromagnetisches Ventil der normalerweise offenen Bauart ist, das vollständig öffnet, wenn seine Erregung gestoppt ist.

5. Kraftstoffeinspritzsystem der Druckspeicherbauart gemäß Anspruch 1, ferner **dadurch gekennzeichnet, dass**
die Kraftmaschinensteuereinheit (10) ein erstes Gewicht, das einer ersten verstrichenen Zeit eines Zustands hinzugefügt wird, in dem der Kraftstoffdruck in der Common-Rail (2) den ersten Bestimmungswert kontinuierlich überschreitet, und ein zweites Gewicht, das einer zweiten verstrichenen Zeit eines Zustands hinzugefügt wird, in welchem der Kraftstoffdruck in der Common-Rail (2) den zweiten Bestimmungswert kontinuierlich überschreitet, so festlegt, dass das zweite Gewicht größer als das erste Gewicht ist, und
die Kraftmaschinensteuereinheit (10) den Betrieb der Kraftmaschine (1) dann stoppt, wenn die Summe aus der ersten verstrichenen Zeit und des ersten Gewichts oder die Summe aus der zweiten verstrichenen Zeit und des zweiten Gewichts einen vorbestimmten Wert überschreitet.

6. Kraftstoffeinspritzsystem der Druckspeicherbauart gemäß Anspruch 1, ferner **dadurch gekennzeichnet, dass**
die Kraftmaschinensteuereinheit (10) den Betrieb der Kraftmaschine (1) stoppt, wenn ein Zustand, in dem der Kraftstoffdruck in der Common-Rail (2) höher als der erste Bestimmungswert und niedriger als der zweite Bestimmungswert ist, für eine vorbestimmte Zeitspanne andauert.

7. Kraftstoffeinspritzsystem der Druckspeicherbauart gemäß Anspruch 1, ferner **dadurch gekennzeichnet, dass**
die Kraftmaschinensteuereinheit (10) den Betrieb der Kraftmaschine (1) stoppt, wenn der Kraftstoffdruck in der Common-Rail (2) den zweiten Bestimmungswert überschreitet.

Revendications

1. Système d'injection de carburant à accumulation de pression destiné à accumuler un carburant à haute pression, qui est pressurisé et fourni par pression par une pompe d'approvisionnement en carburant (4) entraînée par un moteur (1), dans un rail commun (2), et à injecter le carburant à haute pression accumulé dans le rail commun (2) dans un cylindre du moteur (1) par le biais d'un injecteur (3), le système d'injection de carburant à accumulation de pression comprenant une soupape de sécurité (16) qui s'ouvre lorsque la pression du carburant dans le rail commun (2) dépasse une limite de pression prédé-

finie afin de limiter la pression du carburant dans le rail commun (2) à la valeur de pression limite prédéfinie, ou en-dessous, qui comprend :

un moyen de détection de la pression du carburant (35) destiné à détecter la pression du carburant dans le rail commun (2) ; et
une unité de commande du moteur (10) destinée à contrôler le moteur (1) afin d'éviter toute poursuite d'un état de pression anormalement haute, dans lequel la pression du carburant dans le rail commun (2) détectée par le moyen de détection de pression du carburant (35) dépasse au moins l'une d'une zone limite d'utilisation de la pompe, de la pression du carburant dans le rail commun au-dessus de laquelle la fiabilité de la pompe d'alimentation en carburant (4) peut être affectée de manière négative, d'une zone limite d'utilisation de l'injecteur, et de la pression du carburant dans le rail commun au-dessus de laquelle la fiabilité de l'injecteur (3) peut être affectée de manière négative, lorsque l'état de pression anormalement haute se poursuit pendant une durée prédéterminée ;
dans lequel l'unité de commande du moteur (10) comprend un moyen de diagnostic d'anormalité (S5) destiné à détecter toute défaillance de l'injecteur (3) lorsqu'un état de pression anormalement élevée, dans lequel la pression du carburant dans le rail commun (2) détectée par le moyen de détection de pression du carburant (35) dépasse une valeur de détermination qui correspond à la zone limite d'utilisation de l'injecteur, se poursuit pendant une durée prédéterminée ; et
l'unité de commande du moteur (10) exige la limitation de la puissance de sortie du moteur (1) ou une opération d'accélération afin d'augmenter la vitesse de rotation au ralenti du moteur (1) lorsque la défaillance de l'injecteur (3) est détectée par le moyen de diagnostic d'anormalité (S5), dans lequel
l'unité de commande du moteur (10) comprend un moyen de détection de la vitesse de rotation (S3) destiné à détecter la vitesse de rotation du moteur ; **caractérisé en ce que**
la valeur de détermination qui correspond à la zone limite d'utilisation de l'injecteur est calculée selon la vitesse de rotation du moteur détectée par le moyen de détection de la vitesse de rotation (S3).

2. Système d'injection de carburant à accumulation de pression selon la revendication 1, **caractérisé en outre en ce que**
l'unité de commande du moteur (10) comprend un moyen de diagnostic d'anormalité (S4, S5) destiné à détecter une défaillance de la pompe d'alimentation en carburant (4) ou de l'injecteur (3), et un moyen d'affichage visuel ou sonore destiné à demander le remplacement de la pompe d'alimentation en carburant (4) ou de l'injecteur (3) lorsque la défaillance de la pompe d'alimentation en carburant (4) ou de l'injecteur (3) est détectée par le moyen de diagnostic d'anormalité (S4, S5).

3. Système d'injection de carburant à accumulation de pression selon la revendication 1, **caractérisé en outre en ce que**
l'unité de commande du moteur (10) comprend un premier moyen de diagnostic d'anormalité (S2) destiné à détecter une défaillance du moyen de détection de pression du carburant (35), et un second moyen de diagnostic d'anormalité (S4, S5) destiné à détecter une défaillance de la pompe d'alimentation en carburant (4) ou de l'injecteur (3), et
l'unité de commande du moteur (10) empêche la détection de la défaillance de la pompe d'alimentation en carburant (4) ou de l'injecteur (3) avec le second moyen de diagnostic d'anormalité (S4, S5) si la défaillance du moyen de détection de pression du carburant (35) est détectée par le premier moyen de diagnostic d'anormalité (S2).

4. Système d'injection de carburant à accumulation de pression selon la revendication 1, **caractérisé en outre en ce que**
la pompe d'alimentation en carburant (4) comprend une chambre de pressurisation destinée à pressuriser le carburant aspiré par un passage d'aspiration du carburant, et comprend une soupape de commande d'aspiration (5) destinée à réguler la pression du carburant dans le rail commun (2) en modifiant une quantité d'évacuation du carburant évacué par la chambre de pressurisation dans le rail commun (2) selon une zone d'ouverture du passage d'aspiration de carburant ou un degré de levage d'une soupape ; et
la soupape de commande d'aspiration (5) est une soupape électromagnétique normalement ouverte, qui s'ouvre entièrement lorsque son alimentation en énergie est coupée.

5. Système d'injection de carburant à accumulation de pression selon la revendication 1, **caractérisé en outre en ce que**
l'unité de commande du moteur (10) définit un premier poids ajouté à une première durée écoulée d'un état dans lequel la pression du carburant dans le rail commun (2) dépasse en continu la première valeur de détermination, et un second poids ajouté à une seconde durée écoulée d'un état dans lequel la pression du carburant dans le rail commun (2) dépasse en continu la seconde valeur de détermination de sorte que le second poids soit supérieur au premier, et

l'unité de commande du moteur (10) arrête le moteur (1) lorsque la somme de la première durée écoulée et du premier poids ou la somme de la seconde durée écoulée et du second poids dépasse une valeur prédéterminée.

6. Système d'injection de carburant à accumulation de pression selon la revendication 1, **caractérisé en outre en ce que**
l'unité de commande du moteur (10) arrête le moteur (1) lorsqu'un état dans lequel la pression du carburant dans le rail commun (2) est supérieure à la première valeur de détermination et est inférieure à la seconde valeur de détermination se poursuit pendant une durée prédéterminée.

7. Système d'injection de carburant à accumulation de pression selon la revendication 1, **caractérisé en outre en ce que**
l'unité de commande du moteur (10) arrête le moteur (1) lorsque la pression du carburant dans le rail commun (2) dépasse la seconde valeur de détermination.

FIG. 1

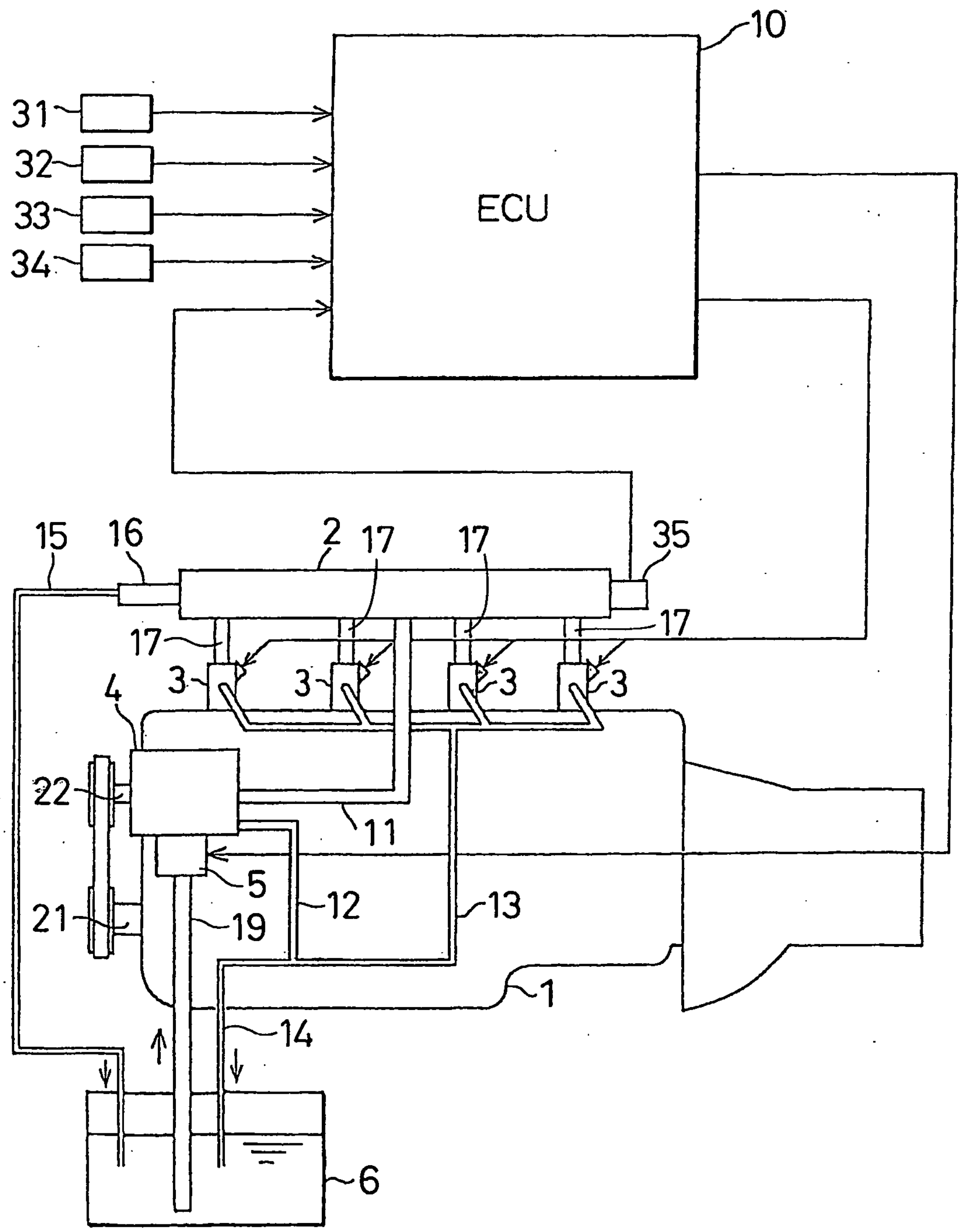

10
ECU
31
32
33
34
15
16
2
17
17
35
17
17
3
3
3
3
4
22
11
5
12
13
21
19
1
14
6

FIG. 2

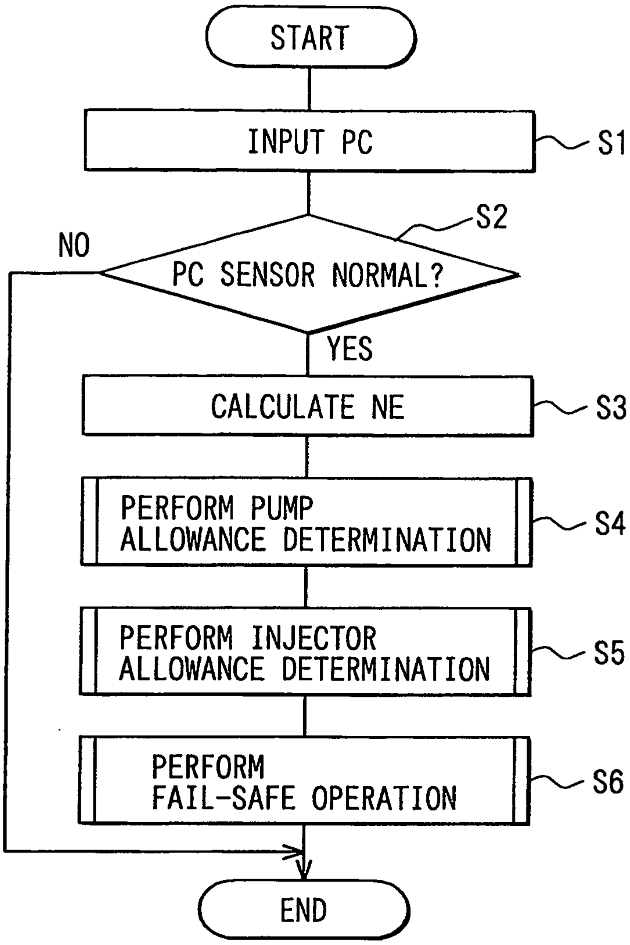

START
INPUT PC
S1
S2
NO
PC SENSOR NORMAL?
YES
CALCULATE NE
S3
PERFORM PUMP ALLOWANCE DETERMINATION
S4
PERFORM INJECTOR ALLOWANCE DETERMINATION
S5
PERFORM FAIL-SAFE OPERATION
S6
END

FIG. 3

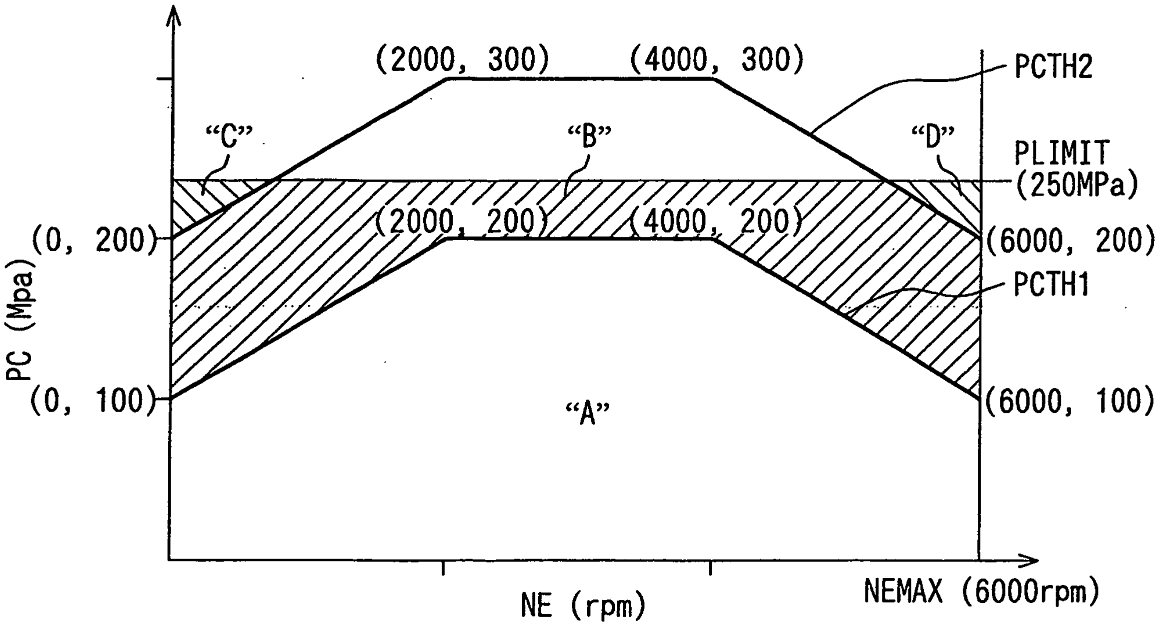

(2000, 300)
(4000, 300)
PCTH2
"C"
"B"
"D"
PLIMIT (250MPa)
(0, 200)
(2000, 200)
(4000, 200)
(6000, 200)
PCTH1
PC (Mpa)
(0, 100)
"A"
(6000, 100)
NE (rpm)
NEMAX (6000rpm)

FIG. 4

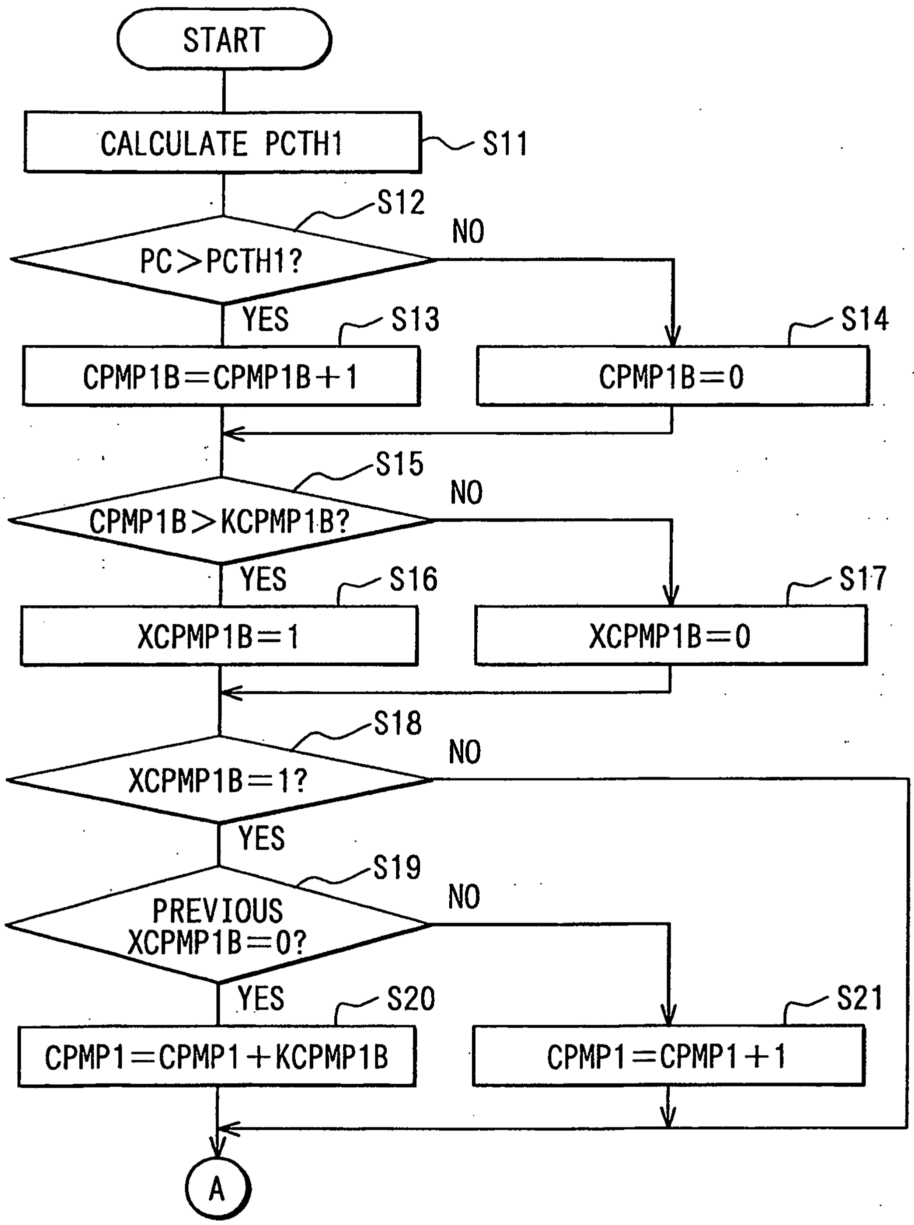

START
CALCULATE PCTH1
S11
S12
PC>PCTH1?
NO
YES
S13
S14
CPMP1B=CPMP1B+1
CPMP1B=0
S15
CPMP1B>KCPMP1B?
NO
YES
S16
S17
XCPMP1B=1
XCPMP1B=0
S18
XCPMP1B=1?
NO
YES
S19
PREVIOUS XCPMP1B=0?
NO
YES
S20
S21
CPMP1=CPMP1+KCPMP1B
CPMP1=CPMP1+1
A

FIG. 5

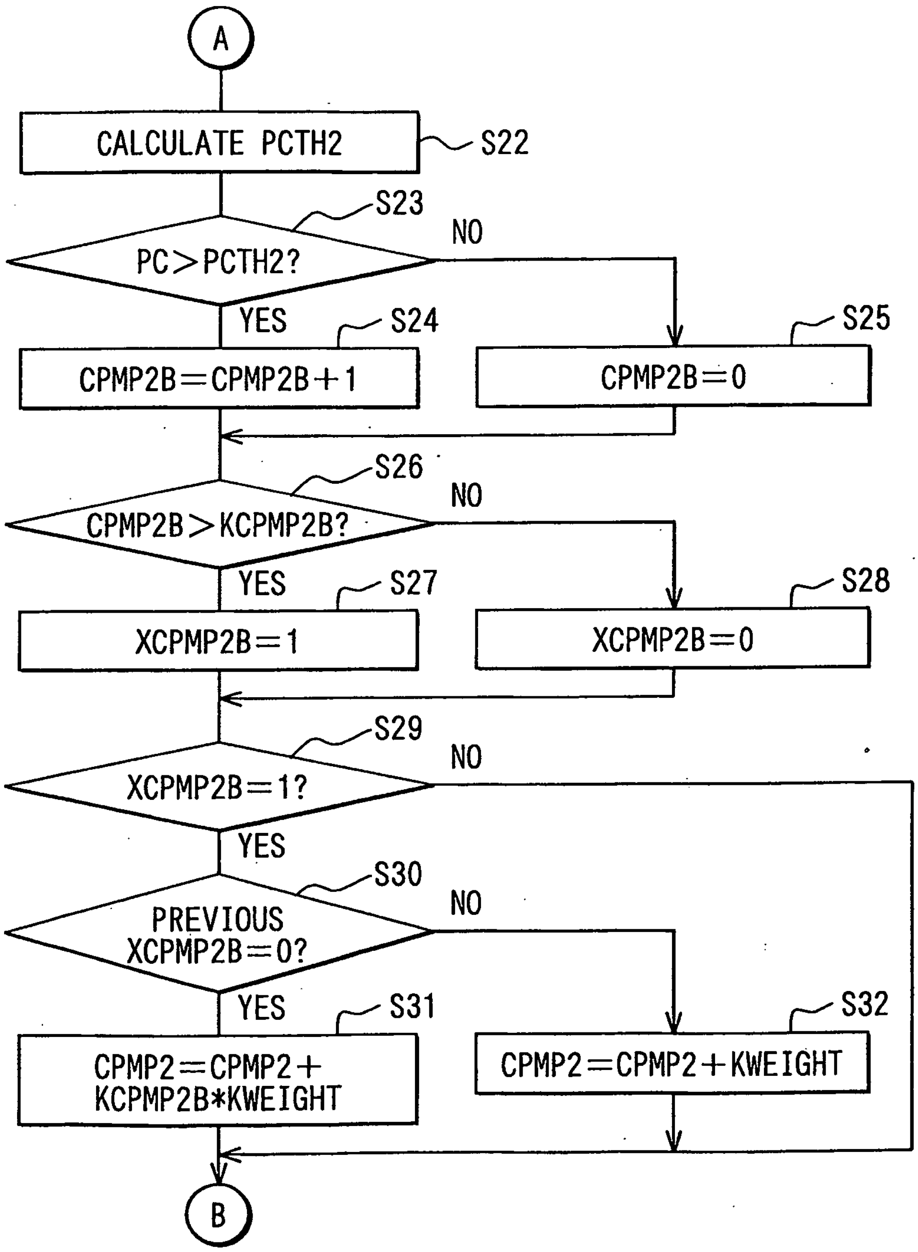

A
CALCULATE PCTH2
S22
S23
PC>PCTH2?
NO
YES
S24
S25
CPMP2B=CPMP2B+1
CPMP2B=0
S26
CPMP2B>KCPMP2B?
NO
YES
S27
S28
XCPMP2B=1
XCPMP2B=0
S29
XCPMP2B=1?
NO
YES
S30
PREVIOUS XCPMP2B=0?
NO
YES
S31
S32
CPMP2=CPMP2+ KCPMP2B*KWEIGHT
CPMP2=CPMP2+KWEIGHT
B

FIG. 6

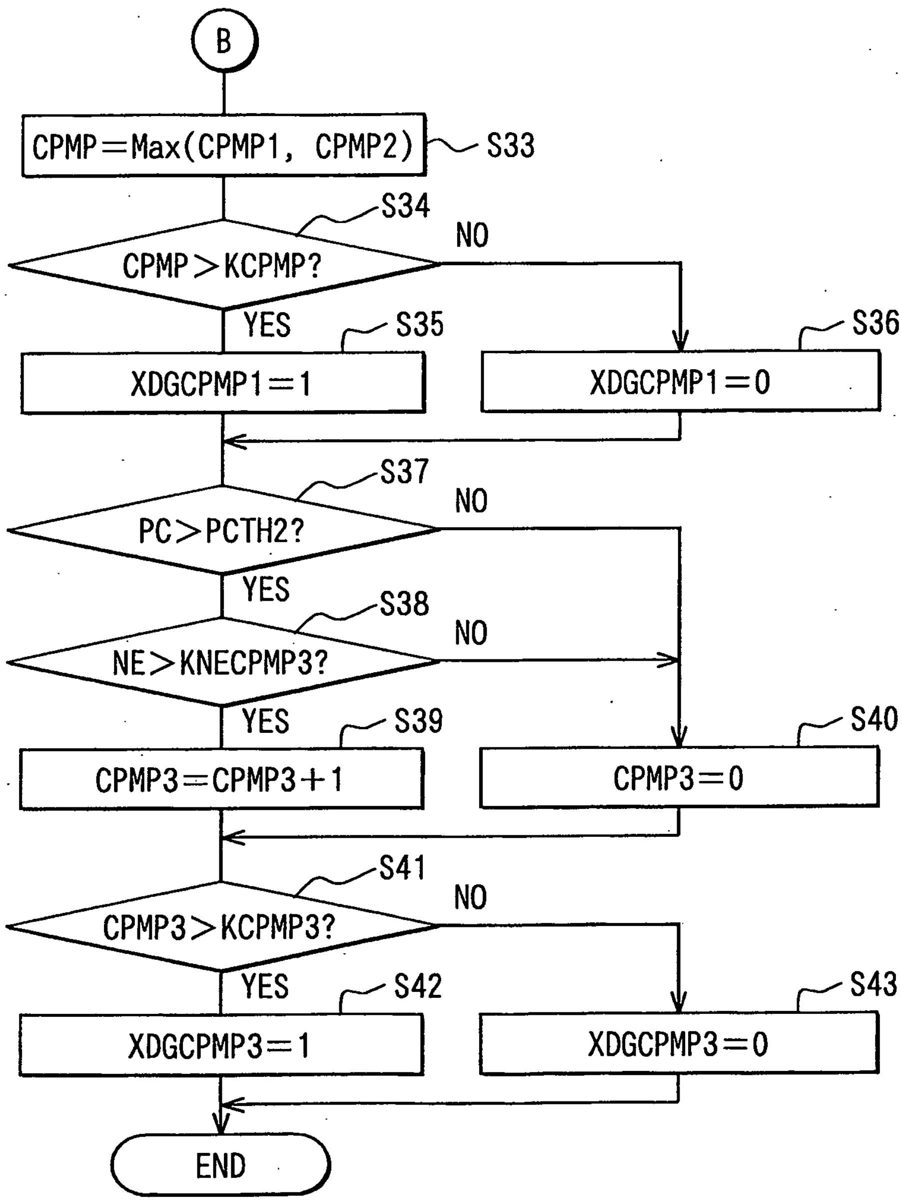

B
CPMP=Max(CPMP1, CPMP2)
S33
S34
CPMP>KCPMP?
NO
YES
S35
XDGCPMP1=1
S36
XDGCPMP1=0
S37
PC>PCTH2?
NO
YES
S38
NE>KNECPMP3?
NO
YES
S39
CPMP3=CPMP3+1
S40
CPMP3=0
S41
CPMP3>KCPMP3?
NO
YES
S42
XDGCPMP3=1
S43
XDGCPMP3=0
END

FIG. 7

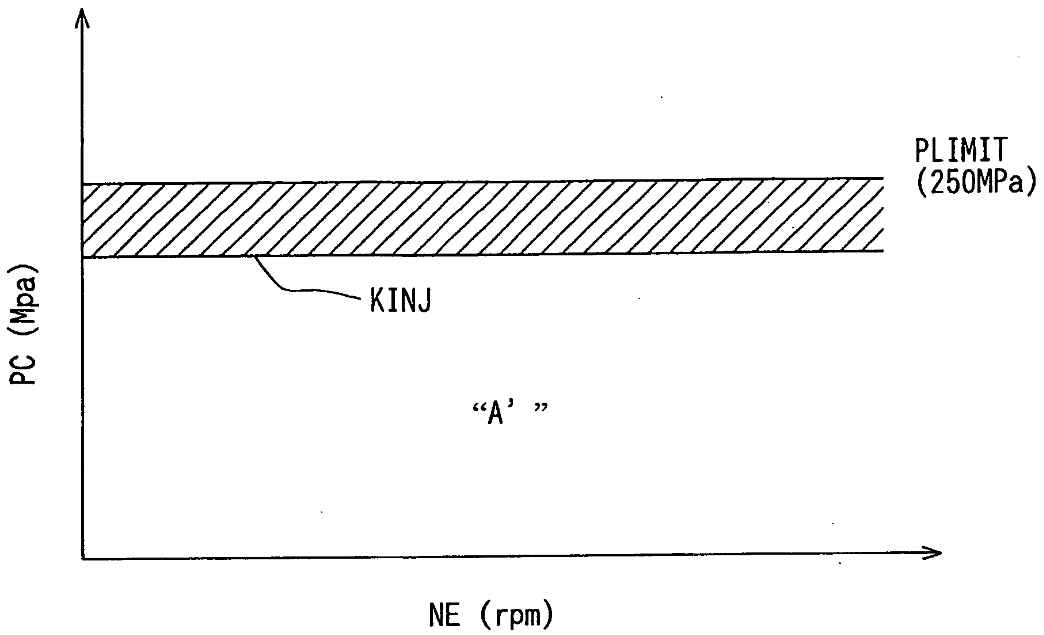

PLIMIT
(250MPa)
KINJ
PC (Mpa)
“A’ ”
NE (rpm)

FIG. 8

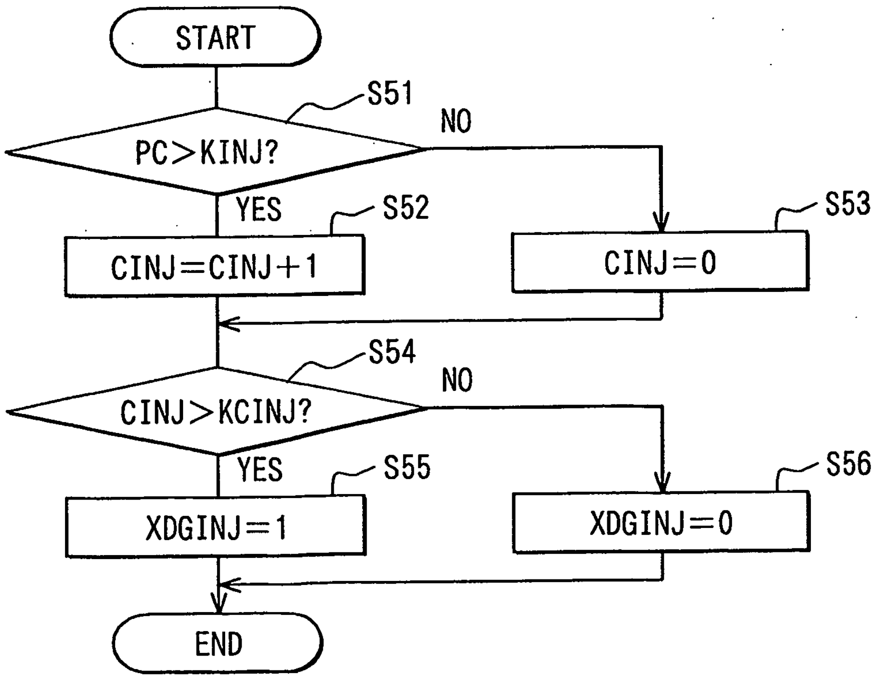

START
S51
NO
PC>KINJ?
YES
S52
S53
CINJ=CINJ+1
CINJ=0
S54
NO
CINJ>KCINJ?
YES
S55
S56
XDGINJ=1
XDGINJ=0
END

FIG. 9

	DEMANDED FAIL-SAFE LEVEL			
DETECTED ABNORMALITY	XFSENG1	XFSENG2	XFSQ	IDLE-UP
XDGCPMP1	NO	YES	YES	YES
XDGCPMP3	YES	NO	NO	NO
XDGINJ	NO	NO	YES	NO

FIG. 10

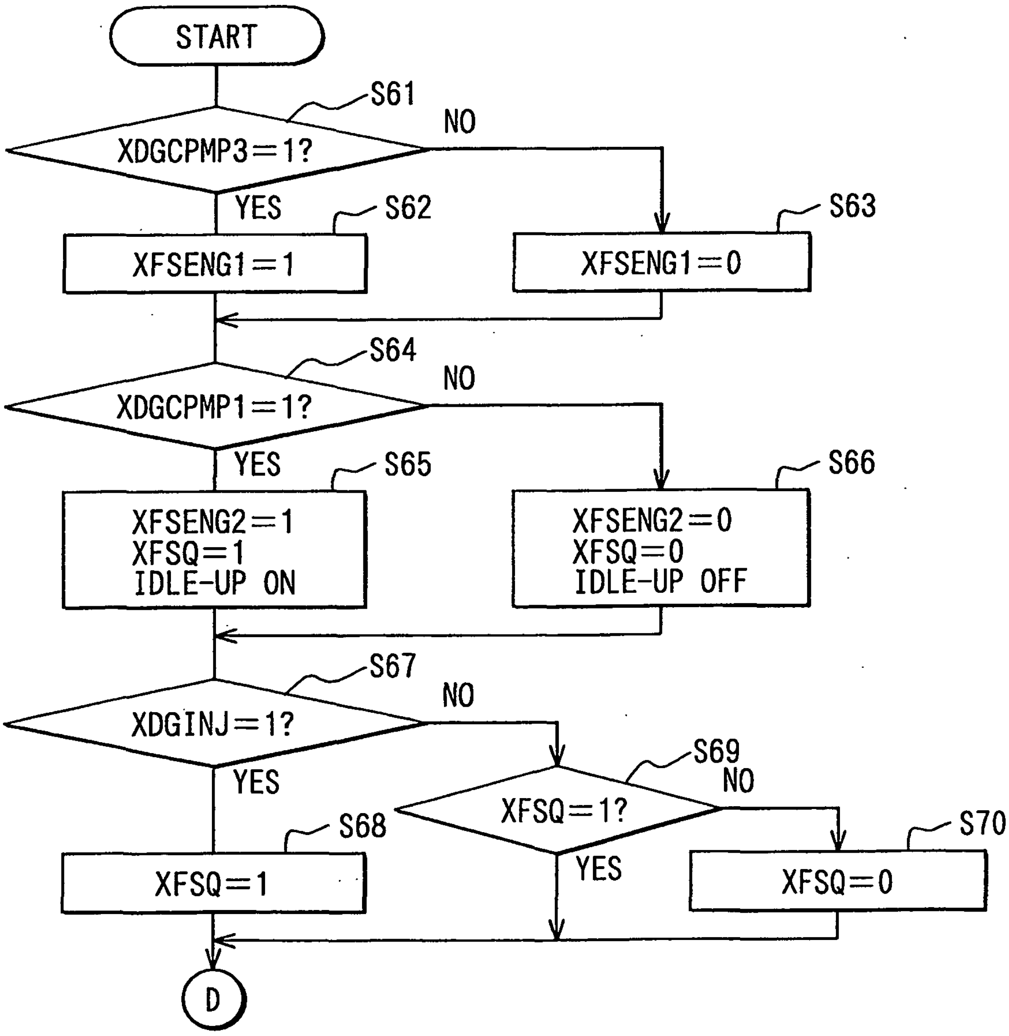
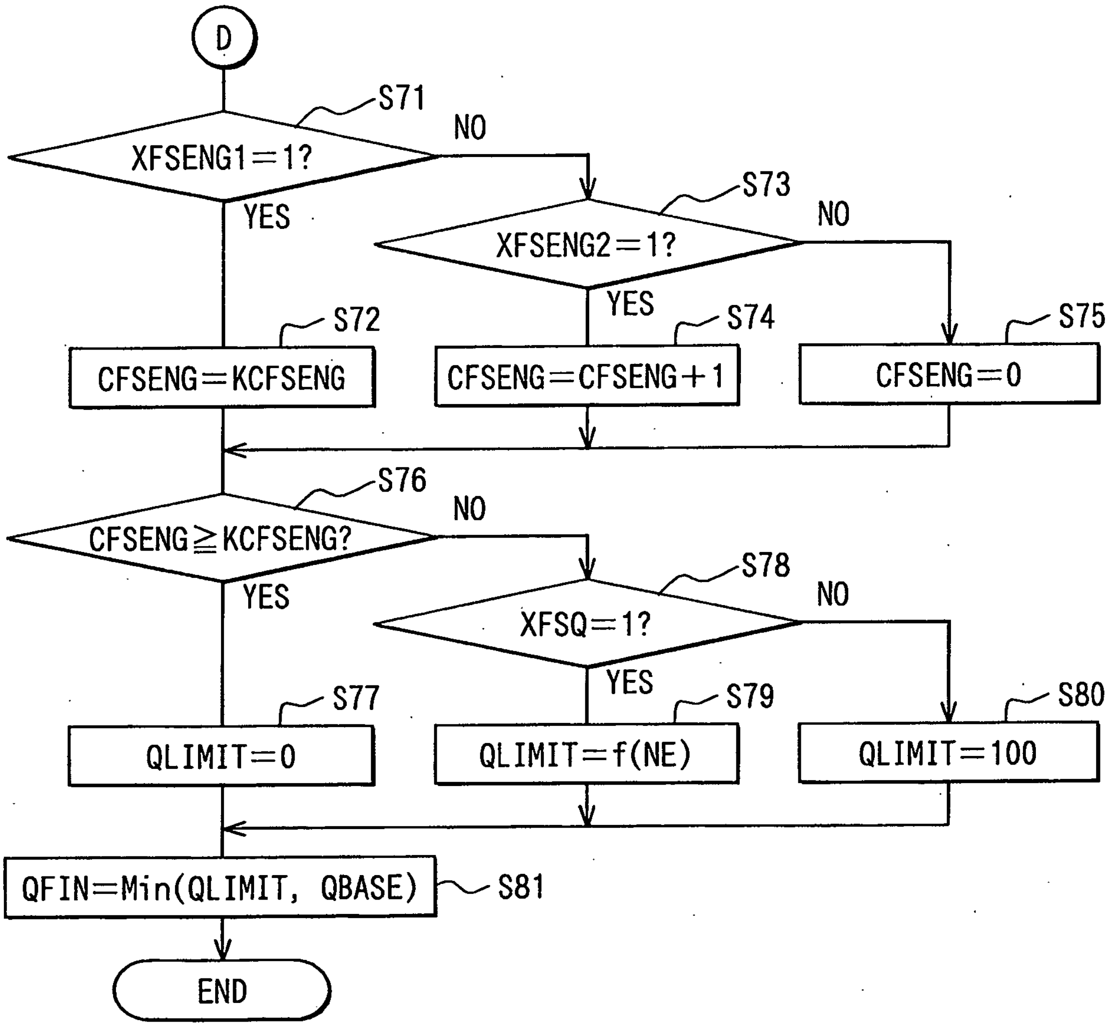


FIG. 11


D
S71
XFSENG1=1?
NO
YES
S73
XFSENG2=1?
NO
YES
S72
CFSENG=KCFSENG
S74
CFSENG=CFSENG+1
S75
CFSENG=0
S76
CFSENG≧KCFSENG?
NO
YES
S78
XFSQ=1?
NO
YES
S77
QLIMIT=0
S79
QLIMIT=f(NE)
S80
QLIMIT=100
QFIN=Min(QLIMIT, QBASE)
S81
END

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2001295685 A **[0002]**