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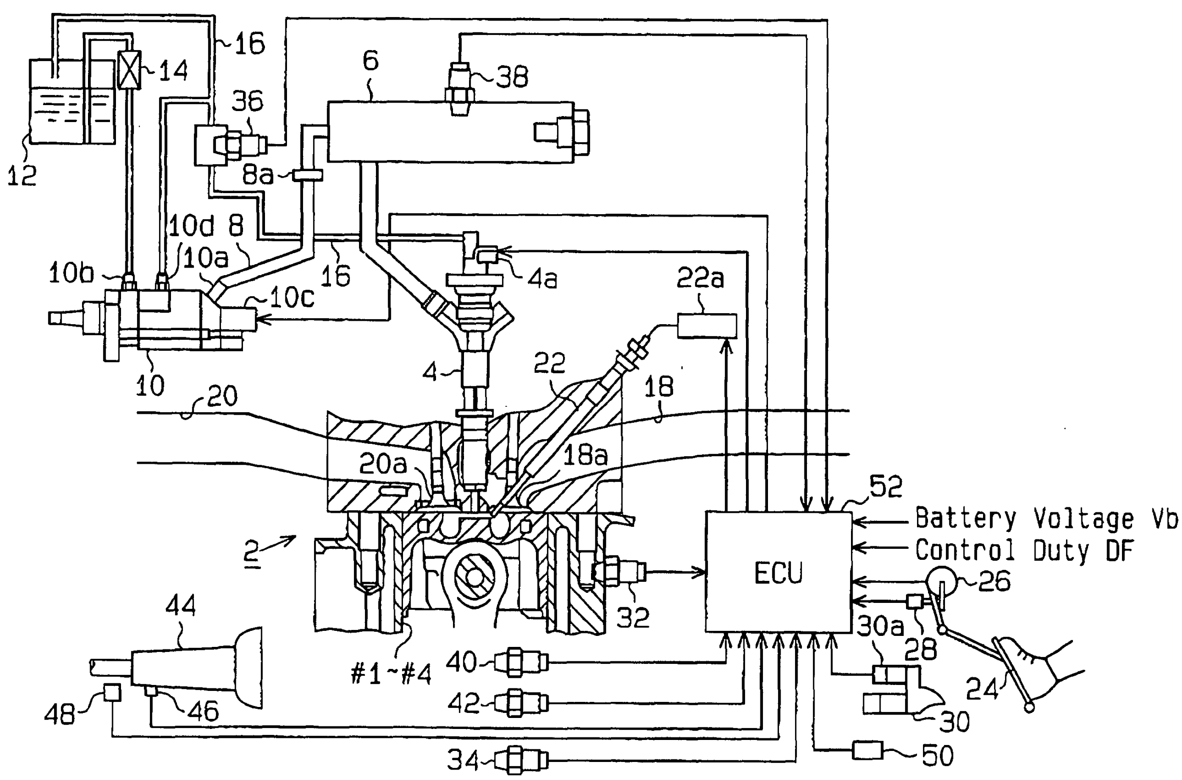
(54) Apparatus for detecting abnormality of glow plugs

(57) An apparatus for detecting abnormality of a glow plug (22) without using special circuits or devices. The glow plug (22) is arranged in a diesel engine (2) and is heated by current supplied from a power supply to help start the diesel engine. The apparatus includes a controller (52) that controls the current supplied from the power supply to the glow plug (22). The controller changes the state of the current and determines abnormality of the glow plug based on the difference between an operating condition of the diesel engine before and after the change.

Fig.1



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Description

[0001] The present invention relates to an apparatus for detecting abnormality of glow plugs used in diesel engines.

[0002] A glow plug is used in a diesel engine to help start the engine in cold weather. To start a diesel engine when the engine is cold, current is supplied to the glow plug to preheat the engine before starting the engine with a starter.

[0003] Such glow plug includes an electric heating element. However, the starting of a cold engine becomes difficult when a wire in the heating element breaks or when a wire for supplying current to the heating element breaks. Accordingly, wire breakage detectors for glow plugs have been proposed to detect glow plug abnormality (Japanese Laid Open Patent Publication Nos. 11-182400, 57-26275, and 58-113581).

[0004] However, in the prior art, special circuits and devices, such as a voltage detection circuit, are required to detect a glow plug wire breakage. This not only increases manufacturing cost but also increases components, which occupy additional space, and decreases reliability.

[0005] It is an object of the present invention to provide an apparatus that detects wire breakage of glow plus without using special circuits and devices.

[0006] To achieve the above object, the apparatus of claim 1 detects abnormality of a glow plug arranged in a diesel engine that is heated by current supplied from a power source to help start the diesel engine. The apparatus includes a controller for controlling the current supplied from the power supply to the glow plug, wherein the controller changes the state of the current and determines abnormality of the glow plug based on the difference between an operating condition of the diesel engine before and after the change.

[0007] The controller does not directly detect an abnormality of the glow plug with a special circuit or device. The controller determines abnormality of the glow plug based on the difference between the operating state of the diesel engine before and after changing the state of the current. The glow plug directly or indirectly receives energy from the diesel engine to heat the glow plug. Thus, an abnormality of the glow plug affects the energy consumed by the glow plug and the operating condition of the diesel engine, which is the energy source.

[0008] Accordingly, abnormality of the glow plug, such as wire breakage, is determined based on the difference between the operating condition of the diesel engine before and after changing the state of the current supplied to the glow plug. Thus, a special circuit or device for directly detecting an abnormality of the glow plug, such as a wire breakage, is not necessary. This avoids an increase in the manufacturing cost and avoids a decrease in reliability. Further, more space is available.

[0009] In the apparatus of claim 2, the controller activates and deactivates the glow plug.

[0010] Since the controller activates and deactivates the glow plug, abnormality of the glow plug is determined based on the difference between the operating condition of the diesel engine before and after switching the glow plug between activated and deactivated states.

[0011] In the apparatus of claim 3, the controller forcibly activates and deactivates the glow plug in a state in which a change in power consumption accurately reflects on the operating condition of the diesel engine.

[0012] For example, when the diesel engine is driven in a low load state, such as in a state in which the engine is running after being warmed, a state in which the battery voltage is greater than or equal to a reference voltage, or a state in which an air conditioner driven by the diesel engine is turned off, fluctuation in power consumption accurately reflects on the operating condition of the diesel engine. In such case, when the state of the current supplied to the glow plug changes, an abnormality of the glow plug significantly affects the operating condition of the diesel engine before and after the change.

[0013] Accordingly, an abnormality is determined based on the operating state, which accurately reflects an abnormality.

[0014] In the apparatus of claim 4, the apparatus determines that a wire breakage occurred in the glow plug when the controller changes the state of the current and the difference between the operating state of the diesel engine before and after the change is smaller than a predetermined reference value.

[0015] When a wire breakage occurs in the glow plug, the state of the current does not change even when the controller tries to change the current state. Thus, if the difference between the operating condition before and after changing the state of the current is smaller than the reference value, it is determined that there is a wire breakage in the glow plug. Thus, a special circuit or device for directly detecting wire breakage of the glow plug is not necessary. This avoids an increase in the manufacturing cost and avoids a decrease in reliability. Further, more space is available.

[0016] The apparatus of claim 5 adjusts a fuel injection amount when the diesel engine is idling so that the engine speed matches a target idling speed and determines that the glow plug has an abnormality based on the difference in the fuel injection amount before and after the controller changes the state of the current when the engine is idling.

[0017] Idling speed control is performed to obtain the difference in the operating condition of the diesel engine. The electric load applied to the diesel engine fluctuates when current flows properly to the glow plug, when the controller supplies power, or when the controller cuts the supply of power. Thus, the idling speed control affects the fuel engine amount.

[0018] Accordingly, abnormality of the glow plug is determined based on the difference between the fuel injection amount of the diesel engine. Thus, a special circuit or device for directly detecting wire breakage of the glow plug is not necessary. This avoids an increase in the manufacturing cost and avoids a decrease in reliability. Further, more space is available.

[0019] In the apparatus of claim 6, a second controller detects the voltage of a battery and maintains the voltage output from an alternator at a proper value. The glow plug is heated by power from the alternator and the battery.

[0020] In the apparatus of claim 7, the apparatus determines abnormality of the glow plug based on the difference between the output of the alternator before and after the controller changes the state of the current.

[0021] The alternator, which is used to obtain the difference in the operating condition of the diesel engine, adjusts the output in accordance with the battery voltage. When current flows properly to the glow plug, the amount of power consumed by the battery changes if an alternator controller starts or stops the flow of current. Thus, the alternator changes the output. However, when the glow plug has an abnormality, such as a wire breakage, and current does not flow through the glow plug at all, the amount of power consumed by the battery does not change even if the alternator controller starts or stops the flow of current. In such state, the alternator does not change the output.

[0022] In the apparatus of claim 8, the difference between the operating condition is the difference in the engine speed when the fuel injection amount of the diesel engine is constant.

[0023] When the fuel injection amount of the diesel engine is constant, a difference in the engine speed may be used as the difference in the operating condition of the diesel engine. If the fuel injection amount of the diesel engine is constant and the glow plug is functioning normally, the electric energy load produced when the alternator controller supplies power decreases the engine speed. The engine speed increases when the power is cut. If the glow plug has an abnormality, such as a wire breakage, and current does not flow through the glow plug at all, an electric energy load is not produced and the engine speed does not decrease even if the alternator controller supplies power. Further, the engine speed does not increase even if the power is cut. Accordingly, an abnormality of the glow plug is detected based on the difference of the engine speed even when the fuel injection amount of the diesel engine is constant. Thus, a special circuit or device for directly detecting an abnormality, such as wire breakage, of the glow plug is not necessary. This avoids an increase in the manufacturing cost and avoids a decrease in reliability. Further, more space is available.

[0024] Other aspects and advantages of the present invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

[0025] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a schematic diagram showing a diesel engine and a control system of the diesel engine according to a first embodiment of the present invention;
Fig. 2 is a block diagram showing a glow plug power supply system employed in the engine of Fig. 1;
Fig. 3 is a flow chart of a fuel injection amount control routine executed by an electronic control unit in the engine of Fig. 1;
Fig. 4 is a flow chart showing the fuel injection amount control routine of Fig. 3;
Fig. 5 is a flow chart showing a glow plug control routine executed by the electronic control unit in the first embodiment;
Fig. 6 is a flow chart showing an activated glow plug abnormality detection routine executed by the electronic control unit in the first embodiment;
Fig. 7 is a timing chart taken in a normal state in the first embodiment;
Fig. 8 is a timing chart taken in an abnormal state in the first embodiment;
Fig. 9 is a flow chart showing a glow pug control routine performed by the electronic control unit in a second embodiment of the present invention;
Fig. 10 is a flow chart showing a deactivated glow plug abnormality detection routine executed by the electronic control unit in the second embodiment;
Fig. 11 is a timing chart taken in a normal state in the second embodiment; and
Fig. 12 is a timing chart taken in an abnormal state in the second embodiment.

[0026] Fig. 1 is a common rail diesel engine 2 and its control system according to a first embodiment of the present invention. The diesel engine 2 is mounted on an automobile.

[0027] A diesel engine 2 has a plurality of (four, in the first embodiment) cylinders #1, #2, #3, #4 (only cylinder #1 is shown). Each of the cylinders #1, #2, #3, #4 has a combustion chamber that is provided with an injector 4. The injection of fuel from each injector 4 to the associated cylinder #1, #2, #3, #4 is controlled by the activation and deactivation of an electromagnetic fuel injection valve 4a.

[0028] The injectors 4 of the cylinders #1, #2, #3, #4 are connected to a common rail 6, which functions as a pressurized fuel pipe. When each electromagnetic valve 4a is opened, the associated injector 4 injects fuel into the corresponding one of the cylinders #1, #2, #3, #4 from the common rail 6. The fuel in the common rail 6 is pressurized to a level equal to the pressure required for fuel injection. To pressurize the fuel, the common rail 6 is connected to a discharge port 10a of a pump 10 via a supply pipe 8. A check valve 8a is arranged in the supply pipe 8. The check valve 8a permits the flow of fuel from the supply pump 10 to the common rail 6 and prohibits the -reversed flow from the common rail 6 to the supply pump 10.

[0029] An intake port 10b of the pump 10 is connected to a fuel tank 12 by way of a filter 14. The pump 10 draws in fuel from the fuel tank 12 via the filter 14. Simultaneously, a cam (not shown), which rotates synchronously with a crankshaft 2a of the diesel engine, reciprocates a plunger of the pump 10 to increase the fuel pressure to a predetermined value and supply the highpressure fuel to the common rail.

[0030] A pressure control valve 10c is arranged near the discharge port 10a of the pump 10. The pressure control valve 10c controls the pressure of the fuel discharged from the discharge port 10a into the common rail 6. The pressure control valve 10c is opened to return surplus fuel, which is not discharged from the discharge port 10a, to a return pipe 16 through a return port 10d, which is provided in the pump 10.

[0031] The combustion chambers of the diesel engine 2 are connected to an intake passage 18 and an exhaust passage 20. A throttle valve (not shown) is arranged in the intake passage 18. The opened degree of the throttle valve is adjusted in accordance with the operating conditions of the diesel engine to adjust the amount of intake air drawn into the combustion chambers.

[0032] Further, a glow plug 22, which helps starting the engine, is arranged in each combustion chamber of the diesel engine 2. A glow plug relay 22a supplies current to the glow plug 22 and heats the glow plug 22 to a red glow before starting the engine. Fuel is then sprayed on the glow·plug 22 to ignite and burn the fuel.

[0033] Various sensors detect the operating conditions of the diesel engine 2. Referring to Fig. 1, an acceleration pedal sensor 26 is arranged near an acceleration pedal 24 to detect the acceleration pedal depression amount ACCPF. A full closure switch 28 is also arranged near the acceleration pedal 24 to generate a fully closure (on) signal when the depression amount of the acceleration pedal 24 is null. Further, the diesel engine 2 is provided with a starter 30, which starts the diesel engine 2. The starter 30 includes a starter switch 30a, which detects the operating conditions of the starter 30. The diesel engine 2 has a cylinder block to which a coolant temperature sensor 32 is attached. The coolant temperature sensor 32 detects the temperature of the coolant (coolant temperature THW) in the cylinder block. Further, the diesel engine 2 is provided with an oil pan (not shown). An oil temperature sensor 34 is arranged in the oil pan to detect the engine oil temperature THO. A temperature sensor 36 is arranged in the return pipe 16 to detect the fuel temperature THF. A fuel pressure sensor 38 is arranged in the common rail 6 to detect the pressure of the fuel in the common rail 6. The crankshaft 2a (Fig. 2) of the diesel engine 2 is provided with a pulser (not shown). An engine speed sensor 40 is arranged near the pulser. The rotation of the crankshaft 2a is transmitted to a camshaft (not shown) by a timing belt or the like. The cam shaft opens and closes suction valves 18a and exhaust valves 20a. The camshaft is rotated at one half the rotating speed of the crankshaft 2a. A cylinder distinguishing sensor 42 is arranged near the pulser. The engine speed NE, the crank angle CA, and the top dead center (TDC) of the first cylinder #1 are calculated from the pulse signals output by the sensors 40, 42. A transmission 44 is provided with a shift position sensor 46 to detect the shifted state of the transmission. The output shaft of the transmission 44 is provided with a vehicle velocity sensor 48 to detect the vehicle velocity SPD from the rotating speed of the output shaft. An air conditioner (not shown) is driven by the diesel engine 2. The air conditioner is activated by an air conditioner switch 50.

[0034] The diesel engine 2 is controlled by an electronic control unit (ECU) 52. The ECU 52 controls the diesel engine 2 by executing a fuel injection amount control routine and a glow plug control routine. Further, the ECU 52 has a microcomputer. The microcomputer includes a central processing unit (CPU), a read only memory (ROM) that prestores various programs and maps, a random access memory (RAM) for temporarily storing the calculation results of the CPU, a backup RAM for storing the calculation results and the prestored data, a timer counter, an input interface, and an output interface. The acceleration pedal sensor 26, the coolant temperature sensor 32, the oil temperature sensor 34, the fuel temperature sensor 36, and the fuel pressure sensor 38 are connected to the input interface of the ECU 52 by a multiplexer (not shown) and an A/D converter (not shown). Further, the engine speed sensor 40, the cylinder distinguishing sensor 42, and the vehicle velocity sensor 48 are connected to the input interface of the ECU 52 via a waveform shaping circuit (not shown). The full closure switch 28, the starter switch 30a, the shift position sensor 46, and the air conditioner switch 50 are directly connected to the input interface of the ECU 52. In addition, the ECU 52 receives and reads the battery voltage Vb and an alternator control duty. The CPU reads the signals from the above switches and sensors via the input interface. The electromagnetic valves 4a, the pressure control valve 10c, and the glow plug relay 22a are each provided with a drive circuit that is connected to the output interface of the ECU 52. The CPU performs calculations based on the input values that are received through the input interface. Further, the CPU controls the electromagnetic valves 4a, the pressure control valve 10c, and the glow plug relay 22a through the output interface.

[0035] With reference to the power supply system diagram of Fig. 2, an alternator 54 and an air conditioner compressor 56 are rotated by means of a belt 2b. A voltage regulator 54a is arranged in the alternator 54. The voltage regulator 54a causes the alternator 54 to output voltage corresponding to a duty ratio signal received from an alternator controller 58. The controller 58 detects the voltage Vb of a battery 60 and duty controls the voltage regulator 54a so that the battery 60 remains charged at an appropriate level. The alternator 54 and the battery 60 supply the glow plugs 22 with power and heats the glow plugs 22 when the ECU 52 activates the glow plug relay 22a.

[0036] The fuel injection control routine and the glow plug control routine will now be discussed.

[0037] Figs. 3 and 4 illustrate the flow chart of the fuel injection control routine. This routine is executed in interrupts corresponding to predetermined crank angles (every power stroke). In the flowchart, the alphabet S followed by a number denotes a step.

[0038] When the fuel injection amount control routine starts, the ECU 52 reads and stores in the RAM, the engine speed NE, which is detected by the engine speed sensor 40, the acceleration pedal depression amount ACCPF, which is detected from the signal of the acceleration pedal sensor 26, the shift position SFT, which is detected from the signal of the shift position sensor 46, and the vehicle velocity SPD, which is detected from the signal of the vehicle velocity sensor 48 (S110).

[0039] Then, the ECU 52 calculates an idle state governor injection amount command value QGOV1 from an idle state governor injection amount command value map, the parameters of which are the engine speed NE and the acceleration pedal depression amount ACCPF (S120). The map is based on experiment results taken when idling the engine and is stored in the ROM of the ECU 52. Since values are dispersed in the map, when a corresponding parameter is not found in the map, the idle state governor injection amount command value QGOV1 is interpolated. Other maps are set in the same way and undergo interpolation in the same way.

[0040] Based on the engine speed NE and the acceleration pedal depression amount ACCPF, the ECU 52 calculates a non-idle state governor injection amount command value QGOV2 from a non-idle governor injection amount command value map, the parameters of which are the engine speed NE and the acceleration pedal depression amount ACCPF (S130). Further, based on the engine speed NE and the acceleration pedal depression amount ACCPF, the ECU 52 calculates an auxiliary governor injection amount command value QGOV3 from an auxiliary governor injection amount command value map, the parameters of which are the engine speed NE and the acceleration pedal depression amount ACCPF (S140). The auxiliary governor injection amount command value QGOV3 functions to apply a secondary characteristic to the non-idle state governor injection amount command value QGOV2.

[0041] The ECU 52 then determines whether the engine 2 is in a non-idling state (S150). For example, if the vehicle velocity SPD is substantially 0km/h and the full closure switch 28 is on, the ECU 52 determines that the engine 2 is idling. If the ECU 52 determines that the engine 2 is idling, the ECU 52 calculates an engine speed deviation NEDL from an idle state target engine speed NTRG and the actual engine speed NE using formula 1 (S160).

$$NEDL = NTRG - NE \qquad \text{formula 1}$$

[0042] The ECU 52 then obtains a fuel injection amount correction value QIIDL, which corresponds to the engine speed deviation NEDL from a map, the parameter of which is the engine speed deviation NEDL (S170). Instead of obtaining the fuel injection amount correction value QIIDL from the map, the value QIIDL may also be obtained from a function that uses the engine speed deviation NEDL.

[0043] Then the ECU 52 calculates an idle state injection amount correction value QII based on the injection amount correction value QIIDL (S180) using formula 2.

$$QII = QII \pm QIIDL \qquad \text{formula 2}$$

[0044] In formula 2, QII in the right side represents the idle state injection amount correction value that was obtained in the previous control cycle. Further, ±QIIDL means +QIIDL when the expression of $NTRG \geq NE$ is satisfied, and ±QIIDL means -QIIDL when the expression of $NTRG < NE$ is satisfied.

[0045] After step S180, the ECU 52 calculates the governor injection amount command value QGOV (S190). If the ECU 52 determines that the engine is in a non-idle state in step S150, the ECU 52 jumps to step S190 and calculates the governor injection amount command value QGOV.

$$QGOV = MAX(QGOV1 + QII + QIP, MAX(QGOV2, QGOV3) + QIPB \qquad \text{formula 3}$$

[0046] In formula 3, QIP is an offset value for a state in which the engine 2 is idling when a load, such as an activated air conditioner, is applied to the engine 2. QIPB is an offset value for a state in which the engine 2 is not idling when a load, such as an activated air conditioner, is applied to the engine 2. Further, MAX( ) is an operator for extracting the maximum value within the parentheses.

[0047] Then, the ECU 52 determines whether the engine 2 is accelerating or decelerating the vehicle (S200). This is performed by, for example, determining whether the governor injection amount command value QGOV is greater than or less than a basic injection amount command value QBASEOL, which was calculated in the previous control cycle.

[0048] If the engine 2 is in an accelerating or decelerating state, the ECU 52 performs a fluctuation inhibiting process on the governor injection amount command value QGOV (S210). This prevents shocks from being produced when the governor injection amount command value QGOV suddenly changes. If the difference between the governor injection amount command value QGOV, which is calculated in step S190, and the basic injection amount command value QBASEOL is large, the ECU 52 corrects the governor injection amount QGOV so that shocks are not produced.

[0049] Then, the governor injection amount command value QGOV is set as the basic injection amount command value QBASE (S220). If the ECU 52 determines that the engine 2 is not accelerating or decelerating the vehicle in step S200, the ECU 52 jumps to step S220.

[0050] Then, the ECU 52 guard-processes the basic injection amount command value QBASE with a maximum injection amount command value QFULL to calculate a final basic injection amount command value QFINC (S230), as indicated in formula 4.

$$QFINC=MIN(QBASE, QFULL) \qquad \text{formula 4}$$

[0051] In formula 4, MIN( ) is an operator for extracting the maximum value within the parentheses.

[0052] Then, the ECU 52 subtracts a pilot injection amount command value QPL from the final basic amount injection command value QFINC to calculate a main injection amount command value QFPL (S240), as indicated in formula 5.

$$QFPL=QFINC-QPL \qquad \text{formula 5}$$

[0053] Then, the ECU 52 calculates a main injection period TQFPL from a map or a function fq based on the main injection amount command value QFPL (S250). Further, the ECU 52 calculates a pilot injection period TQPL from a map or a function fp based on the pilot injection amount command value QPL (S260). The present basic injection amount command value QBASE is then set as the previous basic injection amount command value QBASEOL (S270). This temporarily completes the fuel injection amount control routine.

[0054] The glow plug control routine will now be discussed with reference to Figs. 5 and 6. This routine is executed in a cyclic manner. When the routine is started, the ECU 52 reads the control duty DF of the alternator controller 58, the voltage vb of the battery 60, and the operating conditions of the diesel engine 2 detected by the sensors (S300).

[0055] Steps S310 and S320 are performed to determine whether friction between moving parts of the engine 2 is small enough so that it does not affect other parts. When the friction is small, electric load fluctuations are more accurately reflected on the operating conditions of the diesel engine 2 in comparison to when the friction is large. This facilitates the detection of an abnormality in the glow plug relay 22a. The ECU 52 determines whether the coolant temperature THW is higher than a warm coolant temperature Athw (S310) and whether the engine oil temperature THO is higher than a warm oil temperature Btho (S320). If the expressions of THW>Athw and THO>Btho are both not satisfied in steps S310, S320, the ECU 52 performs normal glow plug control (S360). In other words, based on the operating conditions of the engine 2, the ECU 52 executes a starting assistance process that activates the glow plug relay 22a to heat the glow plugs 22 and facilitate ignition and combustion in the engine 2.

[0056] If the expressions of THW>Athw and THO>Btho are both satisfied in steps S310, S320, it may be presumed that the engine 2 is warm and the friction produced by moving parts in the engine 2 is thus small. Therefore, the ECU 52 determines whether conditions for deactivating the glow plug relay 22a during normal glow plug control are satisfied (S330). If the deactivation conditions are not satisfied in step S330, the normal glow plug control is being executed and the glow plugs 22 are supplied with current. In such state, the abnormality of the glow plugs cannot be determined. Thus, the ECU 52 performs the normal glow plug control (S360).

[0057] If the conditions for deactivating the glow plug relays 22a are satisfied in step 5330 during the normal glow control, the ECU 52 determines whether the air conditioner switch 50 is turned off from the state of the air conditioner switch 50 (S340). When the air conditioner is turned off, electric load fluctuations are more accurately reflected on the operating conditions of the diesel engine 2 in comparison to when the air conditioner is turned on. This facilitates the detection of an abnormality in the glow plug relay 22a. Accordingly, if the air conditioner is not deactivated in step S340, the ECU 52 performs the normal glow plug control (S360).

[0058] If the ECU 52 determines that the air conditioner is deactivated in step S340, the ECU 52 determines whether the voltage Vb of the battery 60 is greater than a reference voltage Cvb, which is a value indicating that the battery 60 is charged to a certain level (S350). If the voltage of the battery 60 is too small due to insufficient charging, electric load fluctuations are not accurately reflected on the control duty DF of the alternator controller 58. Thus, when the ECU 52 determines that the battery voltage Vb is not greater than the reference voltage Cvb in step S350, the ECU 52 performs the normal glow plug control (S360).

[0059] When the ECU 52 determines that the battery voltage Vb is greater than the reference voltage Cvb in step S350, the ECU 52 determines whether the engine 2 is stably idling (S370). For example, if the full closure switch 28 of the acceleration pedal sensor 26 is on and the fluctuation of the engine NE is less that a reference value that indicates stable idling, the ECU 52 determines that the engine 2 is idling stably. If the ECU 52 determines that the engine is not in a stable idling state in step S370, the ECU 52 cannot accurately detect abnormality of the glow plug relay 22a. Thus, the ECU 52 deactivates the glow plug relay 22a, sets an abnormality detection flag Fin to OFF, and clears an on counter Con (S380). The abnormality detection flag Fin is initialized to OFF when the ECU 52 is activated.

[0060] When the ECU 52 determines that the engine 2 is idling in a stable state in step S370, the ECU 52 then determines whether a detection completion flag Fend is OFF (S390). The detection completion flag Fend is initialized to OFF when the ECU 52 is activated. If the execution of an activated glow plug abnormality detection routine is completed, the ECU sets the detection completion flag Fend to ON. In this case, the ECU 52 deactivates the glow plug relay 22a, sets the abnormality detection flag Fin to OFF, and clears the on counter Con (S380).

[0061] If the ECU 52 determines that the detection completion flag Fend is OFF in step S390, the ECU 52 performs the activated glow plug abnormality detection routine (S400). The activated glow plug detection routine is performed in accordance with the routine shown in the flow chart of Fig. 6. When entering the routine, the ECU 52 first determines whether the abnormality detection flag Fin is OFF (S410). The flag is OFF when the routine is performed for the first time. In such case, the ECU 52 sets the abnormality detection flag Fin to ON (S420) and sets the ON counter to zero. Then, the ECU 52 sets the present control duty DF of the alternator controller 58 as a control duty retaining value DFx (S440), and sets the final basic injection amount command value QFINC, which is calculated in the fuel injection amount control routine, as a final basic injection amount retaining value Qx (S450).

[0062] Then, the ECU 52 activates the glow plugs 22 (S460). More specifically, although the glow plugs 22 would be deactivated under normal glow plug control, the ECU 52 forcibly activates the glow plug relay 22a to supply current to the glow plugs 22. The ECU 52 then increments the ON counter Con (S470) and determines whether the value of the ON counter Con is greater than a counter reference value Dcon (S480). If the ECU 52 determines that the ON counter Con is not greater than the counter reference value Dcon, the ECU 52 temporarily terminates the activated glow plug abnormality detection routine and the glow plug control routine.

[0063] Subsequently, as long as the ECU 52 makes positive determinations (YES) in steps S310-S350, S370, and S390, the ECU 52 continues to proceed from step S410 to steps 5460 and S470.

[0064] When the incrementing of step S470 is repeated and the value of the ON counter CON becomes greater than the counter reference value Dcon in step S480, the ECU 52 determines whether the relationship between the present control duty DF and the control duty retaining value DFx satisfies the condition of formula 6 (S490).

$$DF>DFx+Edf \quad \text{formula 6}$$

[0065] In the formula, the DF increase determination value Edf is used to determine whether the control duty DF, which is adjusted by the alternator controller 58, has increased when the glow plugs 22 are activated and supplied with current in a normal manner. The DF increase determination value Edf may be a fixed value. Alternatively, the increase determination value Edf may be a value obtained from a two-dimensional map of the coolant temperature THW and the engine oil temperature THO that is generated beforehand through experiments.

[0066] When formula 6 is satisfied in step S490, the glow plugs 22 are supplied with current in a normal manner. This decreases the voltage of the battery 60. Thus, it is presumed that the voltage decrease increases the control duty DF of the alternator controller 58 by a necessary level. Accordingly, the ECU 52 sets an activated glow plug normal flag Fnr to ON (S510). Then, the ECU 52 sets the detection completion flag Fend to ON (S530) and temporarily terminates the glow plug control routine. The activated glow plug normal flag Fnr is initialized to OFF when the ECU 52 is activated.

[0067] If formula 6 is not satisfied in step S490, the ECU 52 determines whether the present final basic injection amount command value QFINC and the final basic injection amount retaining value Qx satisfies formula 7 (S500).

$$QFINC>Qx+Fqfinc \quad \text{formula 7}$$

[0068] In the formula, the fuel increase determination value Fqfinc is used to determine whether the final basic injection amount command value QFINC, which is calculated in the fuel injection amount control routine (Figs. 3 and 4), has increased to maintain the engine speed NE at the idle state target engine speed NTRG when the glow plugs 22 are activated and supplied with current in a normal manner. The fuel increase determination value Fqfin may be a fixed value. Alternatively, the fuel increase determination value Fqfin may be a value obtained from a two-dimensional map of the coolant temperature THW and the engine oil temperature THO that is generated beforehand through experiments.

[0069] When formula 7 is satisfied in step S500, the glow plugs 22 are supplied with current in a normal manner. The current supply increases the electric load, which in turn, decreases the engine speed NE. However, the idling engine speed control performed in steps S160 to S190 increases the fuel injection amount. Accordingly, the ECU 52 sets the activated glow plug normal flag Fnr to ON (S510) and sets the detection completion flag Fend to ON (S530). This temporarily terminates the activated glow plug detection routine and the glow plug control routine.

[0070] If formula 7 is not satisfied in step S500, the ECU 52 sets an activated glow plug abnormality flag Fab to ON (S520) and sets the detection completion flag Fend to ON (S530). This temporarily terminates the activated glow plug abnormality detection routine and the glow plug control routine. The activated glow plug abnormality flag Fab is initialized to OFF when the ECU 52 is activated.

[0071] Examples of the control performed in the first embodiment are illustrated in the timing charts of Figs. 7 and 8. Fig. 7 illustrates an example of normal glow plugs 22. At time t1, the ECU 52 makes positive determinations (YES) in steps S310-S350, S370, and S390 and starts the activated glow plug abnormality detection process (Fig. 6). After time t1, the control duty DF and the final basic injection amount command value QFINC increase. When the ON counter Con exceeds the counter reference value Dcon (time t2, YES in S480), formula 6 or 7 is satisfied in steps S490 and S500 (in Fig. 7, both formulas are satisfied). Thus, the activated glow plug activation flag Fnr is set to ON (S510). Further, the detection completion flag Fend is set to ON (S530). Thus, the ECU 52 makes a negative determination (NO) in step S390 of the glow plug control routine (Fig. 5) in the next control cycle and deactivates the glow plugs 22 in step 380. Subsequently, the ECU 52 continues to make a negative determination (NO) in step S390 of the glow plug control routine (Fig. 5). Thus, the activated glow plug abnormality detection routine (Fig. 6) is not performed again as long as the diesel engine 2 continues to run.

[0072] In the example of Fig. 8, current does not flow through the glow plugs 22 or the glow plugs 22 are not supplied with power due to wire breakage or an abnormality of the glow plug relay 22a. At time t11, the ECU 52 makes positive determinations (YES) in steps S310-S350, S370, and S390. However, the control duty DF and the final basic injection amount command value QFINC do not increase even when the glow plug relays 22a should be activated. When the ON counter Con exceeds the counter reference value Dcon (time t12, YES in S480), both formulas 6 and 7 are not satisfied in steps S490 and S500 (in Fig. 7, both formulas are satisfied). Thus, the activated glow plug abnormality flag Fab is set to ON (S520). Further, the detection completion flag Fend is set to ON (S530). The ECU 52 makes a negative determination (NO) in step S390 of the glow plug control routine (Fig. 5) and deactivates the glow plugs 22 (S380).

[0073] The first embodiment has the advantages described below.

(a) In the activated glow plug abnormality detection routine (Fig. 6), the ECU 52 determines whether the glow plugs 22 have an abnormality from changes in the current supply state. In this case, the ECU 52 determines whether the glow plugs 22 have an abnormality by comparing the operating conditions of the diesel engine 2 before and after the glow plugs 22 are activated using the control duty DF of the alternator controller 58 and the final basic injection amount command value QFINC. The heat energy of the glow plugs 22 is generated from the electric energy provided by the diesel engine 2. Thus, an abnormality of the glow plugs 22 affect the energy consumption of the glow plugs 22. As a result, an abnormality of the glow plugs 22 affects the operating conditions of the diesel engine 2, which is the energy source.

Accordingly, an abnormality, such as a wire breakage of the glow plugs 22 or abnormal current supply of the glow plug relay 22a, is determined based on the difference in the operating state of the diesel engine 2 before and after supplying current to the glow plugs 22. Thus, special circuits or devices for directly detecting an abnormality, such as wire breakage, of the glow plugs 22 is not necessary. This prevents the manufacturing costs from increasing and avoids a reliability decrease. Further, space may be used effectively.

(b) If the ECU 52 determines that the diesel engine 2 is warm in steps S310, S320, the air conditioner driven by the diesel engine 2 is deactivated in step S340, the battery voltage Vb is higher than the reference voltage Cvb, and the diesel engine 2 is driven in a low load state. In such case, the current supply state of the glow plugs 22 changes. Thus, depending on whether the glow plugs 22 have an abnormality, the change in the current supply state accurately reflects on the operating conditions of the diesel engine 2. Accordingly, an abnormality of the glow plugs 22 is accurately determined.

[0074] A second embodiment according to the present invention differs from the first embodiment in that the second embodiment replaces the glow plug control routine illustrated in Fig. 5 with a glow plug control routine illustrated in Fig.

9. The other parts, unless otherwise described, are the same as the first embodiment.

[0075] The glow plug control routine of Fig. 9 differs from the routine of Fig. 5 in that when the detection completion flag FEND is not OFF (NO in S1390), the ECU 52 outputs to the glow plug relay 22a a signal that stops the flow of current to the glow plugs 22 (S1410). The ECU 52 then executes a deactivated glow plug abnormality detection routine (S1420).

[0076] The deactivated glow plug abnormality detection routine will now be described in detail with reference to Fig. 10. When entering the routine, the ECU 52 determines whether a deactivated glow plug detection completion flag Kend is set at OFF (S1510). If the ECU 52 determines that the deactivated glow plug detection completion flag Kend is not set at OFF in step S1510, the ECU 52 exits the deactivated glow plug abnormality detection routine and temporarily terminates the glow plug control routine (Fig. 9). However, the deactivated glow plug detection completion flag Kend is initialized at OFF when the ECU 52 is activated. Therefore, the ECU 52 determines that the deactivated glow plug detection completion flag Kend is OFF in step S1510. The ECU 52 then determines if the detection completion flag Fend has just been set to ON from OFF (S1520). If the detection completion flag Fend was set to ON in step 5530 of the activated glow plug abnormality detection routine (S1400, which is also performed in Fig. 6) in the previous control cycle, the ECU 52 sets an OFF counter Coff to zero (S1530). The ECU 52 then sets the present control duty DF of the alternator controller 58 as the control duty maintaining value Dfy (S1540) and then sets the final basic injection amount command value QFINC, which is calculated in the fuel injection control routine (Fig. 3), as the final basic injection amount retaining value Qy (S1550).

[0077] The ECU 52 then increments the OFF counter Coff (S1560) and determines whether the value of the OFF counter Coff has exceeded a counter reference value Dcoff (S1570). If the ECU 52 determines that the value of the OFF counter Coff has not exceeded the counter reference value Dcoff in step S1570, the ECU 52 exits the deactivated glow plug abnormality detection routine and temporarily terminates the deactivated glow plug abnormality detection routine.

[0078] Subsequently, as long as the ECU 52 makes positive determinations (YES) in steps S1310-S1350 and S370 and makes a negative determination (NO) in step S1390, the ECU 52 proceeds to the deactivated glow plug abnormality detection routine (Fig. 10) and makes a positive determination (YES) in step S1510 and a negative determination (NO) in step S1520. Thus, step S1560 is repetitively performed. When the OFF counter Coff becomes greater than the counter reference value Dcon in step S1570, the ECU 52 determines whether the relationship between the present control duty DF and the control duty retaining value DFy satisfies the condition of formula 8 (S1580).

$$DF<DFy-Gdf \qquad \text{formula 8}$$

[0079] In the formula, the DF decrease determination value Gdf is used to determine whether the control duty DF, which is adjusted by the alternator controller 58, has decreased when the glow plugs 22 are deactivated and the flow of current to the glow plugs 22 is stopped in a normal manner. The DF decrease determination value Gdf may be a fixed value. Alternatively, the decrease determination value Gdf may be a value obtained from a two-dimensional map of the coolant temperature THW and the engine oil temperature THO that is generated beforehand through experiments.

[0080] When formula 8 is satisfied in step S1580, the glow plugs 22 are supplied with current in a normal manner. This increases the voltage of the battery 60. Thus, it is presumed that the voltage increase decreases the control duty DF of the alternator controller 58 by a necessary level. Accordingly, the ECU 52 sets a deactivated glow plug normal flag Knr to ON (S1600). Then, the ECU 52 sets the deactivated glow plug detection completion flag Kend to ON (S1620). The ECU 52 then exits the deactivated glow plug abnormality detection routine and temporarily terminates the glow plug control routine (Fig. 9). The deactivated glow plug normal flag Knr is initialized to OFF when the ECU 52 is deactivated.

[0081] If formula 8 is not satisfied in step S1580, the ECU 52 determines whether the present final basic injection amount command value QFINC and the final basic injection amount retaining value Qy satisfies formula 9 (S1590).

$$QFINC<Qy-Hqfinc \qquad \text{formula 9}$$

[0082] In the formula, the fuel decrease determination value Hqfinc is used to determine whether the final basic injection amount command value QFINC, which is calculated in the fuel injection amount control routine (Figs. 3 and 4), has decreased to maintain the engine speed NE at the idle state target engine speed NTRG when the glow plugs 22 are deactivated and the flow of current to the glow plugs 22 is stopped in a normal manner. The fuel decrease determination value Hqfin may be a fixed value. Alternatively, the fuel decrease determination value Ilqfin may be a value obtained from a two-dimensional map of the coolant temperature THW and the engine oil temperature THO that is generated beforehand through experiments.

[0083] When formula 9 is satisfied in step S1590, the flow of current to the glow plugs 22 is stopped in a normal manner. The stopped current flow decreasess the electric load, which in turn, increases the engine speed NE. However, the idling engine speed control performed in steps S160 to S190 decreases the fuel injection amount. Accordingly, the ECU 52 sets the deactivated glow plug normal flag Knr to ON (S1600) and sets the deactivated glow plug detection completion flag Kend to ON (S1620). This temporarily terminates the deactivated glow plug abnormality detection routine and the glow plug control routine (Fig. 9).

[0084] If formula 9 is not satisfied in step S1590, the ECU 52 sets a deactivated glow plug abnormality flag Kab to ON (S1610) and sets the deactivated glow plug detection completion flag Kend to ON (S1620). This temporarily terminates the deactivated glow plug abnormality detection routine and the glow plug control routine (Fig. 9). The deactivated glow plug abnormality flag Kab is initialized to OFF when the ECU 52 is activated.

[0085] In the second embodiment, when the glow plugs 22 are forcibly activated, the ECU 52 determines whether the glow plugs 22 have an abnormality by comparing the operating conditions of the diesel engine 2 before and after the glow plugs 22 are activated and then comparing the operating conditions of the diesel engine 2 before and after the glow plugs 22 are deactivated.

[0086] Based on the activated glow plug normal flag Fnr, the activated glow plug abnormality flag Fab, the deactivated glow plug normal flag Knr, and the deactivated glow plug abnormality flag Kab, the ECU 52 detects the abnormality of the glow plugs 22 and the glow plug relay 22a. For example, as shown in the timing chart of Fig. 11, when the activated glow plug normal flag Fnr and the deactivated glow plug normal flag Knr are both set at ON (times t22 and t23), the ECU 52 determines that the glow plugs 22 are functioning normally. Further, as shown in the timing chart of Fig. 11, when the activated glow plug normal flag Fnr is ON at time t32 but the deactivated glow plug abnormality flag Kab is ON at time t33, it may be presumed that the glow plug relay 22a is not deactivating properly. Further, when the activated glow plug abnormality flag Fab and the deactivated glow plug abnormality flag Kab are both ON, it may be determined that there is a wire breakage in the glow plugs 22 or that the glow plug relay 22a is not activating properly.

[0087] The second embodiment has the advantages described below.

(a) Advantages (a) and (b) of the first embodiment are obtained.

(b) In addition to detecting abnormality when the glow plugs 22 are activated, abnormality is detected when the glow plugs 22 are deactivated. Thus, the state of the glow plugs 22 and the glow plug relay 22a is determined more specifically.

[0088] In the first and second embodiments, instead of detecting the fluctuation of the final basic injection amount command value QFINC, fluctuation of the idle state injection amount correction value QII, which is obtained in step S180 of the fuel injection amount control routine (Fig. 3), may be detected.

[0089] In the first and second embodiments, since abnormality is determined when the engine 2 is idling, fluctuation of the final basic injection amount command value QFINC (or the idle injection amount correction value QII) is determined. Instead, the idling engine speed control (S160 to S190) may be eliminated and the idle injection amount correction value QII may be fixed when the ECU 52 executes the activated glow plug abnormality detection routine (S400, S1400) and the deactivated glow plug abnormality detection routine (S1420). In this case, the ECU 52 determines abnormality from the fluctuation of the engine speed NE instead of from the final basic injection amount correction command value QFINC when executing the activated glow plug abnormality detection routine (S400, S1400) and the deactivated glow plug abnormality detection routine (S1420). The electric load applied to the diesel engine 2 increases when the glow plugs 22 are supplied with current in a normal manner. Thus, the engine speed NE decreases when the fuel injection amount is fixed. On the other hand, the electric load applied to the diesel engine 2 decreases when the flow of current to the glow plugs 22 is stopped. Thus, the engine speed NE increases when the fuel injection amount is fixed. When current does not properly flow to the glow plugs 22, the engine speed NE does not fluctuate like in a normal state regardless of whether the glow plugs 22 are activated or deactivated. Thus, abnormality may be determined based on the fluctuation of the engine speed NE.

[0090] In each of the above embodiments, the DF increase determination value Edf, the fuel increase determination value Fqfinc, the DF decrease determination value Gdf, and the fuel decrease determination value Hqfinc are fixed values or obtained from two dimensional maps of the coolant temperature THW and the engine oil temperature THO, which are obtained beforehand through experiments. However, the engine temperature may be used in lieu of the engine oil temperature THO, which is obtained from a two-dimensional map of the coolant temperature THW when the engine 2 is started and an accumulated injection amount (the accumulated injection amount from when the engine 2 is started).

[0091] In each of the above embodiments, abnormality is determined after the engine 2 is warmed. However, abnormality may be determined when the engine 2 is still cold as long as the SN ratio is high enough. In this case, friction decreases gradually. Thus, for example, the DF increase determination value Edf, the fuel increase determination value Fqfinc, the DF decrease determination value Gdf, and the fuel decrease determination value Hqfinc may be corrected in accordance with the elapsed time, the coolant temperature THW, or the engine oil temperature THO.

[0092] It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

[0093] An apparatus for detecting abnormality of a glow plug (22) without using special circuits or devices. The glow plug (22) is arranged in a diesel engine (2) and is heated by current supplied from a power supply to help start the diesel engine. The apparatus includes a controller (52) that controls the current supplied from the power supply to the glow plug (22). The controller changes the state of the current and determines abnormality of the glow plug based on the difference between an operating condition of the diesel engine before and after the change.

Claims

1. An apparatus for detecting abnormality of a glow plug (22) arranged in a diesel engine (2) that is heated by current supplied from a power supply to help start the diesel engine, the apparatus being **characterized by**:

    a controller (52) for controlling the current supplied from the power supply to the glow plug (22), wherein the controller changes the state of the current and determines abnormality of the glow plug based on the difference between an operating condition of the diesel engine before and after the change.

2. The apparatus according to claim 1, **characterized in that** the controller (52) activates and deactivates the glow plug (22).

3. The apparatus according to claim 1 or 2, **characterized in that** the controller (52) forcibly activates and deactivates the glow plug (22) in a state in which a change in power consumption is accurately reflected on the operating condition of the diesel engine.

4. The apparatus according to any one of claims 1 to 3, **characterized in that** the apparatus determines that a wire breakage occurred in the glow plug (22) when the controller (52) changes the state of the current and the difference between the operating state of the diesel engine before and after the change is smaller than a predetermined reference value.

5. The apparatus according to any one of claims 1 to 4, **characterized in that** the apparatus adjusts a fuel injection amount when the diesel engine is idling so that the engine speed matches a target idling speed and determines that the glow plug has an abnormality based on the difference in the fuel injection amount before and after the controller (52) changes the state of the current when the engine is idling.

6. The apparatus according to any one of claims 1 to 5, **characterized by** a second controller (58) for detecting the voltage of a battery (60) and maintaining the voltage output from an alternator (54) at a proper value, wherein the glow plug (22) is heated by power from the alternator (54) and the battery (60).

7. The apparatus according to claim 6, **characterized in that** the apparatus determines abnormality of the glow plug (22) based on the difference between the output of the alternator (54) before and after the controller changes the state of the current.

8. The apparatus according to any one of claims 1 to 7, **characterized in that** the difference between the operating condition is the difference in the engine speed when the fuel injection amount of the diesel engine is constant.

Fig.1

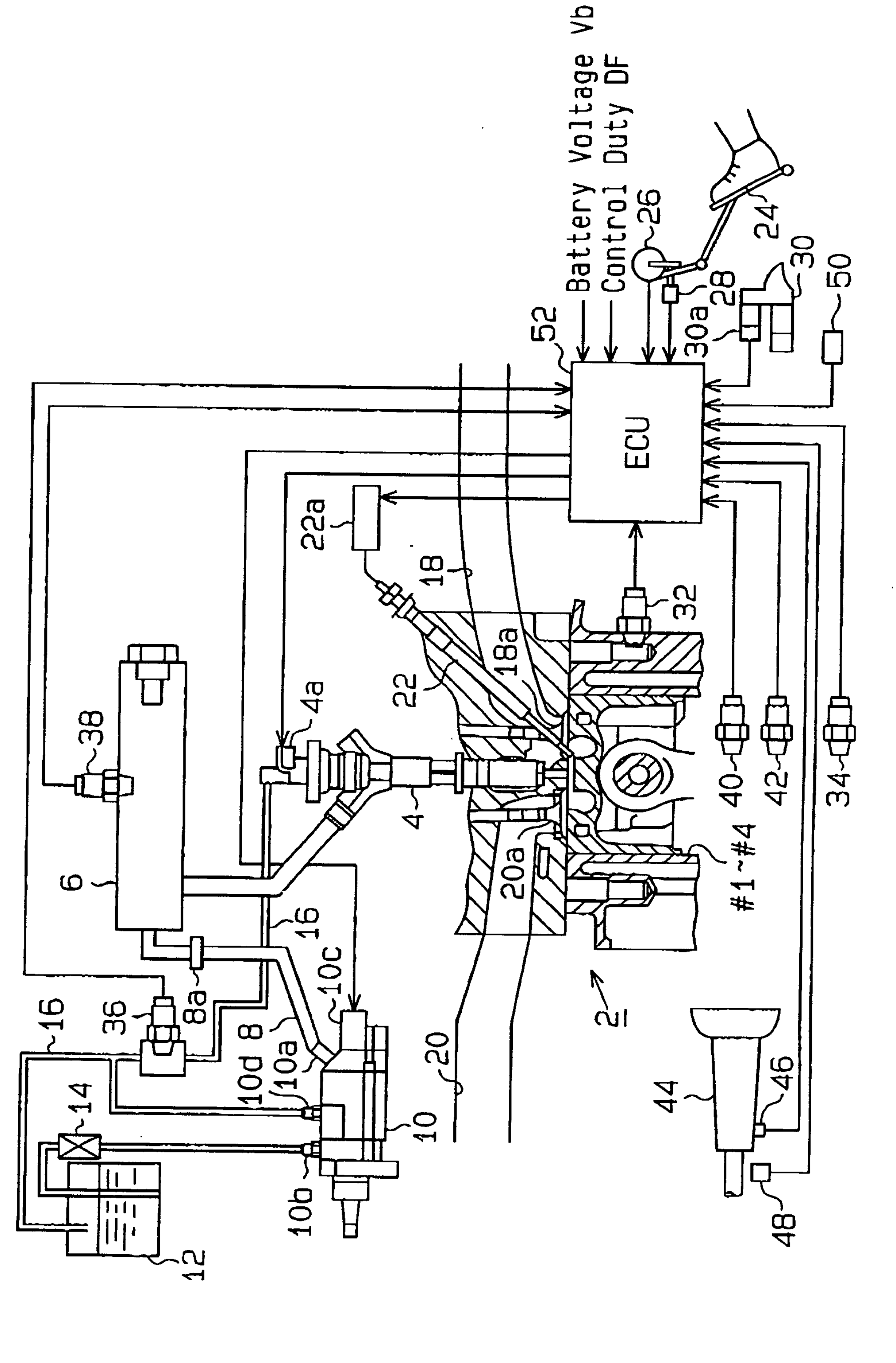

Battery Voltage Vb
Control Duty DF
ECU
52
26
28
24
30a
30
50
22a
18
32
22
18a
4a
38
6
4
40
42
34
#1~#4
20a
16
10c
8a
36
16
10d 8
10a
14
2
20
10
44
46
10b
48
12

Fig.2

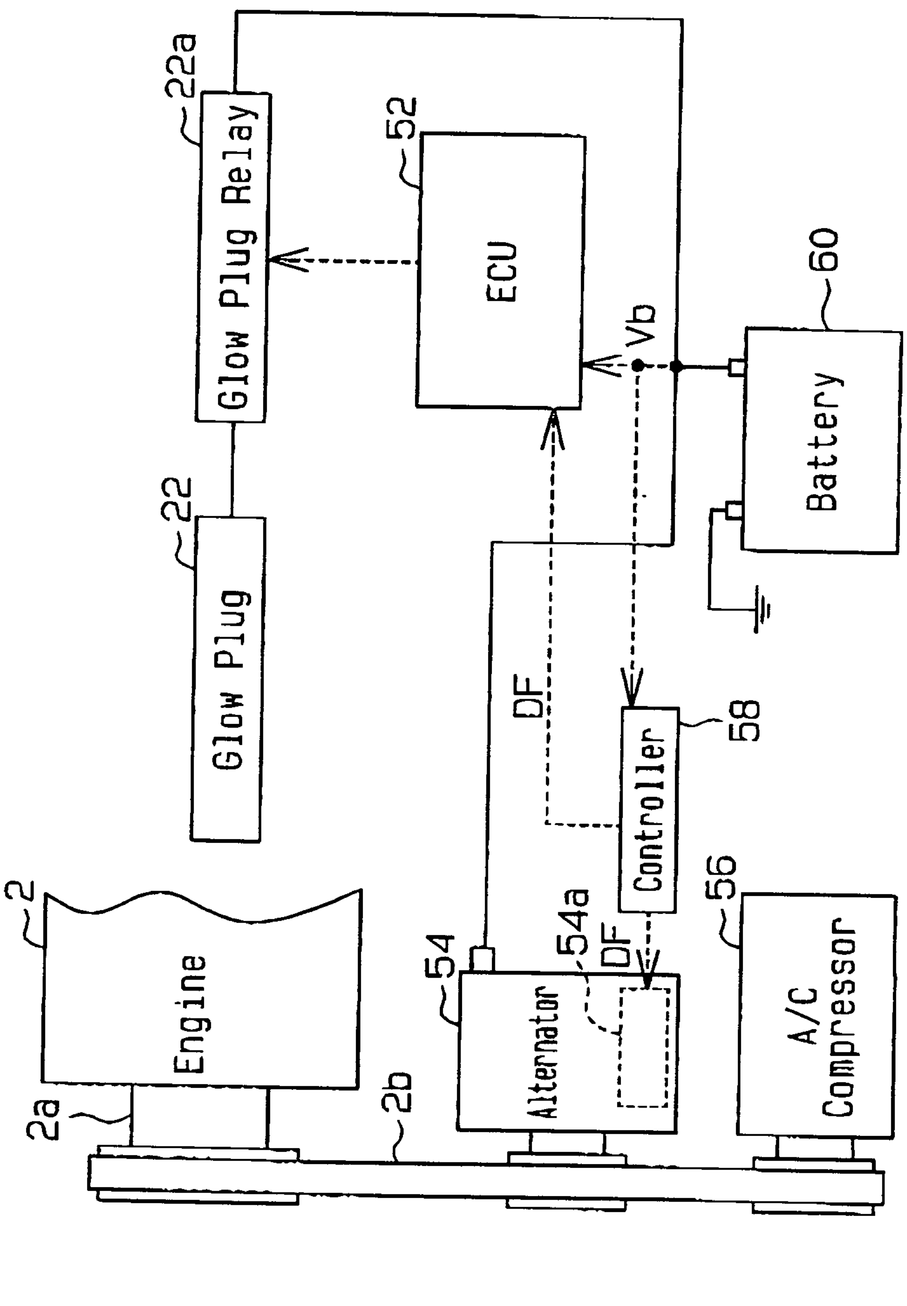

Glow Plug Relay
22a
ECU
52
Battery
60
Vb
Glow Plug
22
DF
Controller
58
Engine
2
2a
2b
Alternator
54
54a
DF
A/C
Compressor
56

Fig.3

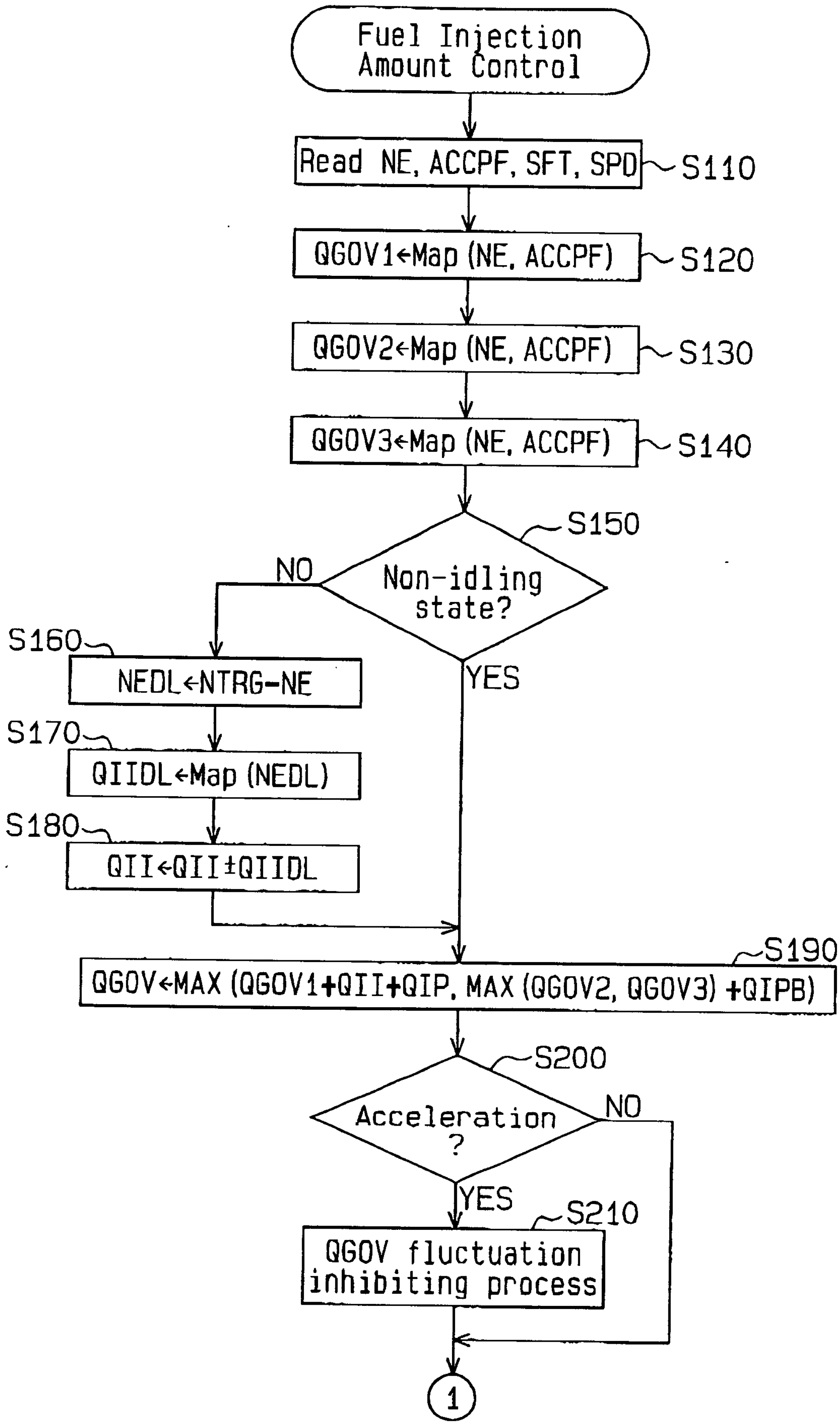

Fuel Injection Amount Control
Read NE, ACCPF, SFT, SPD
S110
QGOV1←Map (NE, ACCPF)
S120
QGOV2←Map (NE, ACCPF)
S130
QGOV3←Map (NE, ACCPF)
S140
S150
Non-idling state?
NO
YES
S160
NEDL←NTRG−NE
S170
QIIDL←Map (NEDL)
S180
QII←QII±QIIDL
S190
QGOV←MAX (QGOV1+QII+QIP, MAX (QGOV2, QGOV3) +QIPB)
S200
Acceleration ?
NO
YES
S210
QGOV fluctuation inhibiting process
1

Fig.4

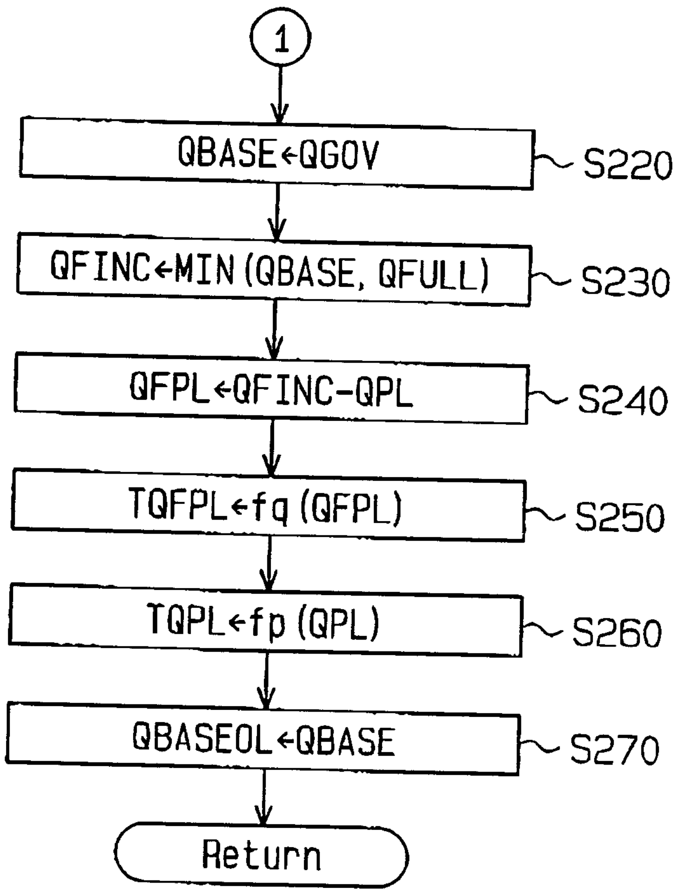

1
QBASE←QGOV
S220
QFINC←MIN (QBASE, QFULL)
S230
QFPL←QFINC-QPL
S240
TQFPL←fq (QFPL)
S250
TQPL←fp (QPL)
S260
QBASEOL←QBASE
S270
Return

Fig.5

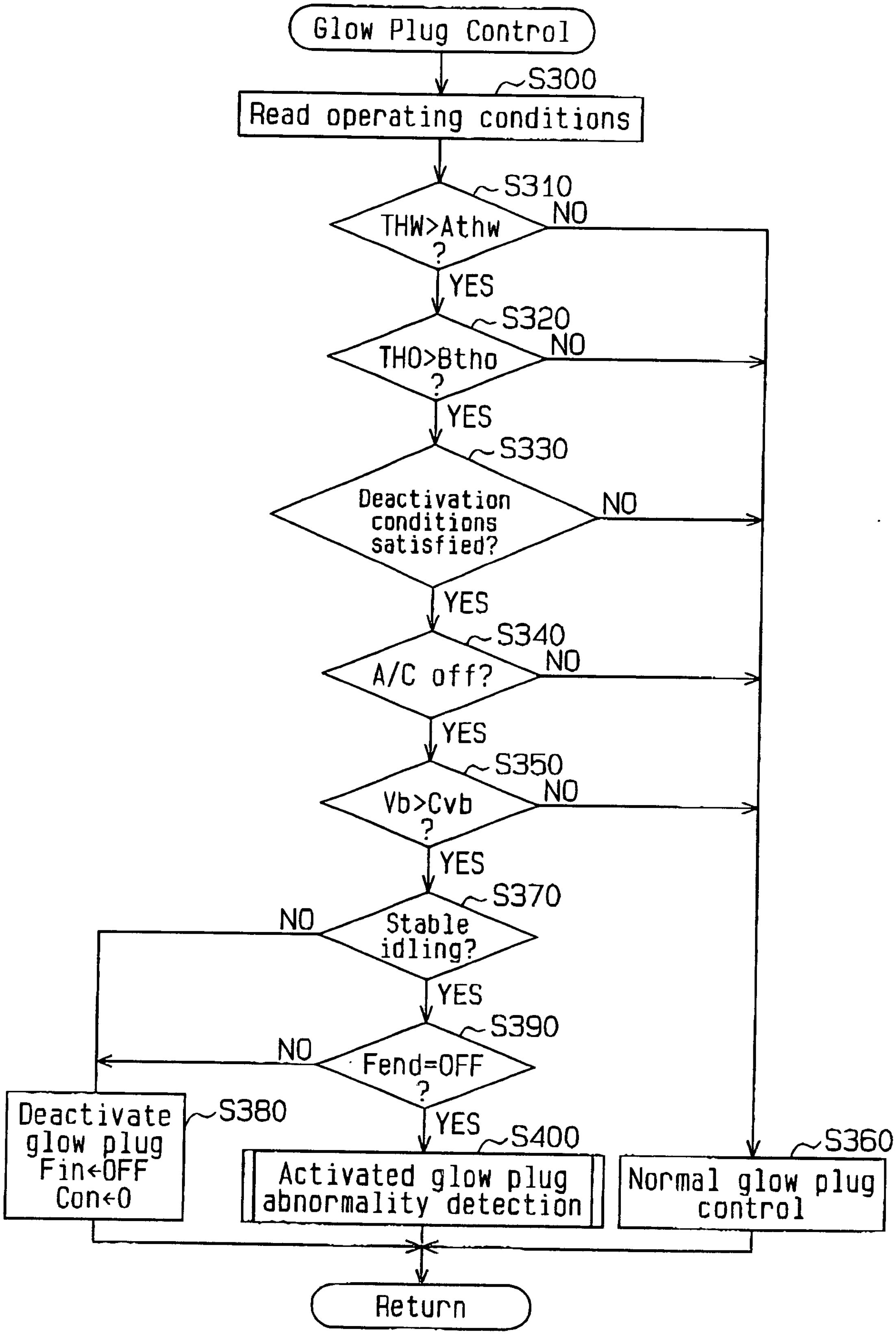

Glow Plug Control
S300
Read operating conditions
S310
THW>Athw ?
NO
YES
S320
THO>Btho ?
NO
YES
S330
Deactivation conditions satisfied?
NO
YES
S340
A/C off?
NO
YES
S350
Vb>Cvb ?
NO
YES
S370
Stable idling?
NO
YES
S390
Fend=OFF ?
NO
YES
S380
Deactivate glow plug Fin←OFF Con←0
S400
Activated glow plug abnormality detection
S360
Normal glow plug control
Return

Fig.6

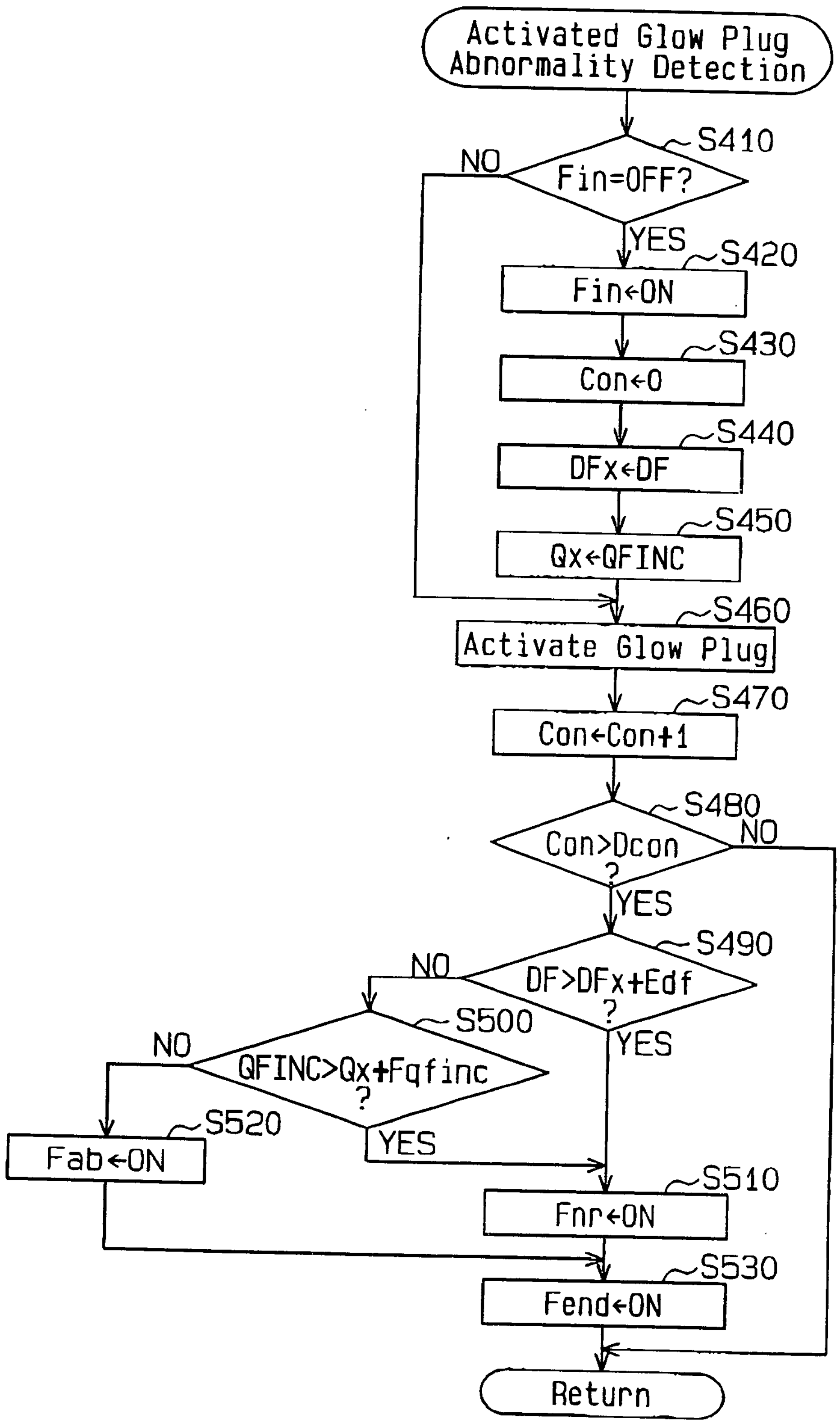

Activated Glow Plug Abnormality Detection
S410
Fin=OFF?
NO
YES
S420
Fin←ON
S430
Con←0
S440
DFx←DF
S450
Qx←QFINC
S460
Activate Glow Plug
S470
Con←Con+1
S480
Con>Dcon ?
NO
YES
S490
DF>DFx+Edf ?
NO
YES
S500
QFINC>Qx+Fqfinc ?
NO
YES
S520
Fab←ON
S510
Fnr←ON
S530
Fend←ON
Return

Fig.7

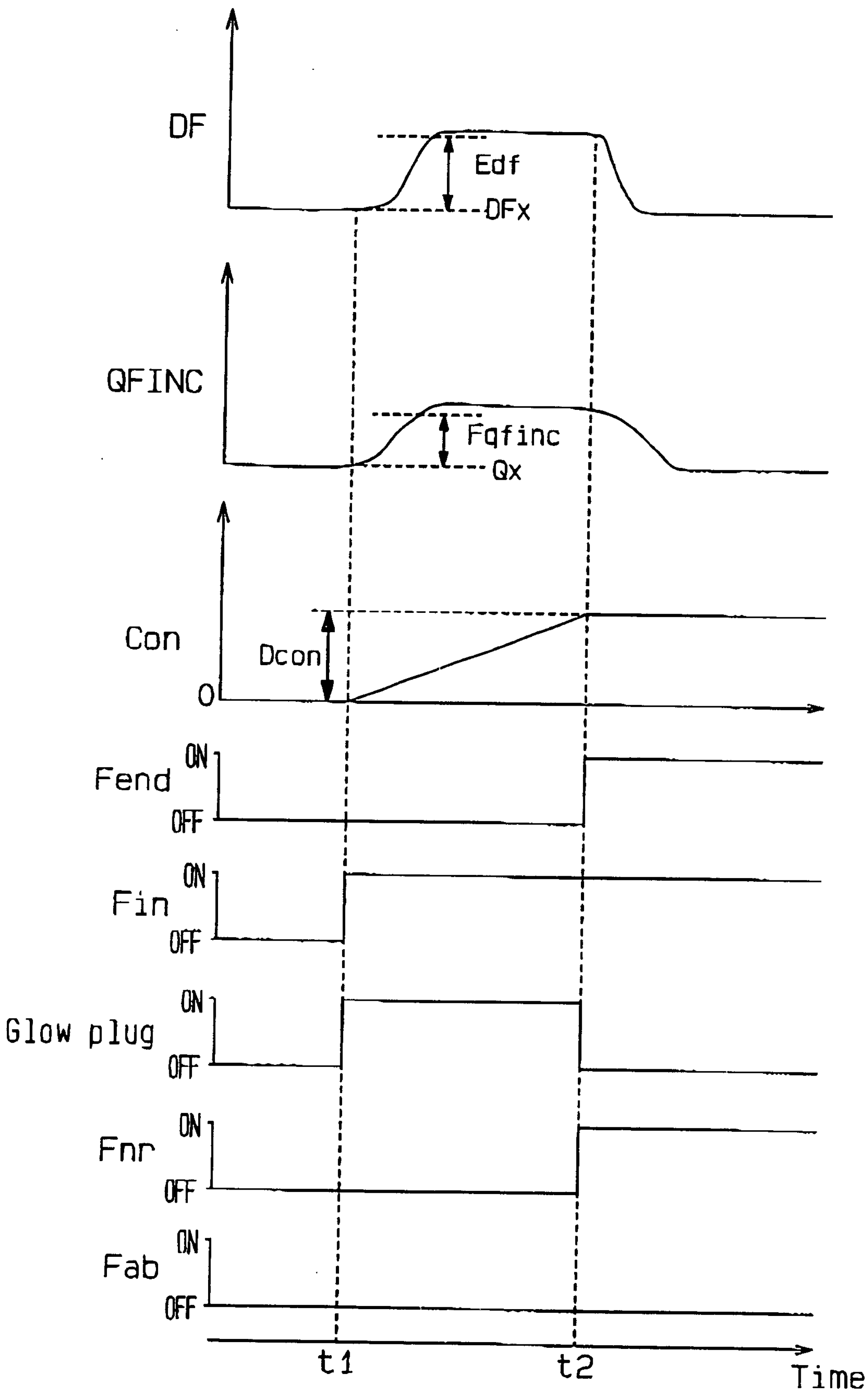

DF
Edf
DFx
QFINC
Fqfinc
Qx
Con
Dcon
0
Fend
ON
OFF
Fin
ON
OFF
Glow plug
ON
OFF
Fnr
ON
OFF
Fab
ON
OFF
t1
t2
Time

Fig.8

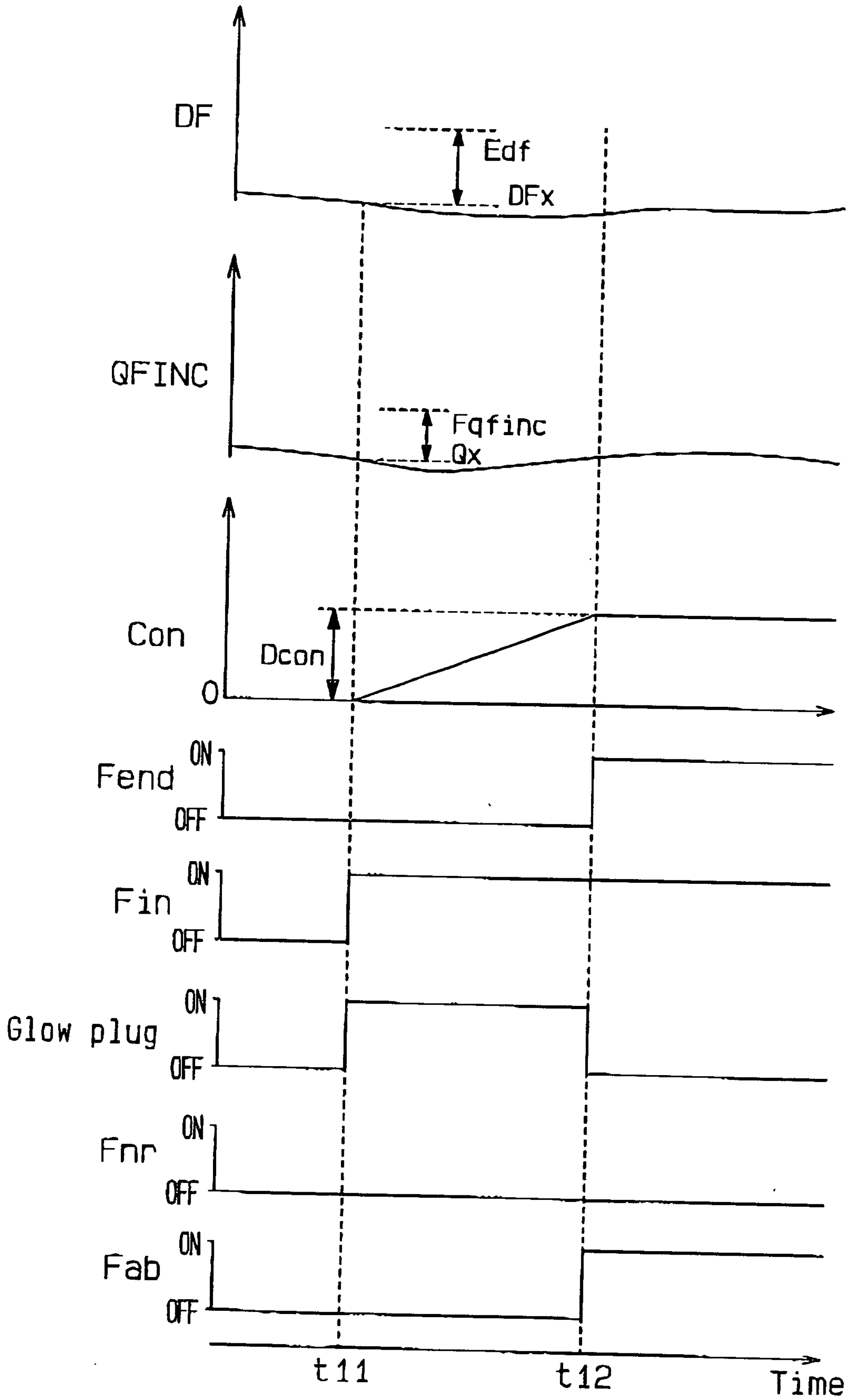

DF
Edf
DFx
QFINC
Fqfinc
Qx
Con
Dcon
0
Fend
ON
OFF
Fin
ON
OFF
Glow plug
ON
OFF
Fnr
ON
OFF
Fab
ON
OFF
t11
t12
Time

Fig.9

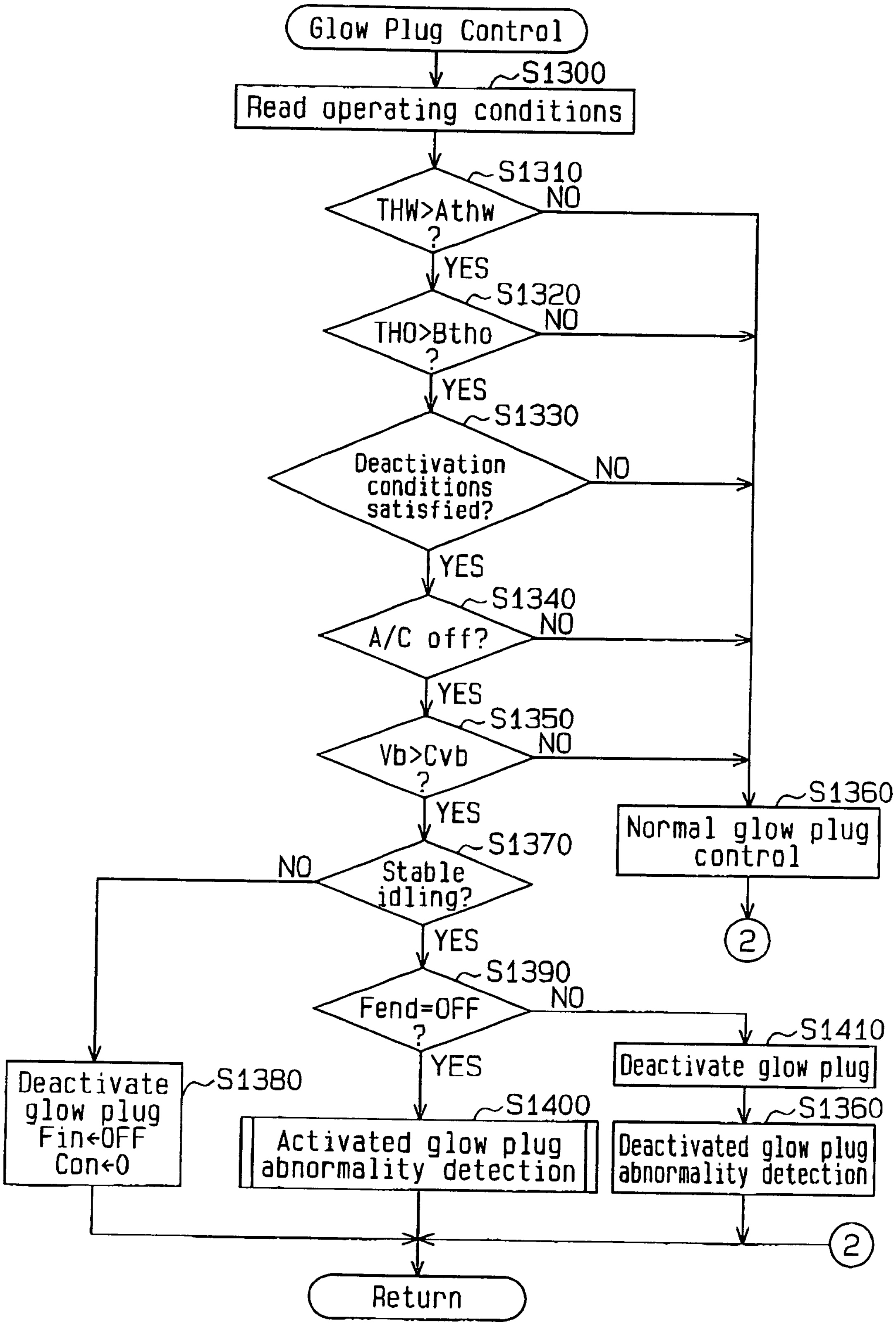

Glow Plug Control
S1300
Read operating conditions
S1310
THW>Athw ?
NO
YES
S1320
THO>Btho ?
NO
YES
S1330
Deactivation conditions satisfied?
NO
YES
S1340
A/C off?
NO
YES
S1350
Vb>Cvb ?
NO
YES
S1360
Normal glow plug control
2
S1370
Stable idling?
NO
YES
S1390
Fend=OFF ?
NO
YES
S1410
Deactivate glow plug
S1360
Deactivated glow plug abnormality detection
S1380
Deactivate glow plug Fin←OFF Con←0
S1400
Activated glow plug abnormality detection
2
Return

Fig.10

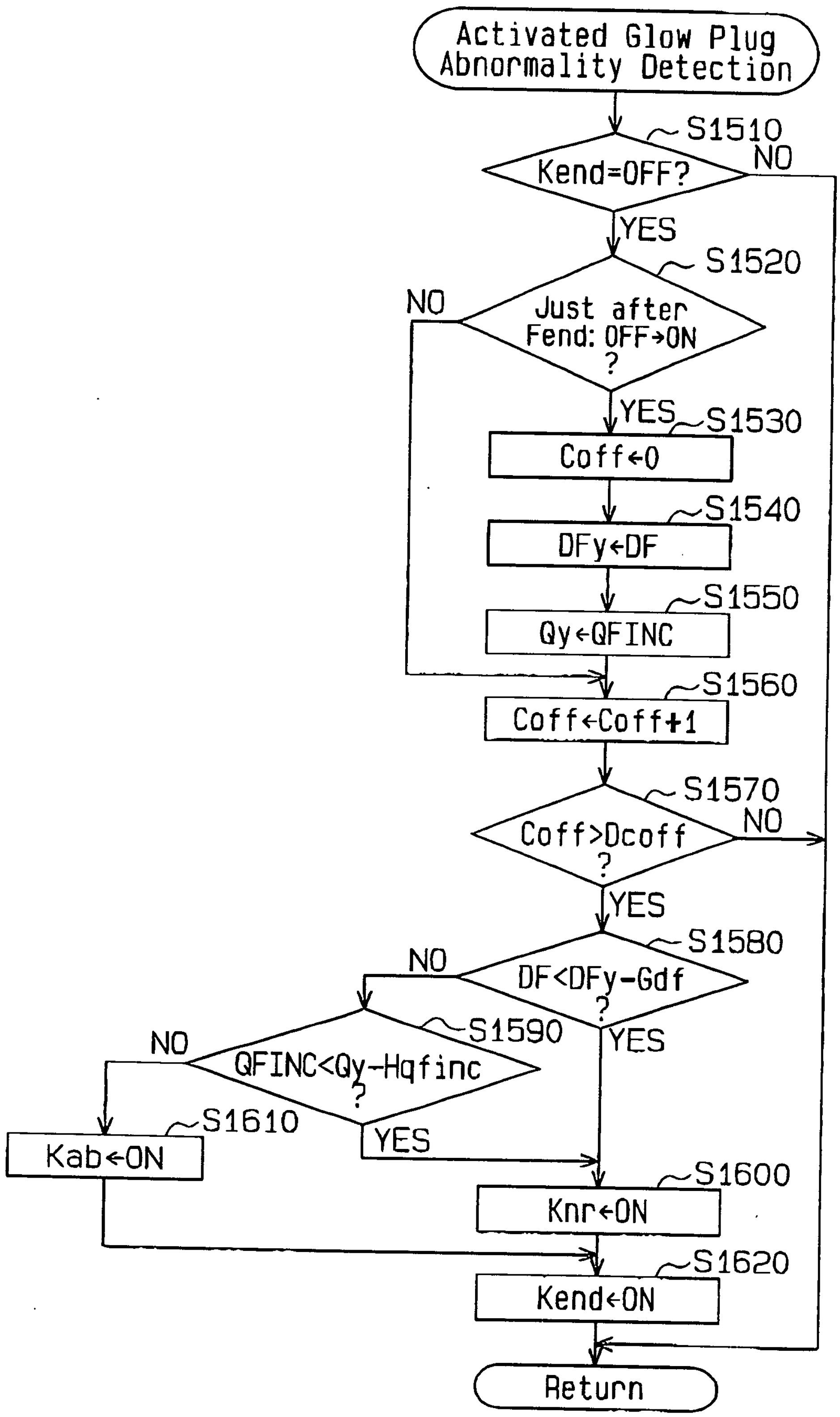

Activated Glow Plug Abnormality Detection
S1510
Kend=OFF?
NO
YES
S1520
Just after Fend: OFF→ON ?
NO
YES
S1530
Coff←0
S1540
DFy←DF
S1550
Qy←QFINC
S1560
Coff←Coff+1
S1570
Coff>Dcoff ?
NO
YES
S1580
DF<DFy-Gdf ?
NO
YES
S1590
QFINC<Qy-Hqfinc ?
NO
YES
S1610
Kab←ON
S1600
Knr←ON
S1620
Kend←ON
Return

Fig.11

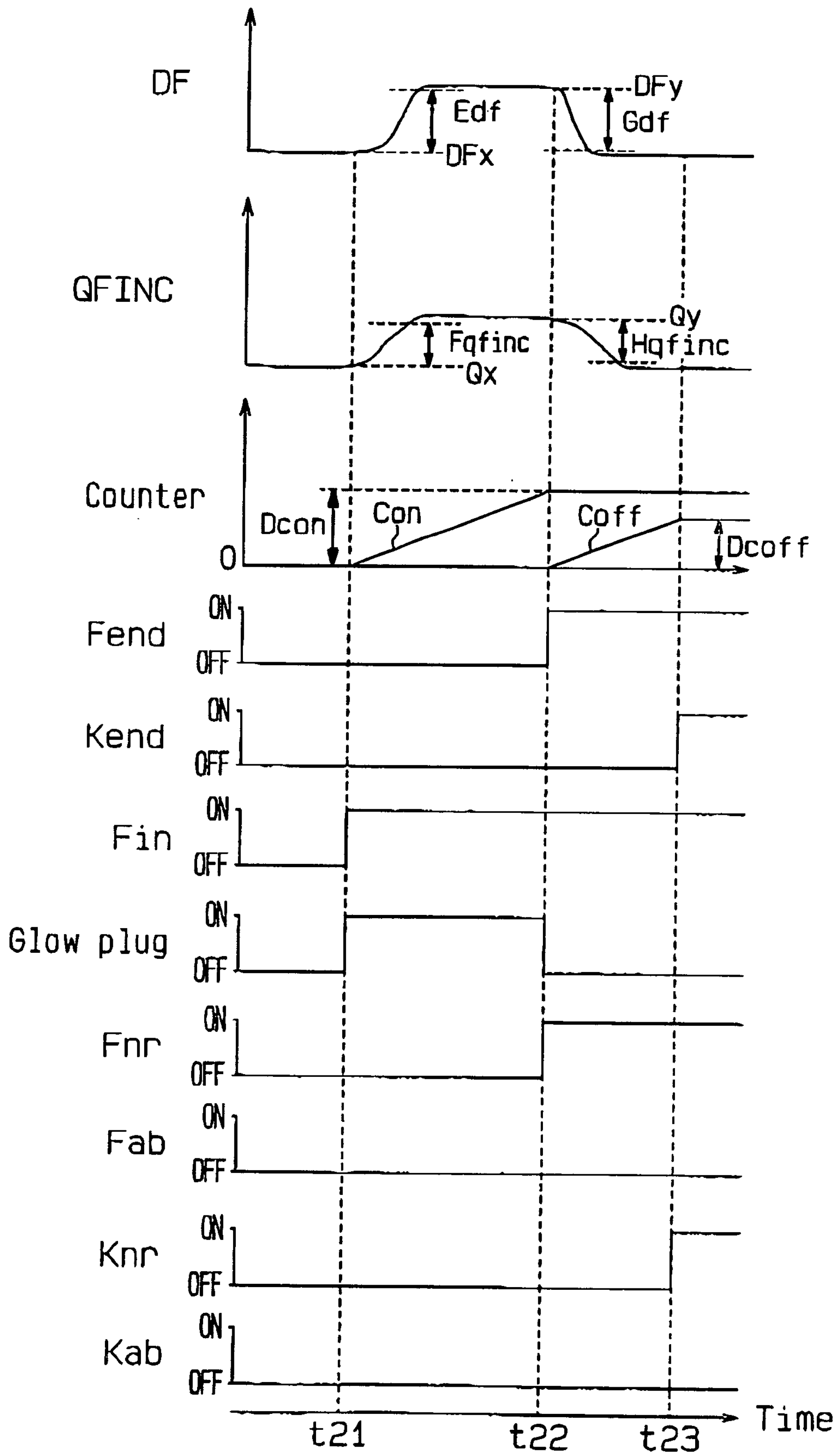
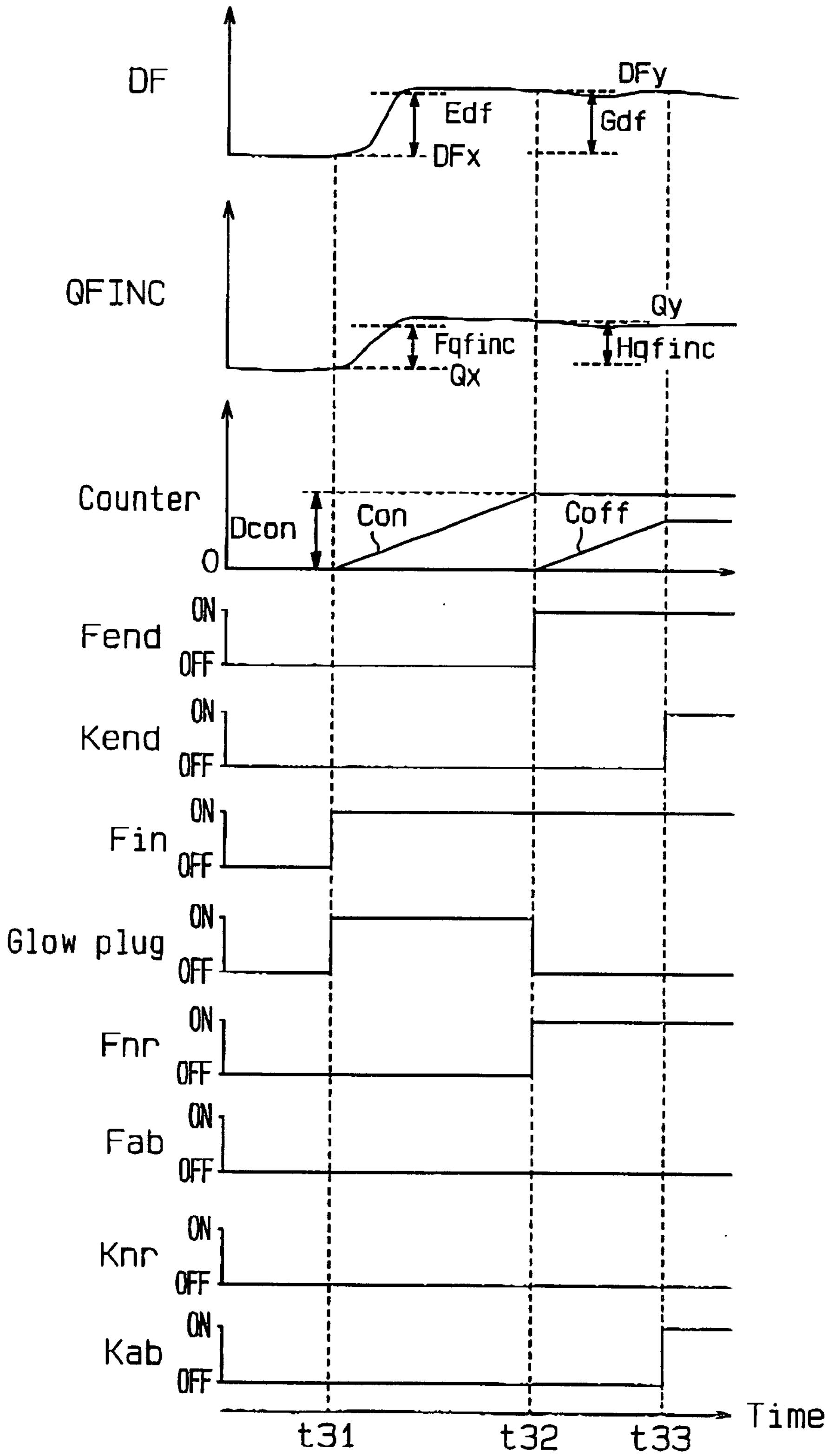

DF
DFy
Edf
Gdf
DFx
QFINC
Qy
Fqfinc
Hqfinc
Qx
Counter
Dcon
Con
Coff
Dcoff
0
Fend
Kend
Fin
Glow plug
Fnr
Fab
Knr
Kab
ON
OFF
t21
t22
t23
Time

Fig.12


DF
DFy
Edf
Gdf
DFx
QFINC
Qy
Fqfinc
Hqfinc
Qx
Counter
Dcon
Con
Coff
0
Fend
Kend
Fin
Glow plug
Fnr
Fab
Knr
Kab
ON
OFF
t31
t32
t33
Time

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 12 9852

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 03, 27 February 1998 (1998-02-27) & JP 09 291873 A (DENSO CORP), 11 November 1997 (1997-11-11) * abstract * ---	1,2,6,7	F02P19/02 F02D41/22
D,A	PATENT ABSTRACTS OF JAPAN vol. 007, no. 221 (M-246), 30 September 1983 (1983-09-30) & JP 58 113581 A (ISUZU JIDOSHA KK;OTHERS: 01), 6 July 1983 (1983-07-06) * abstract * ---	1	
D,A	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 12, 29 October 1999 (1999-10-29) & JP 11 182400 A (ISUZU MOTORS LTD), 6 July 1999 (1999-07-06) * abstract * ---	1	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
D,A	PATENT ABSTRACTS OF JAPAN vol. 006, no. 089 (M-132), 27 May 1982 (1982-05-27) & JP 57 026275 A (NIPPON DENSO CO LTD), 12 February 1982 (1982-02-12) * abstract * -----	1	F02P F02D F23Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	2 May 2002	Röttger, K

CATEGORY OF CITED DOCUMENTS

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& : member of the same patent family, corresponding document

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02-05-2002

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