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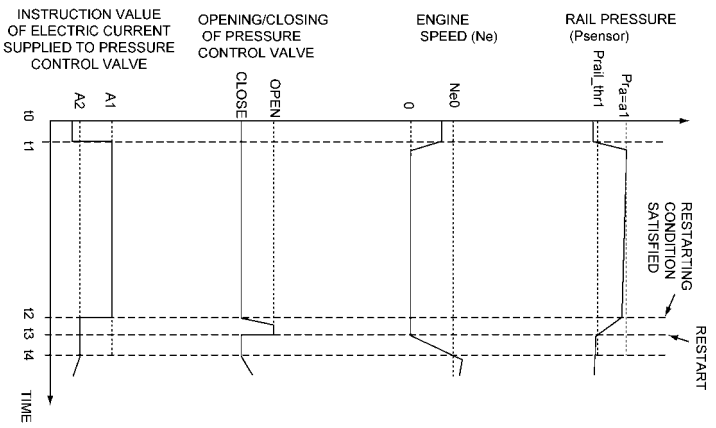
# (54) CONTROL DEVICE FOR INTERNAL COMBUSTION ENGINE

(57) Provided is a control device for an internal combustion engine which can decrease a load applied to a drive system of a high pressure pump at the time of restarting the internal combustion engine from an automatic stop state of the internal combustion engine.

A control device for an internal combustion engine which can execute an idling stop control includes: an idling stop condition satisfaction detection part which detects that a predetermined idling stop condition is satisfied and outputs an instruction to automatically stop the internal combustion engine; a restarting condition satisfaction detection part which detects that a predetermined restarting condition is satisfied during an automatic stop of the internal combustion engine and outputs an instruction to restart the internal combustion engine; a rail pressure detection part which detects pressure in the common rail; and a pressure control valve control part which opens the pressure control valve before restarting the internal combustion engine when the pressure in the common rail becomes a predetermined threshold value or more at the time of satisfying the restarting condition.

Fig.4

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## Description

Technical Field

**[0001]** The present invention relates to a control device for an internal combustion engine for performing a control of the internal combustion engine using an accumulator fuel injection device. The present invention particularly relates to a control device for an internal combustion engine capable of performing an idling stop control.

Background Art

**[0002]** Conventionally, as a device which injects fuel into a cylinder of an internal combustion engine including a diesel engine or the like, an accumulator fuel injection device which includes a common rail for accumulating fuel in a high pressure state supplied by a high pressure pump (common rail system) has been used. Plural fuel injection valves are connected to the common rail. By controlling a valve opening timing and a valve opening time of each fuel injection valve in a state where high pressure fuel is supplied to each fuel injection valve, fuel can be injected into cylinders of the internal combustion engine in various fuel injection patterns.

**[0003]** In such an accumulator fuel injection device, usually, the high pressure pump is configured to be driven by power of the internal combustion engine. To be more specific, a camshaft of the high pressure pump is connected to a drive shaft of the internal combustion engine by way of gears. Accordingly, during the operation of the internal combustion engine, the high pressure pump is also operated, while when the internal combustion engine is stopped, the high pressure pump is also stopped.

**[0004]** In the accumulator fuel injection device, a pressure in the common rail (hereinafter referred to as "rail pressure") largely influences the fuel injection characteristic or combustion property. As a method of controlling a rail pressure, there has been known a control method where a flow rate of high pressure fuel discharged from a common rail is adjusted by a pressure control valve provided to the common rail.

**[0005]** In the control of an internal combustion engine using such an accumulator fuel injection device, recently, for enhancing fuel economy, for reducing an quantity of exhaust gas and noises or the like, an idling stop control has been put into practice where an internal combustion engine is automatically stopped during temporary stop of a vehicle on which the internal combustion engine is mounted. In this idling stop control, when a predetermined idling stop condition is satisfied, the internal combustion engine is automatically stopped, and the internal combustion engine is restarted when a predetermined restarting condition is satisfied during automatic stop. In the vehicle on which the internal combustion engine capable of performing this idling stop control is mounted, restartability from an automatic stop state is a factor which significantly influences a commodity value.

**[0006]** In view of the above, there has been proposed a control device for an internal combustion engine which can shorten a stop time of an internal combustion engine during an idling stop control or can surely enhance restartability. To be more specific, there has been disclosed a control device for an internal combustion engine where a discharge flow rate of a high pressure pump is increased during the automatic stop of the internal combustion engine which is brought about by an idling stop control thus adjusting a load of the internal combustion engine whereby the internal combustion engine is stopped at a predetermined crank angle suitable for restarting so that the fuel injection is started simultaneously with an operation of a starter at the time of restarting (see patent document 1).

Prior Art Document

Patent Document

**[0007]** 1 Patent Document 1: JP-A-2008-163796 (whole specification and all drawings)

Disclosure of the Invention

Problems to be Solved by the Invention

**[0008]** When an internal combustion engine is a diesel engine, for example, to enhance restartability of the engine from an automatic stop state, a factor that a compression ratio in the engine is sufficient and a factor that the fuel injection by an accumulator fuel injection device is possible become important. Out of these two important factors, whether or not the compression ratio is sufficient is a matter related to an engine side, while whether or not the fuel injection is possible is a matter related to an accumulator fuel injection device side. Whether or not the fuel injection is possible in the accumulator fuel injection device depends on whether or not a rail pressure is equal to or above a pressure at which the normal injection of fuel is possible (hereinafter referred to as "injectable pressure"). Accordingly, to enhance restartability of the internal combustion engine, there may be a case where even during automatic stop of the internal combustion engine which is brought about by an idling stop control, a control is performed so as to maintain a rail pressure in a high state.

**[0009]** Here, even when a fuel injection valve, a high pressure pump, a pressure control valve and the like which are connected to the common rail are closed, there may be a case where some of high pressure fuel leaks to a fuel low-pressure system through a fine gap present in a fuel high-pressure system including these constitutional elements and hence, a rail pressure is gradually lowered. Accordingly, a target value of the rail pressure at the time of starting the maintenance of the rail pressure during the automatic stop is set to a value higher than the injectable pressure.

**[0010]** When the internal combustion engine is started with the rail pressure maintained in a high state at the time of restarting the internal combustion engine, a drive torque which is generated when an operation of the high pressure pump is started becomes remarkably large thus imparting a large load on a drive system of the high pressure pump. To be more specific, the internal combustion engine is in a state where an engine speed is rapidly increased at the time of restarting the internal combustion engine. Assuming that a rail pressure control by a pressure control valve is started when the rail pressure is further elevated in such a state, an overshoot or an undershoot of the rail pressure occurs thus giving rise to a possibility that the rail pressure becomes uncontrollable. In view of the above, at the time of restarting the internal combustion engine, to enable a prompt rail pressure control, usually, a rail pressure control is not performed until an engine speed of the internal combustion engine reaches a predetermined engine speed so that a flow rate control valve which adjusts the supply quantity of fuel to a common rail is opened and a pressure control valve provided to the common rail is closed.

**[0011]** Here, between a pressurizing chamber of the high pressure pump and the common rail, a fuel discharge valve is provided which is opened when the pressure in the pressurizing chamber exceeds the sum of a rail pressure and a set force of a valve spring. Accordingly, when fuel is supplied to the pressurizing chamber of the high pressure pump at the time of restarting the internal combustion engine and the high pressure pump is driven in a state where a rail pressure is high, the pressure in the pressurizing chamber becomes remarkably high during a period until the fuel discharge valve is opened. As a result, a large force which pushes up a plunger for pressurizing fuel becomes necessary so that a large load is generated in the drive system of the high pressure pump.

**[0012]** Further, in a state where the high pressure pump is stopped, in a contact portion between a cam which is fixed to a cam shaft and a tappet which transmits a rotational force of the cam as an elevating force of the plunger, a lubricant or a fuel for lubrication flows out so that the high pressure pump is in a state where the oil film at the contact portion is insufficient. At the time of starting an operation of the high pressure pump which is in a state where the oil film at the contact portion between the tappet and the cam is insufficient as described above, when a large load is applied to the drive system of the high pressure pump, a decrease in durability of the high pressure pump is brought about.

**[0013]** In view of the above, inventors of the present invention have made extensive studies, and have found out that when a rail pressure is higher than necessary at the time of restarting an internal combustion engine from an automatic stop state of the internal combustion engine which is brought about by an idling stop control, the above-mentioned drawbacks can be overcome by opening a pressure control valve provided to a common rail before restarting the internal combustion engine, and have completed the present invention based on such finding. That is, it is an object of the present invention to provide a control device for an internal combustion engine which can decrease a load applied to a drive system of a high pressure pump at the time of restarting the internal combustion engine from an automatic stop state of the internal combustion engine.

Means for solving the problem

**[0014]** According to the present invention, there is provided a control device for an internal combustion engine which is a control device for performing a control of the internal combustion engine by an accumulator fuel injection device which includes: a common rail to which a fuel injection valve is connected; a high pressure pump which supplies fuel to the common rail under pressure; and a pressure control valve which adjusts a flow rate of fuel discharged from the common rail, the control device of the internal combustion engine capable of performing an idling stop control, wherein the control device includes: an idling stop condition satisfaction detection part which detects that a predetermined idling stop condition is satisfied and outputs an instruction to automatically stop the internal combustion engine; a restarting condition satisfaction detection part which detects that a predetermined restarting condition is satisfied during an automatic stop of the internal combustion engine and outputs an instruction to restart the internal combustion engine; a rail pressure detection part which detects pressure in the common rail; and a pressure control valve control part which opens the pressure control valve before restarting the internal combustion engine when the pressure in the common rail becomes a predetermined threshold value or more at the time of the satisfaction of the restarting condition. With such a control device for an internal combustion engine, the above-mentioned drawbacks can be overcome.

**[0015]** Further, in constituting the control device for an internal combustion engine according to the present invention, it is preferable that the threshold value is a value set based on a load allowed to be applied to a drive system of the high pressure pump from the high pressure pump.

**[0016]** In constituting the control device for an internal combustion engine according to the present invention, it is preferable that the restarting condition satisfaction detection part detects that the restarting condition is satisfied in a short time before the satisfaction of the restarting condition, and the pressure control valve control part opens the pressure control valve when it is detected that the restarting condition is satisfied in a short time and the pressure in the common rail assumes the threshold value or more.

**[0017]** Further, in constituting the control device for an internal combustion engine according to the present invention, it is preferable that the control device includes

a rail pressure determination part which restarts the internal combustion engine when the pressure in the common rail becomes less than the threshold value after the restarting condition is satisfied.

Advantage of the Invention

**[0018]** According to the control device for an internal combustion engine of the present invention, when a rail pressure is maintained at a higher level than necessary at the time of restarting the internal combustion engine from an automatic stop state of the internal combustion engine which is brought about by the idling stop control, the pressure control valve is opened before restarting of the internal combustion engine and hence, the rail pressure is forcibly lowered. Accordingly, a possibility that the internal combustion engine is restarted while the rail pressure is held at a higher level than necessary is eliminated and hence, the sharp elevation of the pressure in a pressurizing chamber can be suppressed whereby a load applied to the drive system of the high pressure pump can be decreased. Further, when the rail pressure is elevated after starting the internal combustion engine so that the pressure in the pressurizing chamber is increased, a lubricant or a fuel for lubrication permeates in a contact portion between a tappet and a cam due to driving of the high pressure pump thus forming an oil film and hence, a decrease in durability of the high pressure pump can be suppressed.

Brief Description of the Drawings

**[0019]**

[Fig. 1] Fig. 1 is an overall view showing a constitutional example of an accumulator fuel injection device.
[Fig. 2] Fig. 2 is a view for explaining a constitutional example of a high pressure pump.
[Fig. 3] Fig. 3 is a block diagram for explaining a constitutional example of a control device according to a first embodiment of the present invention.
[Fig. 4] Fig. 4 is a time chart diagram for explaining a control method executed by the control device according to the first embodiment.
[Fig. 5] Fig. 5 is a flow chart showing a control flow for explaining the control method executed by the control device according to the first embodiment.
[Fig. 6] Fig. 6 is a time chart diagram for explaining a control method executed by the control device according to the second embodiment.
[Fig. 7] Fig. 7 is a flow chart showing a control flow for explaining the control method executed by the control device according to the second embodiment.

Mode for Carrying Out the Invention

**[0020]** Hereinafter, embodiments relating to a control device for an internal combustion engine according to the present invention are specifically explained in conjunction with drawings. However, these embodiments show one mode of the present invention and do not limit the present invention, and the mode of the invention can be desirably changed within the scope of the present invention. In the respective drawings, identical members are given the same symbols, and the explanation of the parts is omitted when appropriate.

1. Accumulator fuel injection device

**[0021]** Fig. 1 shows a constitutional example of an accumulator fuel injection device 50 used in a control of an internal combustion engine. The accumulator fuel injection device 50 is a device for injecting fuel to cylinders of a diesel engine 40 mounted on a vehicle and includes, as main components thereof, a fuel tank 1, a low pressure pump 2, a flow rate control valve 8, a high pressure pump 5, a common rail 10, a pressure control valve 12, fuel injection valves 13, a control device 60 and the like.

**[0022]** A speed sensor 45 used for detecting an engine speed and a starter 44 for forcibly rotating a drive shaft at the time of starting are provided to the diesel engine 40.

**[0023]** The low pressure pump 2 and pressurizing chambers 5a of the high pressure pump 5 are connected to each other through low pressure fuel passages 18a, 18b, the pressurizing chambers 5a of the high pressure pump 5 and the common rail 10 are connected to each other through a high pressure fuel passage 37, and the common rail 10 and the fuel injection valves 13 are connected to each other through a high pressure fuel passage 39. Further, return passages 30a to 30c for returning surplus fuel which is not injected from the fuel injection valves 13 to the fuel tank 1 are connected to the high pressure pump 5, the common rail 10, and the fuel injection valves 13 or the like.

**[0024]** A flow rate control valve 8 is arranged in a middle portion of the low pressure fuel passage 18b in the high pressure pump 5. As the flow rate control valve 8, for example, an electromagnetic proportional type flow rate control valve in which a stroke quantity of a valve element is variable corresponding to a supply current value so that an area of a fuel passing passage can be adjusted is used. The flow rate control valve 8 is used for adjusting a flow rate of fuel supplied to the pressurizing chambers 5a. The flow rate control valve 8 used in this embodiment is constituted as a normally open flow rate control valve where a flow passage of fuel is fully opened in a non-energizing state. However, the flow rate control valve 8 may be a normally closed flow rate control valve where a flow passage of fuel is fully closed in a non-energizing state.

**[0025]** A pressure adjusting valve 14 which is arranged parallel to the flow rate control valve 8 is provided to a fuel passage branched from the low pressure fuel passage 18b on an upstream side of the flow rate control valve 8. The pressure adjusting valve 14 is connected to

a return passage 30a communicating with the fuel tank 1. As the pressure adjusting valve 14, an overflow valve which is opened when the difference in pressure between in front of and behind the pressure adjusting valve 14, that is, the difference in pressure between the pressure in the low pressure fuel passage 18b and the pressure in the return passage 30a exceeds a predetermined value is used. Accordingly, in a state where fuel is supplied under pressure by the low pressure pump 2, the pressure in the low pressure fuel passages 18a, 18b is adjusted to a value larger than the pressure in the return passage 30a by predetermined difference in pressure.

**[0026]** The low pressure pump 2 pumps up fuel in the fuel tank 1 and supplies fuel under pressure to the pressurizing chambers 5a of the high pressure pump 5 through the low pressure fuel passages 18a, 18b. The low pressure pump 2 shown in Fig. 1 is an in-tank electrically operated pump arranged in the inside of the fuel tank 1, and is driven with a Voltage supplied from a battery so as to supply fuel under pressure. However, the low pressure pump 2 may be a pump which is arranged outside the fuel tank 1 or the low pressure pump 2 may be a gear pump driven using power of the diesel engine 40.

**[0027]** The high pressure pump 5 pressurizes fuel introduced into the pressurizing chamber 5a by the low pressure pump 2 through a fuel intake valve 6 by a plunger 7, and supplies fuel in a high pressure state to the common rail 10 through a fuel discharge valve 9 and the high pressure fuel passage 37 under pressure. The fuel discharge valve 9 adopts the check valve structure where the higher a rail pressure on a discharge side becomes, the higher the sealing property is acquired.

**[0028]** A cam 15 which drives the high pressure pump 5 is fixed to a cam shaft connected to a drive shaft of the diesel engine 40 by way of gears. The high pressure pump 5 shown in Fig. 1 includes two plungers 7. When these two plungers 7 are pushed up by the cam 15, fuel is pressurized in two pressurizing chambers 5a so that high pressure fuel is supplied under pressure to the common rail 10.

**[0029]** The high pressure pump 5 of the accumulator fuel injection device 50 according to this embodiment has the fuel lubrication type constitution where injection-use fuel is used as lubricant. That is, fuel supplied to the inside of the high pressure pump 5 through the low pressure fuel passage 18a temporarily flows into the cam chamber 16, and is supplied to the pressurizing chambers 5a from the cam chamber 16 through the low pressure fuel passage 18b.

**[0030]** The common rail 10 accumulates high pressure fuel supplied under pressure from the high pressure pump 5, and supplies the high pressure fuel to plural fuel injection valves 13 connected to the common rail 10 through the high pressure fuel passages 39. The common rail 10 is provided with the pressure control valve 12 and a pressure sensor 21. Out of these parts, as the pressure sensor 21, a known pressure sensor such as a piezoelectric element sensor or a semiconductor sensor is used.

**[0031]** Further, as the pressure control valve 12, for example, used is an electromagnetic proportional type control valve in which a stroke quantity of a valve element is variable corresponding to a supply current value so that an area of a fuel passing passage can be adjusted. A rail pressure is adjusted by controlling an energizing quantity to the pressure control valve 12 corresponding to a target rail pressure and a required injection quantity thus adjusting a flow rate of high pressure fuel discharged to a return passage 30b from the common rail 10. The pressure control valve 12 used in this embodiment is constituted of a normally open type pressure control valve where a fuel flow passage is fully opened in a non-energizing state. However, the pressure control valve 12 may be constituted of a normally closed type pressure control valve where the fuel flow passage is fully closed in a non-energizing state.

**[0032]** The fuel injection valve 13 connected to the common rail 10 includes a nozzle body in which an injection hole is formed, and a nozzle needle which opens or closes the injection hole due to an advancing or retracting movement thereof. The fuel injection valve 13 is configured such that the injection hole is closed when a back pressure is applied to a rear end side of the nozzle needle as a load, while the injection hole is opened by releasing the applied back pressure thus injecting high pressure fuel supplied from the common rail 10 into the cylinder of the diesel engine. The fuel injection valve 13 can perform the normal fuel injection when the rail pressure assumes the predetermined injectable pressure or more.

**[0033]** As the fuel injection valve 13, a piezoelectric injector which includes a piezoelectric element as a back pressure control means or a magnetic control type fuel injection valve which includes an electromagnetic solenoid as a back pressure control means is used. In this embodiment, the piezoelectric injector is used as the fuel injection valve 13. The piezoelectric injector adopts the structure where fuel hardly leaks to a return passage 30c except for a passage for releasing a back pressure.

2. High pressure pump

**[0034]** Fig. 2 shows one example of the specific constitution of the high pressure pump 5. The high pressure pump 5 includes: a pump housing 51; a cylinder head 52 which is mounted in the inside of a circular columnar space 51a formed in the pump housing 51; the plunger 7 which is slidably held by a cylinder 52a of the cylinder head 52; a spring 55 which has both ends thereof engaged with the cylinder head 52 and a spring sheet 59 respectively and biases the plunger 7 downwardly; and a tappet structural body 58 which is interposed between the plunger 7 and the cam 15, and pushes up the plunger 7 while centering the plunger 7 along with the rotation of the cam 15. Further, a fuel intake valve 6 is arranged on an upper opening portion of the cylinder 52a of the cyl-

inder head 52, and the fuel discharge valve 9 is arranged in the lateral direction with respect to the axial direction of the cylinder 52a through a fuel discharge passage 52b. In Fig. 2, the flow rate control valve 8 and the pressure adjusting valve 14 provided to the high pressure pump 5 are not shown in the drawing.

**[0035]** In this high pressure pump 5, a portion of the cylinder 52a of the cylinder head 52 is closed by an inner peripheral surface of the cylinder head 52, the plunger 7, the fuel intake valve 6 and the fuel discharge valve 9 thus constituting the pressurizing chamber 5a. Fuel which flows into the pressurizing chamber 5a through the fuel intake valve 6 is pressurized, in the pressurizing chamber 5a, by the plunger 7 which is pushed up along with the rotational movement of the cam 15. When the pressure in the pressurizing chamber 5a exceeds the sum of a set force of a valve spring of the fuel discharge valve 9 and the rail pressure, the fuel discharge valve 9 is opened by pushing whereby pressurized fuel is supplied to the common rail under pressure.

**[0036]** As described above, the high pressure pump 5 is configured such that after fuel supplied under pressure by the low pressure pump flows into the cam chamber 16, some of the fuel flows back and forth between the cam chamber 16 and the columnar space 51a. This fuel reaches a contact portion between a roller 54 of the tappet structural body 58 and the cam 15, a slide portion between the columnar space 51a and the tappet structural body 58, the above-mentioned slide portion between the cylinder 52a and the plunger 7, a slide portion between the cam shaft 11 and a bearing of the pump housing 51 or the like, and functions as a lubricant.

**[0037]** In a state where the high pressure pump 5 is driven, due to whirling by the cam 15 or a discharge pressure of the low voltage pump 2, fuel in the cam chamber 16 reaches respective contact portions, the slide portions and the like and hence, the fuel lubrication using the injection-use fuel normally functions. On the other hand, in a state where the high pressure pump 5 is stopped, fuel in the cam chamber 16 hardly reaches the respective contact portions, the slide portions and the like or the fuel flows out from the respective contact portions, slide portions and the like and hence, the fuel lubrication is liable to be brought into a state where an oil film is insufficient.

3. Control device for internal combustion engine

**[0038]** Fig. 3 shows, in the control device 60 of the diesel engine 40 according to this embodiment, a constitutional example of a part relating to a control which is performed at the time of restarting the diesel engine 40 from an automatic stop state of the diesel engine 40 brought about by an idling stop control by functional blocks.

**[0039]** The control device 60 includes: an idling stop control part 63 which includes an idling stop condition satisfaction detection part 61 and a restart condition satisfaction detection part 62; a target rail pressure calculation part 65; a rail pressure detection part 67; a rail pressure determination part 69; a fuel injection valve control part 71; a flow rate control valve control part 73; a pressure control valve control part 75; a starter control part 77 and the like. The control device 60 is mainly constituted of a microcomputer having the known constitution, and the respective parts are realized by executing programs using the microcomputer. Further, the control device 60 is provided with a storage means such as a RAM (Random Access Memory) not shown in the drawing for storing calculation results and detection results at the respective parts.

(1) Idling stop control part

**[0040]** The idling stop control part 63, when the satisfaction of a predetermined idling stop condition is detected by the idling stop condition satisfaction detection part 61, transmits an instruction to stop the diesel engine 40 by stopping the fuel injection to the fuel injection valve control part 71. Here, the idling stop control part 63 transmits an instruction to interrupt the energizing of the flow rate control valve 8 to the flow rate control valve control part 73. Further, the idling stop control part 63, for holding a rail pressure at a predetermined pressure, transmits an instruction to energize the pressure control valve 12 at a predetermined holding current A1 to the pressure control valve control part 75.

**[0041]** Further, the idling stop control part 63, when the satisfaction of a predetermined restarting condition is detected by the restarting condition satisfaction detection part 62 during a period where the diesel engine 40 is automatically stopped by the idling stop control, transmits an instruction to restart the diesel engine 40 by restarting the fuel injection to the fuel injection valve control part 71 and the starter control part 77. Further, the idling stop control part 63 transmits the satisfaction of the restarting condition to the rail pressure determination part 69 when the restarting condition is satisfied.

**[0042]** The idling stop condition detected by the idling stop condition satisfaction detection part 61 may be set such that the idling stop condition includes at least one of, for example, a condition that an engine switch Sw is in an ON state, a condition that a gear sensor indicates a neutral position as a detection position Sg, a condition that a brake pedal sensor indicates that a detection position Sb is in a pedal stepped-in state, a condition that an engine speed Ne of the diesel engine 40 is equal to or less than a predetermined threshold value, and a condition that a state where a vehicle speed V is 0 continues for a predetermined time or more and the like. However, the idling stop condition is not limited to these conditions.

**[0043]** Further, the restarting condition detected by the restart condition satisfaction detection part 62 may be set such that the restart condition includes some conditions out of conditions such as a condition that the detection position Sg of the gear sensor is released from a neutral state during an automatic stop of the diesel engine

40, and a condition that an acceleration pedal Acc is stepped in during the automatic stop of the diesel engine 40. However, the restart condition is not limited to these conditions.

(2) Fuel injection valve control part

**[0044]** The fuel injection valve control part 71 calculates a target fuel injection quantity Qtgt based on an engine speed Ne, an acceleration operation quantity Acc or the like, and also generates a control signal for the fuel injection valve 13 corresponding to the target fuel injection quantity Qtgt, and outputs the control signal to the fuel injection valve 13. When a signal indicative of the satisfaction of an idling stop condition is transmitted to the fuel injection valve control part 71 from the idling stop control part 63, the fuel injection valve control part 71 stops the fuel injection, and restarts the fuel injection when a signal indicative of the satisfaction of a restarting condition is transmitted to the fuel injection valve control part.

**[0045]** The fuel injection valve control part 71 of the control device 60 according to this embodiment is configured not to restart the fuel injection control until the fuel injection valve control part 71 receives a start permission instruction from the rail pressure determination part 69 even when the satisfaction of a restart condition is transmitted to the fuel injection valve control part 71 after the diesel engine 40 is automatically stopped by an idling stop control.

(3) Starter control part

**[0046]** The starter control part 77 performs a control where the starter 44 is operated at the time of starting the diesel engine 40 so that a drive shaft is forcibly rotated whereby the inside of the cylinder is brought into a compression state. The starter control part 77 of the control device 60 according to this embodiment is configured not to operate the starter 44 until the starter control part 77 receives a start permission instruction from the rail pressure determination part 69 even when the satisfaction of the restart condition is transmitted to the starter control part 77 after the diesel engine 40 is automatically stopped by an idling stop control.

(4) Target rail pressure calculation part and rail pressure detection part

**[0047]** The target rail pressure calculation part 65 calculates a target rail pressure Ptgt based on an engine speed Ne, an acceleration operation quantity Acc or the like, and stores the calculated target rail pressure Ptgt in the storage means. Further, the rail pressure detection part 67 continuously reads a sensor value of the pressure sensor 21 provided to the common rail 10, acquires a detected rail pressure Psensor and stores the acquired detected rail pressure Psensor in the storage means.

(5) Rail pressure determination part

**[0048]** The rail pressure determination part 69, when the satisfaction of a restarting condition is transmitted from the restarting condition satisfaction detection part 62, continuously reads a detected rail pressure Psensor and determines whether or not the detected rail pressure Psensor is equal to or more than a predetermined threshold value Prail-thr1. The threshold value Prail_thr1 is set to a value which prevents a load applied to a driving system of the high pressure pump 5 from being increased even when driving of the high pressure pump 5 is started. For example, the threshold value Prail_thr1 is set to a value which is larger than the injectable pressure which enables normal injection from the fuel injection valve 13 and smaller than rail pressure $Pr_{a=a1}$ which is estimated to be generated when a holding current A1 is supplied to the pressure control valve 12 when the diesel engine 40 is automatically stopped by an idling stop control.

**[0049]** The rail pressure determination part 69, when the detected rail pressure Psensor is equal to or more than the threshold value Prail_thr1, transmits an instruction signal for opening the pressure control valve 12 to the pressure control valve control part 75. Further, the rail pressure determination part 69 is configured to transmit a start permission instruction to the fuel injection valve control part 71 and the starter control part 77 when the detected rail pressure Psensor takes a value less than the threshold value Prail_thr1.

(6) Flow rate control valve control part and pressure control valve control part

**[0050]** The flow rate control valve control part 73 and the pressure control valve control part 75 execute, basically, an energization control of the flow rate control valve 8 and the pressure control valve 12 respectively so that a detected rail pressure Psensor becomes a target rail pressure Ptgt. To be more specific, the flow rate control valve control part 73 controls a flow rate of fuel to be supplied to the pressurizing chamber 5a of the high pressure pump 5 by adjusting opening of the flow rate control valve 8 so that a flow rate of high pressure fuel supplied under pressure to the common rail 10 from the high pressure pump 5 is changed whereby a rail pressure is adjusted. On the other hand, the pressure control valve control part 75 controls a flow rate of return fuel discharged to the return passage 30b from the common rail 10 by adjusting opening of the pressure control valve 12 thus adjusting a rail pressure.

**[0051]** Whether a control of a rail pressure is performed by the flow rate control valve control part 73, by the pressure control valve control part 75 or by both the flow rate control valve control part 73 and the pressure control valve control part 75 is determined depending on a traveling state of the vehicle and an operation state of the diesel engine 40. However, at the time of starting the diesel engine 40, the control of the rail pressure is not

performed until the engine speed Ne detected by the speed sensor 45 reaches a predetermined engine speed NeO, and the flow rate control valve 8 is basically held in a fully opened state and the pressure control valve 12 is basically closed.

**[0052]** 1 Further, the flow rate control valve control part 73 interrupts the energizing of the flow rate control valve 8 when a signal indicating the satisfaction of an idling stop condition is transmitted to the flow rate control valve control part 73 from the idling stop control part 63. Since the flow rate control valve 8 of this embodiment has the normally-open constitution, when the energizing is interrupted at the moment the diesel engine 40 is automatically stopped, the flow rate control valve 8 is fully closed.

**[0053]** Further, when the pressure control valve control part 75 receives an instruction of a control to be performed accompanying with the satisfaction of an idling stop condition from the idling stop control part 63, the pressure control valve control part 75 performs a control of continuously supplying a predetermined holding current A1 to the pressure control valve 12. This holding current A1 is a control value by which a rail pressure is adjusted to a value larger than the injectable pressure, and is set to a value by which the rail pressure at the time of restarting the engine which is equal to or more than the injectable pressure is ensured even when the diesel engine 40 is automatically stopped for a relatively long time.

**[0054]** By supplying the holding current A1 to the pressure control valve 12, after the diesel engine 40 is automatically stopped, in an initial stage, some of high pressure fuel in the common rail 10 is discharged to the return passage 30b until a rail pressure becomes the pressure $Pr_{a=a1}$ corresponding to the holding current A1. Thereafter, although the rail pressure is gradually lowered due to leaking of fuel thorough a fine gap present in a fuel high-pressure system, the rail pressure at the time of restarting can be easily maintained at the injectable pressure or more unless the diesel engine 40 is continuously stopped for a long time.

**[0055]** Further, the pressure control valve control part 75, when a rail pressure assumes a threshold value Prail_thr1 or more when a restarting condition of the diesel engine 40 is satisfied and the pressure control valve control part 75 receives an instruction to open the pressure control valve 12 outputted from the rail pressure determination part 69, performs a control of changing over a current value of an electric current supplied to the pressure control valve 12 from a holding current Al to a valve opening current A2. This valve opening current A2 is set in advance to a current value by which the rail pressure becomes less than the threshold value Prail_thr1 and is equal to or more than the injectable pressure.

**[0056]** When a valve opening current A2 is supplied to the pressure control valve 12 in a state where the rail pressure is threshold value Prail_thr1 or more, the pressure control valve 12 is opened so that the rail pressure is lowered to become lower than the threshold value Prail_thr1. That is, although the pressure control valve 12 is basically closed at the time of restarting the diesel engine 40, a valve opening current A2 is supplied to the pressure control valve 12 when the detected rail pressure Psensor at the time of satisfying a restarting condition assumes a threshold value Prail_thr1 or more so that the pressure control valve 12 is opened.

**[0057]** As described above, the valve opening current A2 is set to the current value by which the rail pressure becomes less than the threshold value Prail_thr1 and becomes equal to or more than the injectable pressure and hence, even when the rail pressure is lowered to a value less than the threshold value Prail_thr1, the restartability of the diesel engine 40 is not influenced by such lowering of the rail pressure.

**[0058]** Besides setting the valve opening current A2 supplied to the pressure control valve 12 to a fixed value in advance, for example, when a detected rail pressure Psensor immediately before the diesel engine 40 is automatically stopped by an idling stop control takes a value less than the threshold value Prail_thr1, a current value of an electric current supplied to the pressure control valve 12 in such a state may be also set as the valve opening current A2. By setting the valve opening current A2 in such a manner, it is possible to prevent the rail pressure after the valve opening current A2 is supplied to the pressure control valve 12 from becoming less than the injectable pressure.

4. Specific flow of method of controlling internal combustion engine

**[0059]** Next, one example of a control of the diesel engine 40 executed by the above-mentioned control device 60 of the internal combustion engine is specifically explained in conjunction with a time in chart shown in Fig. 4 and a control flow shown in Fig. 5.

**[0060]** In the control flow shown in Fig. 5, in step S11 after starting the control, it is determined whether or not a predetermined idling stop condition is satisfied (period from t0 to t1 in Fig. 4). When the idling stop condition is satisfied, the processing advances to step S12 where the fuel injection by the fuel injection valve 13 is stopped so that the diesel engine 40 is stopped, and the supply of a holding current A1 to the pressure control valve 12 is started in step S13 (t1 in Fig. 4).

**[0061]** Next, it is determined whether or not a predetermined restarting condition is satisfied in step S14. This step S14 is repeated until the restarting condition is satisfied (period from t1 to t2 in Fig. 4), and when the restarting condition is satisfied, the processing advances to step S15.

**[0062]** In step S15, a detected rail pressure Psensor is read, and it is also determined whether or not the detected rail pressure Psensor is equal to or more than a threshold value Prail_thr1 (t2 in Fig. 4). When it is determined that the detected rail pressure Psensor takes a value less than the threshold value Prail_thr1, the

processing advances to step S18 where the starter 44 is operated in such a state and the fuel injection from the fuel injection valve 13 is started so that the diesel engine 40 is restarted. On the other hand, when it is determined that the detected rail pressure Psensor is equal to or more than the threshold value Prail_thr1 in step S15, the processing advances to step S16 where an electric current supplied to the pressure control valve 12 is changed over to a valve opening current A2 from the holding current A1. Due to such an operation, the pressure control valve 12 is opened so that the lowering of the rail pressure is started along with such valve opening.

**[0063]** Then, the detected rail pressure Psensor is continuously read, and it is determined whether or not the detected rail pressure Psensor takes a value less than the threshold value Prail_thr1 in step S17 until the detected rail pressure Psensor becomes less than the threshold value Prail_thr1 (period from t2 to t3 in Fig. 4). When the detected rail pressure Psensor becomes less than the threshold value Prail_thr1, the processing advances to step S18 where the starter 44 is operated and the fuel injection from the fuel injection valve 13 is started so that the diesel engine 40 is restarted (t3 in Fig. 4).

**[0064]** After the diesel engine 40 is restarted, it is determined whether or not an engine speed Ne reaches a predetermined engine speed NeO in step S19 (period from t3 to t4 in Fig. 4). When it is determined that the engine speed Ne reaches the predetermined engine speed NeO, the processing advances to step S20 so that the control of the diesel engine 40 is shifted to a rail pressure control mode (t4 in Fig. 4).

**[0065]** By opening the pressure control valve 12 at the time of restarting the diesel engine 40 in this manner, when the fuel injection from the fuel injection valve 13 is started so that driving of the high pressure pump 5 is started, a state where the rail pressure is lowered is brought about. Accordingly, there is no possibility that the pressure in the pressurizing chamber 5a is remarkably increased and hence, a large force for elevating the plunger 7 becomes unnecessary. Accordingly, it is possible to obviate a phenomenon that a large load is applied to a drive system of a high pressure pump 5 in a state where an oil film at a contact portion between a cam 15 and the roller 54 of the tappet structural body 58 is insufficient.

**[0066]** In the above-mentioned embodiment, the explanation has been made with respect to the example which uses the accumulator fuel injection device 50 having the constitution where a leak passage for fuel other than fuel used for a back pressure control is not provided to the fuel injection valve so that a rail pressure is hardly lowered at the time of automatically stopping the diesel engine 40. However, the present invention is not limited to the case which uses such an accumulator fuel injection device 50.

Even when an accumulator fuel injection device having the constitution where a fuel injection valve includes a leak passage for fuel other than fuel used for a back pressure control so that a rail pressure is lowered at the time of automatically stopping the diesel engine is used, by opening the pressure control valve 12 when the rail pressure is at a relatively high state at the time of satisfaction of a restarting condition of the diesel engine 40, a load applied to a drive system of a high pressure pump can be decreased.

[Second embodiment]

**[0067]** A control device of the internal combustion engine according to the second embodiment of the present invention is configured to perform a control of opening a pressure control valve before a restarting condition of the internal combustion engine is satisfied. Hereinafter, the control device for an internal combustion engine and a method of controlling the internal combustion engine according to this embodiment are explained by focusing on a point by which the control device for an internal combustion engine and the method of controlling the internal combustion engine according to this embodiment differ from the control device for an internal combustion engine and the method of controlling the internal combustion engine according to the first embodiment.

1. Control device

**[0068]** A control device for a diesel engine 40 according to this embodiment basically has the substantially same constitution as the control device 60 for an internal combustion engine according to the first embodiment. However, in the control device for a diesel engine 40 according to this embodiment, a function of opening a pressure control valve in advance by determining that a restarting condition will be satisfied in a short time at the time of automatically stopping the diesel engine 40 by an idling stop control is added to a restarting condition satisfaction detection part and a rail pressure determination part.

**[0069]** In the control device of this embodiment, the restarting condition satisfaction detection part basically has substantially same function as the restarting condition satisfaction detection part of the control device according to the first embodiment. Further, the restarting condition satisfaction detection part is configured to determine that a restarting condition will be satisfied in a short time when some of the plural restarting conditions are satisfied and to transmit a restarting condition satisfying preliminary signal to a rail pressure determination part.

**[0070]** To be more specific, it is often the case where out of the plural restarting conditions exemplified in the first embodiment, for example, the release of the detection position of the gear sensor from a neutral state is performed in a stage prior to a step-in operation of an acceleration pedal. When the restarting condition satisfaction detection part detects information based on which it can be determined that such a restarting condition will

be satisfied in a short time, the restarting condition satisfaction detection part transmits a restarting condition satisfying preliminary signal to the rail pressure determination part. Information for determining that the restarting condition will be satisfied in a short time is not limited to information used in the above-mentioned example.

**[0071]** Then, when the rail pressure determination part receives the restarting condition satisfying preliminary signal from the restarting condition satisfaction detection part, the rail pressure determination part determines whether or not the detected rail pressure Psensor is equal to or more than a predetermined threshold value Prail_thr1. When it is determined that the detected rail pressure Psensor is equal to or more than the threshold value Prail_thr1, the rail pressure determination part transmits an instruction to open a pressure control valve 12 to a pressure control valve control part 75. As a result, the pressure control valve 12 is opened before the satisfaction of the restarting condition so that the lowering of the rail pressure is started along with such valve opening. Accordingly, the rail pressure becomes less than the threshold value Prail_thr1 at the time of satisfaction of the restarting condition, or even when the rail pressure is equal to or more than the threshold value Prail_thr1 at the time of satisfaction of the restarting condition, thereafter, time necessary for the rail pressure to become the threshold value Prail_thr1 is shortened so that a time before restarting can be shortened.

2. Specific flow of method of controlling internal combustion engine

**[0072]** Next, one example of a control of the diesel engine 40 executed by the above-mentioned control device of this embodiment is specifically explained in conjunction with a time chart shown in Fig. 6 and a control flow shown in Fig. 7.

**[0073]** In the control flow shown in Fig. 7, in step S51 after starting the control, it is determined whether or not a predetermined idling stop condition is satisfied (period from t0 to t1 in Fig. 6). When the idling stop condition is satisfied, the processing advances to step S52 where the fuel injection by the fuel injection valve 13 is stopped so that the diesel engine 40 is stopped, and the supply of a holding current A1 to the pressure control valve 12 is started in step S53 (t1 in Fig. 6).

**[0074]** Next, it is determined whether or not the diesel engine 40 will be restarted in a short time in step S54. This step S54 is repeated until a restarting condition satisfying preliminary signal is detected (period from t1 to t2 in Fig. 6), and when it is determined that the diesel engine 40 will be restarted in a short time, the processing advances to step S55.

**[0075]** In step S55, a detected rail pressure Psensor is read, and it is also determined whether or not the detected rail pressure Psensor is equal to or more than a threshold value Prail_thr1 (t2 in Fig. 6). When it is determined that the detected rail pressure Psensor takes a value less than the threshold value Prail_thr1, the processing directly advances to step S57. On the other hand, when it is determined that the detected rail pressure Psensor is equal to or more than the threshold value Prail_thr1, the processing advances to step S56 where an electric current supplied to the pressure control valve 12 is changed over to a valve opening current A2 from the holding current A1 and, thereafter, the processing advances to step S57. Due to the supply of the valve opening current A2 to the pressure control valve 12, the pressure control valve 12 is opened so that the lowering of the rail pressure is started along with such valve opening.

**[0076]** In step S57, the determination on whether or not the restarting condition is satisfied is repeated until the restarting condition is satisfied (period from t2 to t3 in Fig. 6). When the restarting condition is satisfied, the processing advances to step S58, and it is determined whether or not the detected rail pressure Psensor takes a value less than the threshold value Prail_thr1 (t3 in Fig. 6). When it is determined that the detected rail pressure Psensor takes a value less than the threshold value Prail_thr1, the processing advances to step S59 where a starter 44 is operated and the fuel injection from the fuel injection valve 13 is started thus restarting the diesel engine 40 (t4 in Fig. 6). On the other hand, when it is determined that the detected rail pressure Psensor is not lowered to a value less than the threshold value Prail_thr1, this step S58 is repeated until the detected rail pressure Psensor becomes less than the threshold value Prail_thr1 (period from t3 to t4 in Fig. 6).

**[0077]** After the diesel engine 40 is restarted, it is determined whether or not an engine speed Ne reaches a predetermined engine speed NeO in step S60 (period from t4 to t5 in Fig. 6). When it is determined that the engine speed Ne reaches the predetermined engine speed NeO, the processing advances to step S61 so that the control of the diesel engine 40 is shifted to a rail pressure control mode (point of time t5 in Fig. 6).

**[0078]** By opening the pressure control valve 12 before the satisfaction of the restarting condition of the diesel engine 40 in this manner, the rail pressure can be lowered during a period before the restarting condition is satisfied. Accordingly, a time from a point of time that the restarting condition is satisfied to a point of time that restarting is allowed can be shortened so that restartability of the diesel engine 40 can be enhanced. Further, when the fuel injection from the fuel injection valve 13 is started so that driving of the high pressure pump 5 is started, a state where the rail pressure is lowered is brought about. Accordingly, there is no possibility that the pressure in the pressurizing chamber 5a is remarkably increased and hence, a large force for elevating a plunger 7 becomes unnecessary. Accordingly, it is possible to obviate a phenomenon that a large load is applied to a drive system of a high pressure pump 5 in a state where an oil film at a contact portion between a cam 15 and a roller 54 of a tappet structural body 58 is insufficient.

## Claims

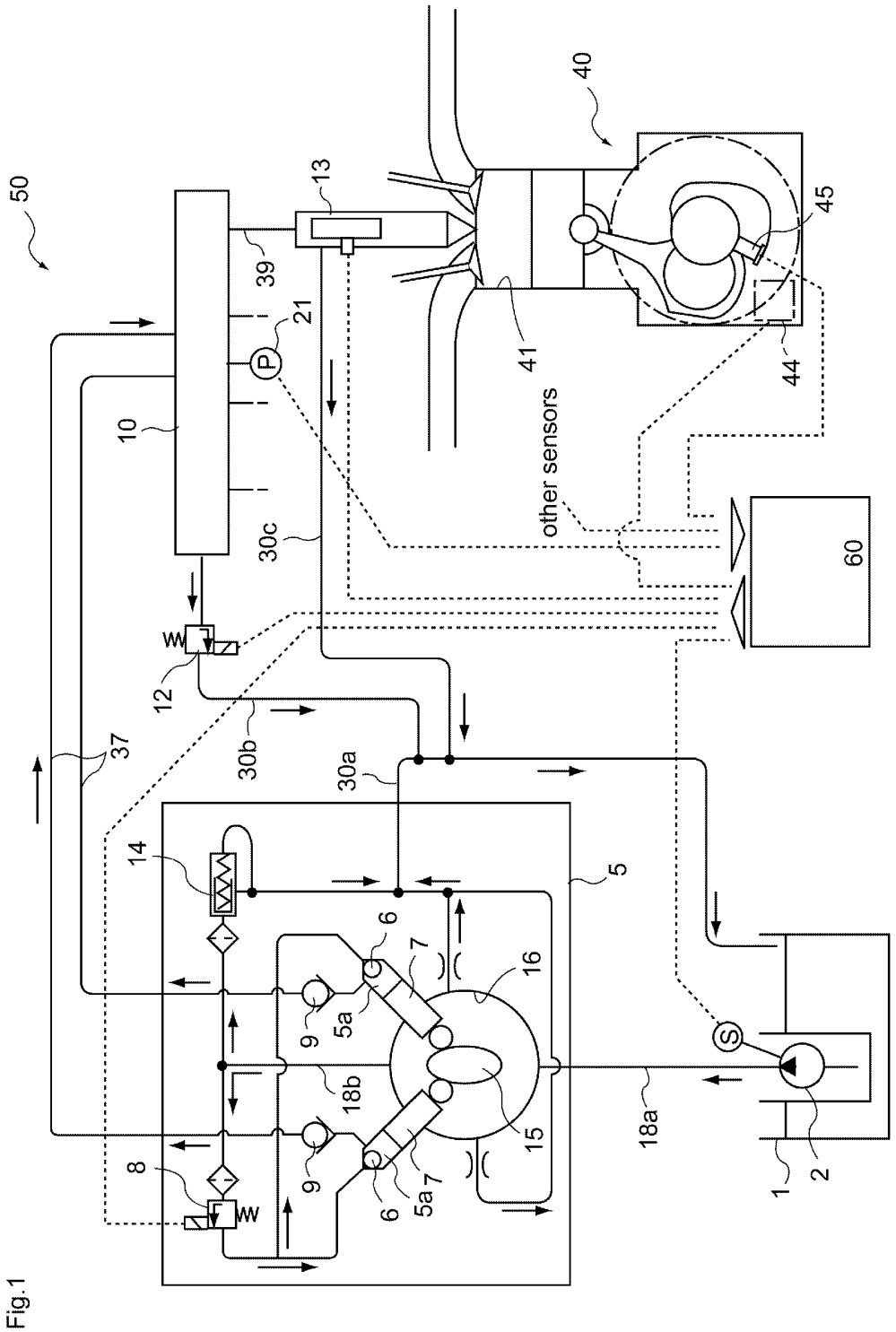
1. A control device for an internal combustion engine which is a control device for performing a control of the internal combustion engine by an accumulator fuel injection device, the control device comprising: a common rail to which a fuel injection valve is connected; a high pressure pump which supplies fuel to the common rail under pressure; and a pressure control valve which adjusts a flow rate of fuel discharged from the common rail, the control device of the internal combustion engine capable of performing an idling stop control, the control device comprising:

   an idling stop condition satisfaction detection part which detects that a predetermined idling stop condition is satisfied and outputs an instruction to automatically stop the internal combustion engine;
   a restarting condition satisfaction detection part which detects that a predetermined restarting condition is satisfied during an automatic stop of the internal combustion engine and outputs an instruction to restart the internal combustion engine;
   a rail pressure detection part which detects pressure in the common rail; and
   a pressure control valve control part which opens the pressure control valve before restarting the internal combustion engine when the pressure in the common rail becomes a predetermined threshold value or more at the time of the satisfaction of the restarting condition.

2. The control device for an internal combustion engine according to claim 1, wherein the threshold value is a value set based on a load allowed to be applied to a drive system of the high pressure pump from the high pressure pump.

3. The control device for an internal combustion engine according to claim 1 or 2, wherein the restarting condition satisfaction detection part detects that the restarting condition is satisfied in a short time before the satisfaction of the restarting condition, and
   the pressure control valve control part opens the pressure control valve when it is detected that the restarting condition is satisfied in a short time and the pressure in the common rail assumes the threshold value or more.

4. The control device for an internal combustion engine according to any one of claims 1 to 3, wherein the control device comprises a rail pressure determination part which restarts the internal combustion engine when the pressure in the common rail becomes less than the threshold value after the restarting condition is satisfied.


50
40
13
39
45
21
P
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44
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other sensors
60
30c
W
12
30b
30a
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14
5
6
7
16
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18b
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18a
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8
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9
6
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7
1
2

Fig.1

Fig.2

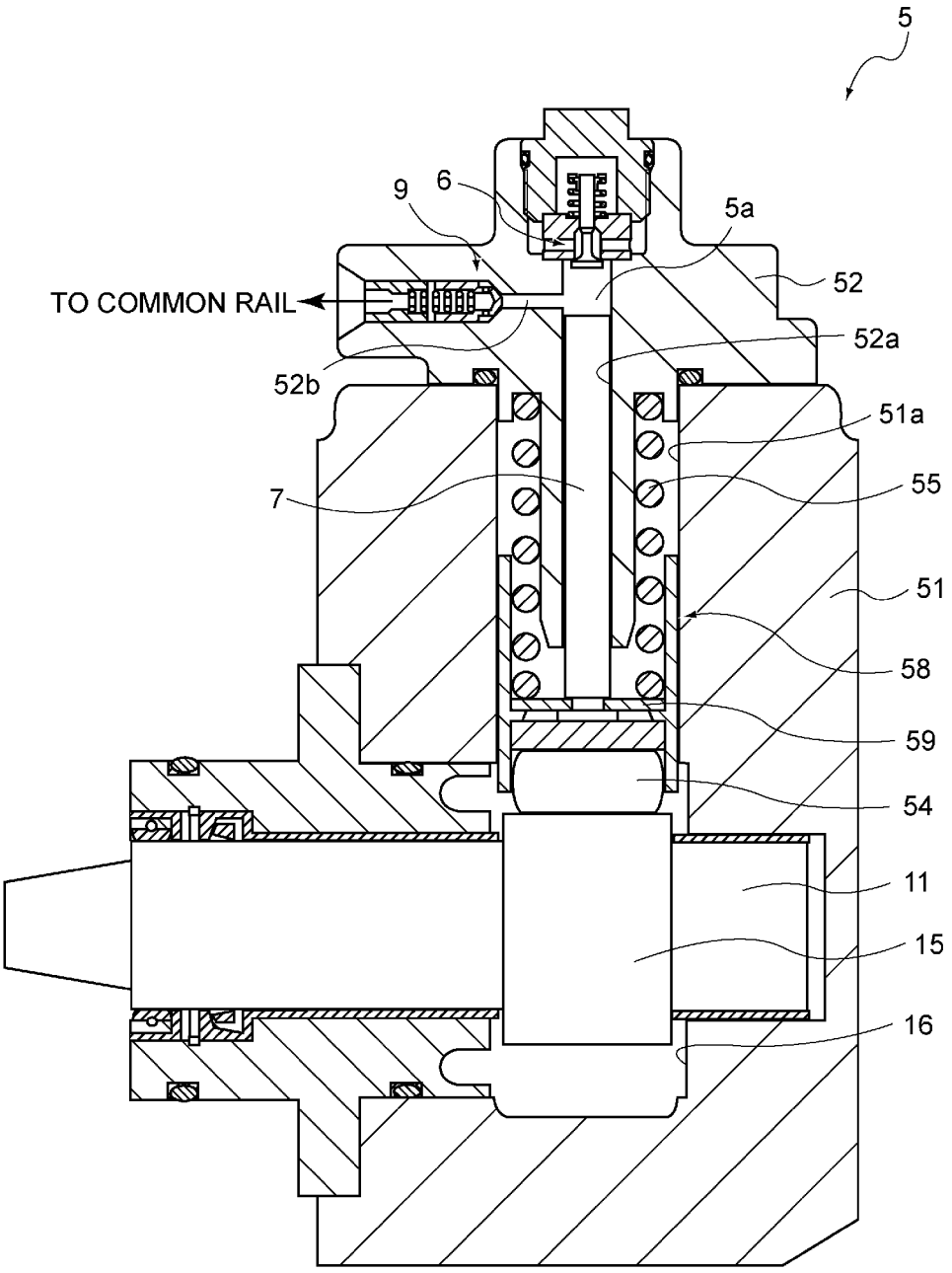
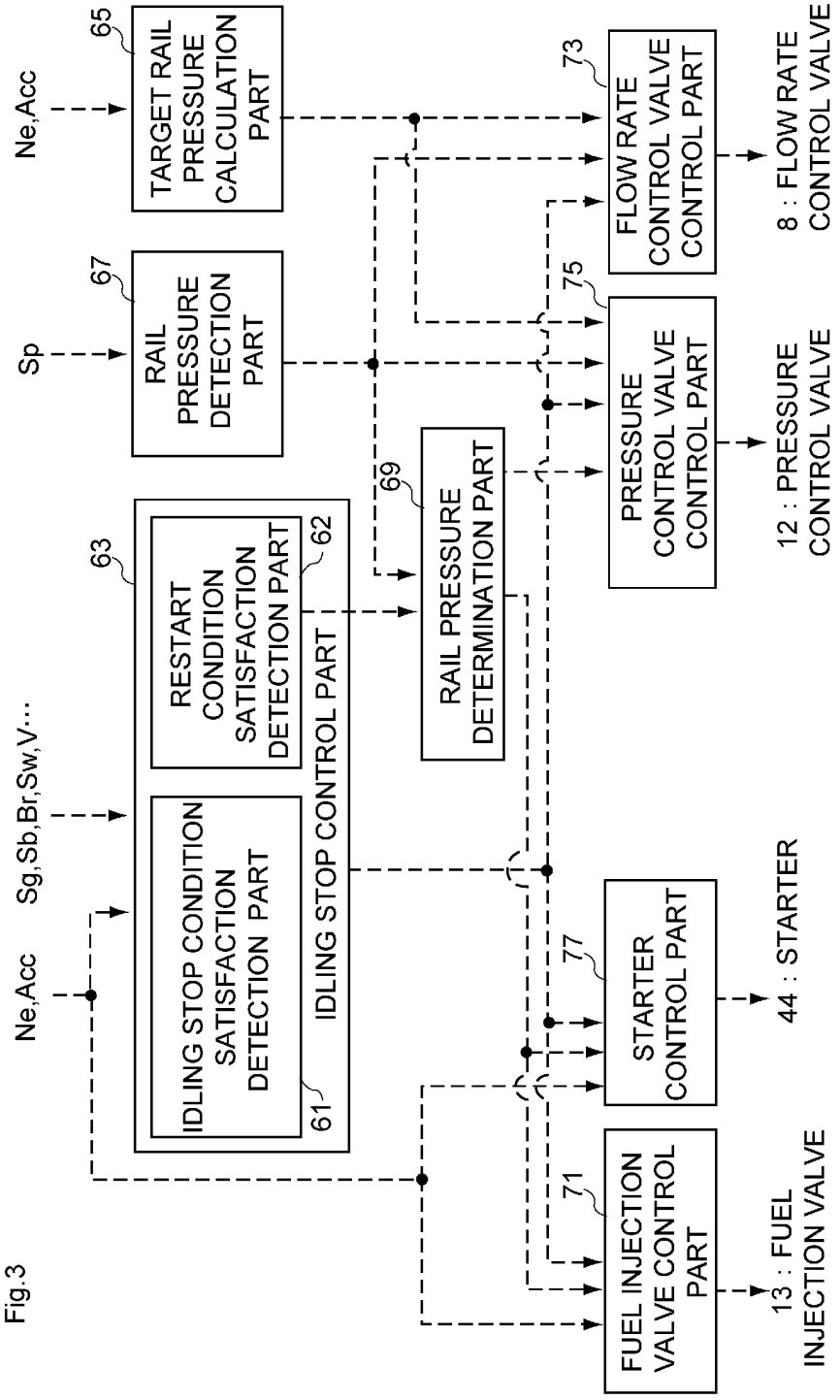


Fig.3


Ne,Acc
Sg,Sb,Br,Sw,V···
IDLING STOP CONTROL PART
IDLING STOP CONDITION SATISFACTION DETECTION PART
61
RESTART CONDITION SATISFACTION DETECTION PART
62
63
RAIL PRESSURE DETERMINATION PART
69
Sp
RAIL PRESSURE DETECTION PART
67
Ne,Acc
TARGET RAIL PRESSURE CALCULATION PART
65
FUEL INJECTION VALVE CONTROL PART
71
13 : FUEL INJECTION VALVE
STARTER CONTROL PART
77
44 : STARTER
PRESSURE CONTROL VALVE CONTROL PART
75
12 : PRESSURE CONTROL VALVE
FLOW RATE CONTROL VALVE CONTROL PART
73
8 : FLOW RATE CONTROL VALVE

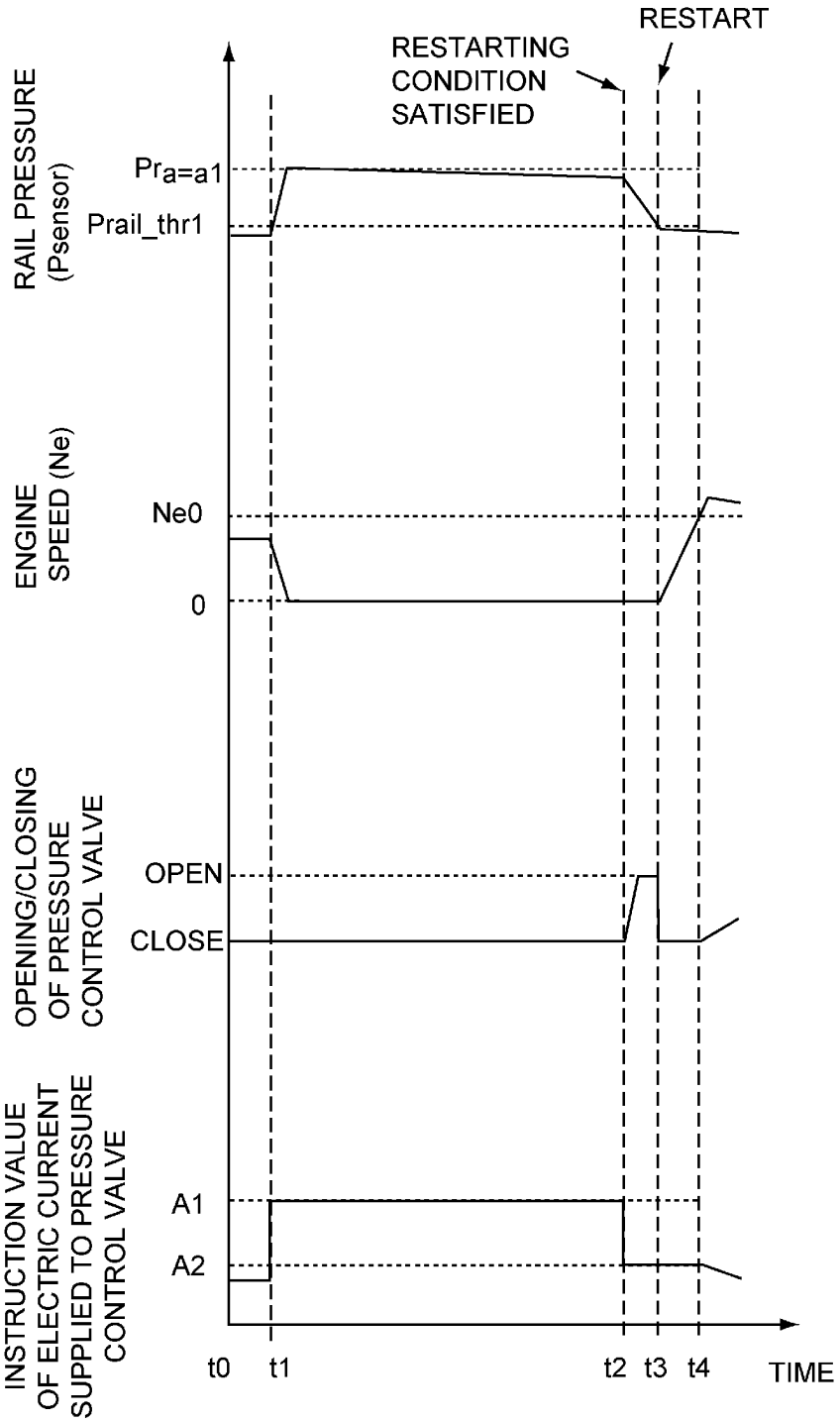
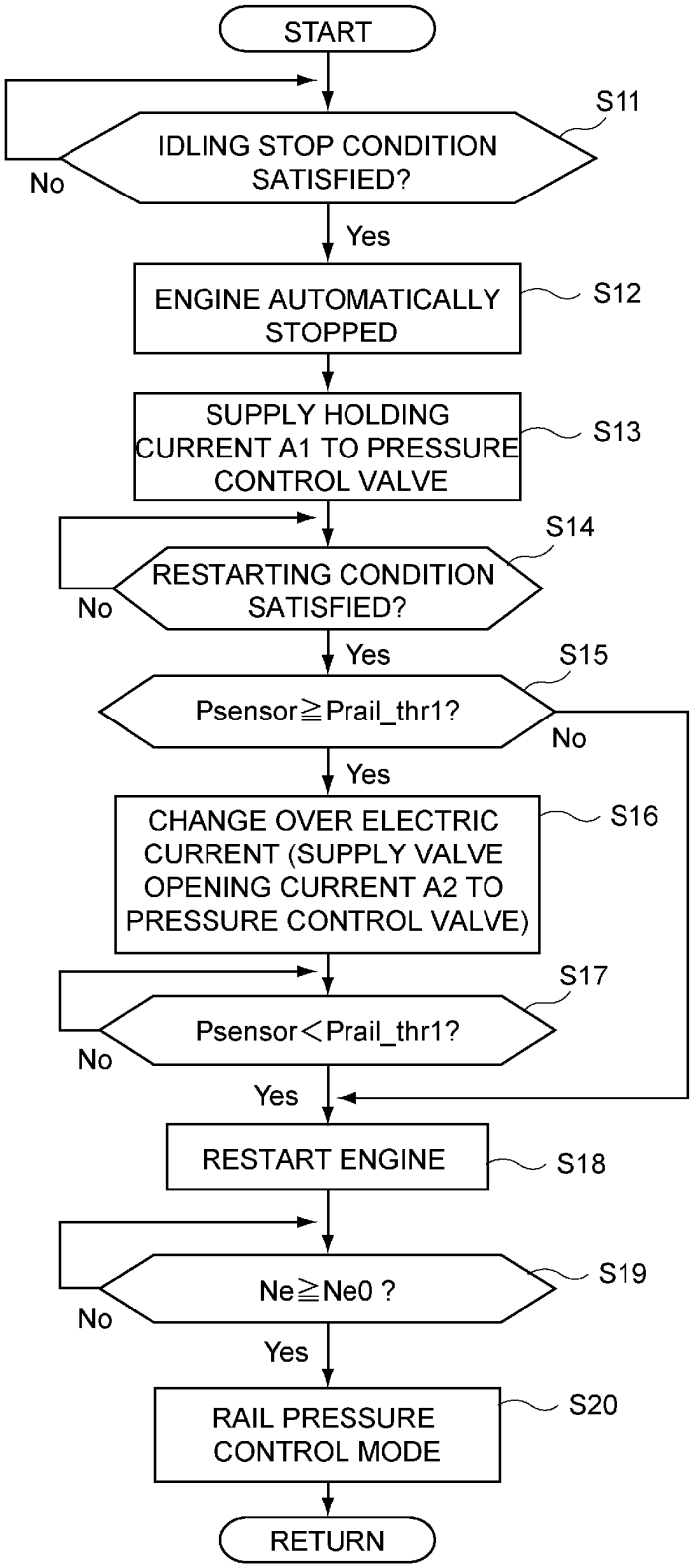

RESTART
RESTARTING CONDITION SATISFIED
RAIL PRESSURE (Psensor)
Pra=a1
Prail_thr1
ENGINE SPEED (Ne)
Ne0
0
OPENING/CLOSING OF PRESSURE CONTROL VALVE
OPEN
CLOSE
INSTRUCTION VALUE OF ELECTRIC CURRENT SUPPLIED TO PRESSURE CONTROL VALVE
A1
A2
t0
t1
t2
t3
t4
TIME

Fig.4

Fig.5


START
S11
IDLING STOP CONDITION SATISFIED?
No
Yes
ENGINE AUTOMATICALLY STOPPED
S12
SUPPLY HOLDING CURRENT A1 TO PRESSURE CONTROL VALVE
S13
S14
RESTARTING CONDITION SATISFIED?
No
Yes
S15
Psensor≧Prail_thr1?
No
Yes
CHANGE OVER ELECTRIC CURRENT (SUPPLY VALVE OPENING CURRENT A2 TO PRESSURE CONTROL VALVE)
S16
S17
Psensor＜Prail_thr1?
No
Yes
RESTART ENGINE
S18
S19
Ne≧Ne0 ?
No
Yes
RAIL PRESSURE CONTROL MODE
S20
RETURN

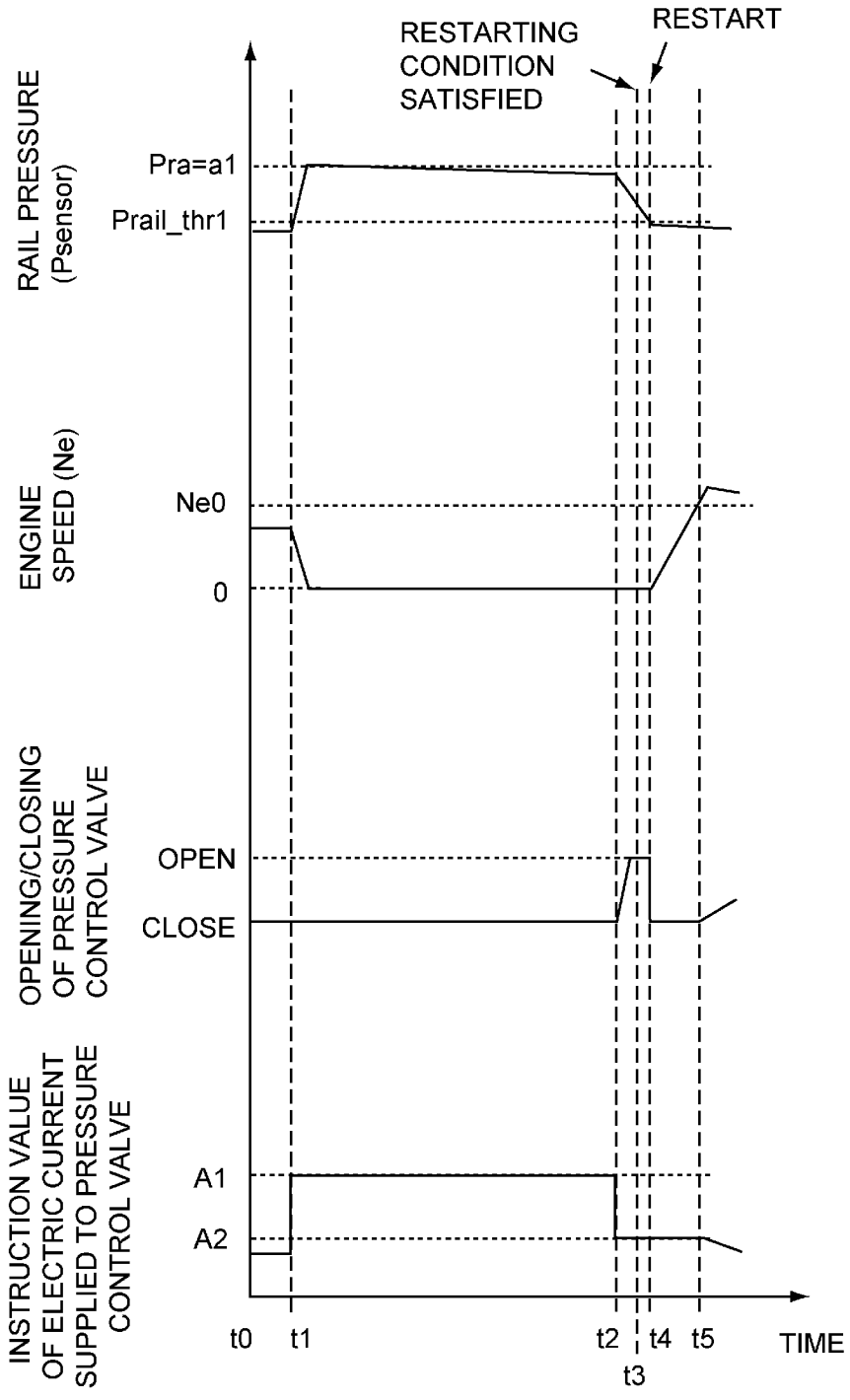
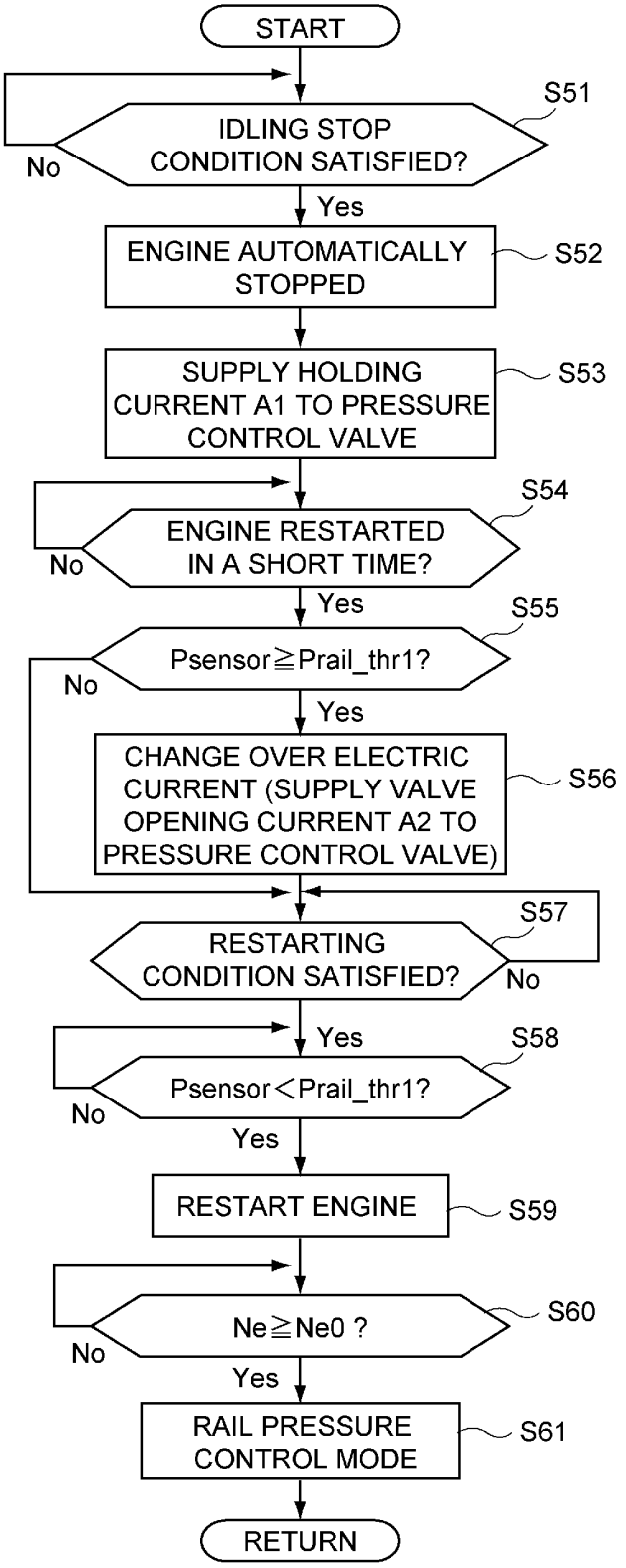

RESTARTING CONDITION SATISFIED
RESTART
RAIL PRESSURE (Psensor)
Pra=a1
Prail_thr1
ENGINE SPEED (Ne)
Ne0
0
OPENING/CLOSING OF PRESSURE CONTROL VALVE
OPEN
CLOSE
INSTRUCTION VALUE OF ELECTRIC CURRENT SUPPLIED TO PRESSURE CONTROL VALVE
A1
A2
t0
t1
t2
t3
t4
t5
TIME

Fig.6

Fig.7


START
S51
IDLING STOP CONDITION SATISFIED?
No
Yes
ENGINE AUTOMATICALLY STOPPED
S52
SUPPLY HOLDING CURRENT A1 TO PRESSURE CONTROL VALVE
S53
S54
ENGINE RESTARTED IN A SHORT TIME?
No
Yes
S55
Psensor≧Prail_thr1?
No
Yes
CHANGE OVER ELECTRIC CURRENT (SUPPLY VALVE OPENING CURRENT A2 TO PRESSURE CONTROL VALVE)
S56
S57
RESTARTING CONDITION SATISFIED?
No
Yes
S58
Psensor＜Prail_thr1?
No
Yes
RESTART ENGINE
S59
S60
Ne≧Ne0 ?
No
Yes
RAIL PRESSURE CONTROL MODE
S61
RETURN

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2010/054317

A. CLASSIFICATION OF SUBJECT MATTER
*F02D41/22*(2006.01)i, *F02D17/00*(2006.01)i, *F02D41/06*(2006.01)i, *F02M51/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02D41/22, F02D17/00, F02D41/06, F02M51/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010
Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 2004-324440 A (Toyota Motor Corp.), 18 November 2004 (18.11.2004), entire text; all drawings (Family: none) | 1-4 |
| A | WO 2006/004101 A1 (Bosch Corp.), 12 January 2006 (12.01.2006), entire text; all drawings & JP 2006-22649 A & EP 1775457 A1 & US 2008/0271707 A1 | 1-4 |
| A | JP 2006-161716 A (Denso Corp.), 22 June 2006 (22.06.2006), entire text; all drawings (Family: none) | 1-4 |

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 07 May, 2010 (07.05.10) | 18 May, 2010 (18.05.10) |
| Name and mailing address of the ISA/ Japanese Patent Office<br>Facsimile No. | Authorized officer<br>Telephone No. |

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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2010/054317

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 2007-92717 A (Toyota Motor Corp.), 12 April 2007 (12.04.2007), entire text; all drawings (Family: none) | 1-4 |
| A | JP 2008-163796 A (Mitsubishi Fuso Truck and Bus Corp.), 17 July 2008 (17.07.2008), entire text; all drawings (Family: none) | 1-4 |

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- JP 2008163796 A **[0007]**