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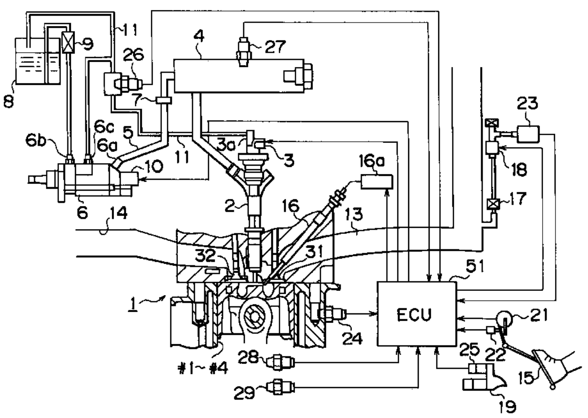
(54) Injection quantity control apparatus of diesel engine and method

(57) In fuel injection quantity control of a diesel engine, to suppress deterioration of drivability caused by smoothing processing during increase in the fuel injection for acceleration, a road load injection quantity lower limit is set as a basic fuel injection quantity QBASE at start of the smoothing processing for acceleration. This road load injection quantity lower limit is the one corresponding to a minimum friction allowed in the diesel engine. Thus, if a diesel engine to be controlled has a friction smaller than the average friction, the fuel injection quantity can be prevented from being increased sharply far beyond an actual road load injection quantity, thus suppressing the acceleration shock to prevent deterioration of drivability. Further, the stepwise increase in the fuel injection quantity for acceleration at the start of smoothing processing is maintained, thus satisfying the acceleration performance.

FIG. 1



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Description

INCORPORATION BY REFERENCE

[0001] The disclosure of Japanese Patent Application No. HEI 9-338847 filed on December 9, 1997 including the specification, drawings and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] This invention relates to an injection quantity control apparatus of a diesel engine and method, and more particularly to an injection quantity control apparatus of a diesel engine and method for carrying out smoothing processing so as to increase an actual fuel injection quantity of the diesel engine for acceleration, depending on an operating condition of the diesel engine.

2. Description of the Related Art

[0003] Conventionally, in the diesel engine of a vehicle, smoothing processing is carried out for the purpose of preventing acceleration shock by suppressing the sudden torque increase accompanied with the fuel increase for acceleration. Further Examined Published Japanese Patent Application No.HEI 5-34501 discloses that the fuel injection quantity is increased stepwise up to the road load injection quantity (fuel injection quantity of smoothing processing) and it is further increased by the smoothing processing thereafter so as to prevent the acceleration shock and to cause acceleration performance to reflect the acceleration by the smoothing processing.
[0004] Nevertheless, the aforementioned smoothing processing and stepwise increase in the fuel injection quantity may fail to prevent the acceleration shock, nor achieve acceleration reflecting the driver's accelerating operation.
[0005] It has been proved that the following phenomenon exists as a cause of drivablility deterioration such as the acceleration shock or a drop in the acceleration response even when the smoothing processing or the stepwise increase in the fuel injection quantity at the start thereof is being carried out.
[0006] In case of increasing the fuel injection stepwise at the start of the smoothing processing, the fuel injection quantity is increased stepwise up to a road load injection quantity by which the engine torque becomes 0 at a current revolution. This road load injection quantity is set corresponding to friction of the diesel engine.
[0007] However, as the friction may be varied depending on the individual engine in spite of the same type, the aforementioned injection quantity control uses the road load injection quantity corresponding to an average value of the faction allowed in the diesel engine.
[0008] Actually the road load injection quantity has to be changed in accordance with the faction which varies with the individual diesel engine in spite of the same type. In the conventional art, however, the fuel injection quantity is increased stepwise up to an average road load injection quantity for all the diesel engines.
[0009] If the diesel engine having the fuel injection increased to the average road load injection quantity yields the friction substantially at a lower level than the average, the fuel injection quantity may be sharply increased far beyond the actual road load injection quantity. This may cause the acceleration shock at a tune of increasing the fuel injection quantity for acceleration, resulting in deteriorated drivability.
[0010] Even if a diesel engine has the friction varied with the operating condition in an averaged way, the road load injection quantity used for fuel injection control may not be well in accord with the friction. The road load injection quantity used for the control may become larger than the actual road load injection quantity as described above, thus generating the acceleration shock. On the contrary if the road load injection quantity for the control becomes smaller than the actual road load injection quantity, the stepwise increase in the injection quantity will be terminated without reaching the actual road load injection quantity, thus deteriorating the acceleration response.
[0011] For example, the friction of the diesel engine in a cold state is higher than that of the diesel engine in warm-up state because of high engine oil viscosity in the cold state. Thus, if the temperature of the diesel engine, for example, cooling water temperature is low, the value of the road load injection quantity for the control might become too low.
[0012] Further, there are an air conditioner (A/C), an alternator and the like driven by the output of the diesel engine. When the air conditioner is turned ON, the same operation as in the case of the friction increases is generated in the diesel engine. When the air conditioner is turned OFF, the same operation as in the case of the friction decreases is generated. Likewise, when a power supply of a headlamp is turned ON, the same operation as in the case of increase in the alternator load and friction is caused in the diesel engine. When the power supply of the headlamp is turned OFF, the same operation as in the case of decrease in the alternator load and the friction is caused in the diesel engine.
[0013] Therefore, there is a fear that the acceleration shock or a deterioration of acceleration response may be pro-

duced depending on the state of the rotational resistance including the aforementioned friction.

[0014] In the smoothing processing, a problem may occur as well. For example, if the diesel engine has a friction larger than an average friction,the actual road load injection quantity becomes larger than the average road load injection quantity for the control. Thus, there may be a case in which the smoothing processing is terminated to proceed to the regular injection quantity control before the engine torque is sufficiently increased by the smoothing processing, or the smoothing processing is switched to the one for further increasing the injection quantity sharply. In such a case, the engine torque is brought into a state for sharp increase at a relatively low engine torque. As a result, the acceleration shock is generated by gear backlash in the mechanism for transmitting driving force from the diesel engine. On the contrary, if the diesel engine has a lower friction than the average, the actual road load injection quantity is smaller than the average road load injection quantity for the control. In such a case, the smoothing processing will be continued even after the engine torque is sufficiently increased by the smoothing processing, resulting in a deteriorated responsiveness.

[0015] In multiple stage smoothing processing, for example, two stage smoothing processing for increasing the actual fuel injection quantity by the smoothing processing at an initial increase state and for increasing the actual fuel injection quantity by the increase rate higher than the smoothing processing at the initial stage, the problem may occur. More specifically, when the smoothing processing is executed, the difference between a fuel injection quantity directly corresponding to an accelerator operating quantity by a driver (hereinafter referred to as "governor fuel injection quantity") and the actual fuel injection quantity set by the smoothing processing will become larger with a passage of time. As a result, the governor fuel injection quantity becomes quite smaller than the actual fuel injection quantity.

[0016] Thus, even if the accelerator operating quantity has reached a constant level at the end of initial smoothing processing, the actual fuel injection quantity has not reached the governor fuel injection quantity yet. Thus, the second stage smoothing processing is started immediately to increase the actual fuel injection quantity by an increase rate higher than the initial stage smoothing processing such that the governor fuel injection quantity is reached sharply. This may generate the acceleration shock owing to the increase in fuel injection quantity against the driver's intention.

SUMMARY OF THE INVENTION

[0017] The present invention has been achieved to prevent deterioration of drivability which may occur at a time of smoothing processing to increase fuel injection quantity for acceleration under fuel injection quantity control for a diesel engine, i.e. it is the object to avoid an acceleration shock and a deterioration of an acceleration responsiveness.

[0018] The above object is solved by combination of features of the independent claims. The dependent claims disclose further advantageous embodiments of the invention.

[0019] To achieve the above object, from an aspect, the present invention provides an injection quantity control apparatus of a diesel engine in which upon increasing an actual fuel injection quantity for acceleration of a diesel engine corresponding to an operating condition thereof, a road load injection quantity is set as an initial value for increasing the fuel quantity for acceleration and the actual fuel injection quantity to be continuously increased subsequently is set by smoothing processing, characterized in that the road load injection quantity set as the initial value for increasing the fuel quantity for acceleration is set to be smaller than the road load injection quantity corresponding to friction at an average level of the diesel engine.

[0020] That is, in the case where the fuel injection quantity is increased stepwise to the road load injection quantity at the start of increasing fuel injection quantity by the smoothing processing, a road load injection quantity lower than the average road load injection quantity is used.

[0021] In the case where the road load injection quantity is increased at the start of smoothing processing for increasing the quantity, and a friction of the diesel engine is smaller than the average friction the sharp increase in the fuel injection quantity far beyond the actual road load injection quantity can be prevented. As a result, the acceleration shock is suppressed to prevent deterioration of drivability. As the stepwise acceleration increase quantity at the start of smoothing processing is maintained, the acceleration performance corresponding to the accelerator operation can be satisfied.

[0022] The control executed by the injection quantity control apparatus of diesel engine according to the present invention is capable of suppressing the acceleration shock by using the road load injection quantity lower than the average road load injection quantity. As this mechanism can be realized easily using existing hardware and software, the program does not have to be complicated, thus maintaining the current processing speed for control.

[0023] Further, the road load injection quantity may be set to the value corresponding to the friction at a minimum level allowable in the diesel engine. This makes it possible to prevent the fuel injection quantity from increasing sharply far beyond the actual road load injection quantity in the case of all diesel engines to be controlled. Therefore, the acceleration shock is further suppressed effectively, thus preventing deterioration of drivability completely.

[0024] According to another aspect, the present invention provides an injection quantity control apparatus of a diesel engine in which upon increasing an actual fuel injection quantity for acceleration of a diesel engine corresponding to an operating condition thereof, an actual fuel injection quantity to be continuously increased subsequent to the increase to a road load injection quantity is set by smoothing processing, characterized by including friction detecting means for detecting a rotational resistance including friction of the diesel engine, in which the road load injection quantity is enlarged as the rotational resistance increases depending on the rotational resistance detected by the friction detecting means.

[0025] Since the road load injection quantity is increased as the increase in the rotational resistance including friction of the diesel engine and is decreased as the decrease in the rotational resistance, if the friction or other rotational resistance of the diesel engine has shifted to be lower depending on the condition, the value of the road load injection quantity used for use in controlling stepwise increase in the fuel injection quantity can be reduced. Therefore, this makes it possible to prevent sharp increase in the fuel injection quantity far beyond the actual road load injection quantity. The acceleration shock can be suppressed, thus preventing deterioration of drivability.

[0026] Conversely, if the friction or other rotational resistance of the diesel engine has shifted to be higher, the road load injection quantity used for the control can be increased. This makes it possible to prevent the start of smoothing processing without achieving the actual road load injection quantity. The acceleration response is maintained, thus suppressing deterioration of drivability.

[0027] The aforementioned friction detecting means may be designed to detect a cooling water temperature of the diesel engine as a physical quantity corresponding to faction of the diesel engine such that the road load injection quantity is enlarged as the cooling water temperature becomes lower.

[0028] As the fraction of the diesel engine in a cold state is relatively at a higher level than that of the diesel engine in a warm up state because of high viscosity of the engine oil. When the cooling water temperature is at a lower level, the road load injection quantity is set to a larger value so as to prevent the start of smoothing processing without achieving the actual road load injection quantity. As a result, the acceleration response is maintained, thus suppressing deterioration of drivability. Conversely, when the cooling water temperature is at a higher level, the road load injection quantity is set to a smaller value so as to prevent sharp increase in the fuel injection quantity far beyond the actual road load injection quantity. As a result, the acceleration shock can be suppressed, thus preventing deterioration of drivability.

[0029] Further, it is permissible that the friction detecting means detects ON/OFF state of a mechanism driven by an output of the diesel engine as a rotational resistance thereof, wherein said road load injection quantity is set to be larger when said mechanism is in ON state than in case when said mechanism is in OFF state. There are an air conditioner, an alternator and the like driven by the output of the diesel engine. When the air conditioner is turned ON, the same operation as in the case of the friction increases is generated in the diesel engine. When the air conditioner is turned OFF, the same operation as in the case of the friction decreases is generated. Likewise, when a power supply of a headlamp is turned ON, the same operation as in the case of increase in the alternator load and friction is caused in the diesel engine. When the power supply of the headlamp is turned OFF, the same operation as in the case of decrease in the alternator load and the friction is caused in the diesel engine.

[0030] For this, ON/OFF state of a mechanism driven by the output of the diesel engine is detected. If the mechanism is in OFF state, the road load injection quantity is set to value smaller than that when it is in ON state. This may prevent sharp increase in the fuel injection quantity far beyond the actual road load injection quantity, resulting in suppressed acceleration shock and deterioration of drivability. Conversely if the mechanism is in ON state, the road load injection quantity is set to the value larger than that when it is in OFF state. This may prevent the start of smoothing processing without achieving the actual road load injection quantity, thus maintaining the response and suppressing deterioration of drivability.

[0031] According to a still another aspect, the present invention provides an injection quantity control apparatus of a diesel engine in which upon increasing an actual fuel injection quantity for acceleration of a diesel engine corresponding to an operating condition thereof, an actual fuel injection quantity to be increased continuously subsequent to the increase to a road load injection quantity is set by smoothing processing, characterized by including friction detecting means for detecting a rotational resistance including friction of the the diesel engine, in which a period for the smoothing processing is prolonged depending on the rotational resistance detected by the friction detecting means as the rotational resistance becomes higher.

[0032] As described above, the period for the smoothing processing is increased as the rotational resistance becomes larger. If the friction of the diesel engine is larger than the average friction the smoothing processing by usual injection quantity or for sharp increase in the injection quantity can be executed after the engine torque is sufficiently increased by the smoothing processing over the period corresponding to a magnitude of the actual road load injection quantity. This makes it possible to prevent the acceleration shock caused by a gear backlash in the mechanism for transmitting the driving power from the diesel engine. Meanwhile even if the friction of the diesel engine is smaller than the average friction, the engine torque is increased sufficiently by the smoothing processing over a period corresponding to the magnitude of the actual road load injection quantity. This may achieve the smoothing processing by an ordinary injection quantity or for sharp increase in the injection quantity, thus preventing the smoothing processing from being continued at an engine torque that has been already increased to the sufficient level by the smoothing processing. As a result, the acceleration response can be maintained.

[0033] It is permissible that the friction detecting means detects a revolution increase rate of the diesel engine as a physical quantity corresponding to the rotational resistance of the diesel engine, a period for said smoothing processing being shortened as the revolution increase rate becomes higher. This is because if the increase rate of the revolution of the diesel engine is at a higher level, the revolution may be assumed to be low. Conversely if the increase rate of the revolution is at a lower level, the revolution may be assumed to be high.

[0034] According to a further aspect, the present invention provides an injection quantity control apparatus of a diesel engine in which upon increasing an actual fuel injection quantity for acceleration of a diesel engine corresponding to an operating condition thereof, the actual fuel injection quantity is increased by smoothing processing for a first period at which the fuel injection is increased continuously subsequent to the increase to the road load injection quantity; the actual fuel injection quantity is increased by a higher increase rate than in the first period for a second period next thereto; and an intermediate increase rate period is provided for changing the increase rate smoothly at the transition from the first period to the second period, characterized by including accelerating operation detecting means for detecting an acceleration state of the diesel engine, in which intermediate increase rate setting means reduces the intermediate increase rate period depending on a degree of the accelerating operation detected by the accelerating operation detecting means as the degree of the accelerating operation becomes larger.

[0035] As described above, in the intermediate increase rate setting means, if the accelerating operation is at a large degree, the intermediate increase rate period for changing the increase rate smoothly upon transfer from the initial smoothing processing to the next smoothing processing is shortened. Meanwhile if the accelerating operation is at a small degree, the intermediate increase rate period is prolonged. As a result, at the end of the initial smoothing processing, the accelerator operating quantity reaches a constant level. That is, when the accelerating operation is at a small degree, the intermediate increase rate period is prolonged. In the case where a great difference occurs between the governor fuel injection quantity and actual fuel injection quantity during the initial smoothing processing period and the actual fuel injection quantity becomes substantially smaller than the governor fuel injection quantity, the second stage smoothing processing is not started immediately, but the increase rate changes smoothly to the second stage smoothing control through a relatively long intermediate increase rate period. Thus, the fuel injection quantity is never increased against a driver's intention, thus preventing the acceleration shock.

[0036] Conversely, if the driver quickly operates for acceleration, the intermediate increase rate period may be shortened or expired such that the initial smoothing processing can be changed to the second stage smoothing control at an earlier stage, thus ensuring sufficient acceleration. Although in this case, acceleration shock may occur at a time between the initial smoothing processing and second stage smoothing processing, such acceleration shock may be negligible and never give uncomfortable feeling to the driver, thus preventing deterioration of drivability.

[0037] It is permissible that the accelerating operation detecting means detects a revolution of the diesel engine as a physical quantity corresponding to a degree of the accelerating operation, in which the intermediate increase rate setting means shortens the intermediate increase rate period as the revolution becomes higher at a transition from the first period to the second period. This is because if the revolution of the diesel engine is at a higher level, the degree of a conducted accelerating operation is assumed to be large, and if the revolution is at a lower level, the degree of the conducted accelerating operation is assumed to be small.

[0038] Further it is permissible that the accelerating operation detecting means detects an operating quantity to an accelerator as a physical quantity corresponding to the degree of the accelerating operation, in which the intermediate increase rate setting means shortens the intermediate increase rate period as the revolution becomes higher at a transition from the first period to the second period. Because the accelerator operating quantity is reflected directly by the driver's intention, a control satisfying the driver's intention can be achieved.

[0039] This summary of the invention does not necessarily described all necessary features so that the invention may also reside in a sub-combination of these described features.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040]

FIG. 1 is a schematic structural diagram of a fuel injection control apparatus of an accumulator type diesel engine according to the first embodiment of the present invention;

FIG. 2 is a block diagram showing an electrical structure of an ECU for use in the first embodiment;

FIGs. 3 and 4 are flow charts showing a basic injection quantity calculation routine to be executed by the ECU according to the embodiment;

FIGs. 5A and 5B are explanatory diagrams of a C table for use in calculation of a governor injection quantity and a smoothing quantity $\triangle Q$;

FIG. 6 is an explanatory view showing differences depending on friction of the diesel engine in a table of a road load injection quantity corresponding to a revolution NE;

FIG. 7 is a timing chart showing an effect of the first embodiment;

FIG. 8 is a flow chart showing a road load injection quantity calculation routine to be executed by the ECU according to a second embodiment;

FIG. 9 is an explanatory diagram of a table on temperature corrective injection quantity KTHWQRL to be set corresponding to a cooling water temperature THW;

FIGs. 10-12 are flow charts showing a basic injection quantity calculation routine to be executed by the ECU according to a third embodiment;

FIGs. 13A and 13B are explanatory diagrams of a map of a first smoothing quantity QSMA1 to be set depending on a diesel revolution NE and an accelerator opening degree ACCPF and a second smoothing quantity QSMA2 to be set depending on the diesel revolution NE and accelerator opening degree ACCPF;

FIG. 14 is a timing chart showing an effect of the third embodiment;

FIGs. 15-17 are flow charts showing the basic injection quantity calculation routine to be executed by the ECU according to a fourth embodiment;

FIGs. 18A and 18B are explanatory diagrams of a table on a revolution reference value KNESF to be set depending on a shift position and a revolution reference value KNESF to be set depending on a minimum revolution NEMIN during deceleration; and

FIGs. 19A-19C are timing charts showing an effect of the fourth embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0041] FIG. 1 is a schematic configuration diagram showing an embodiment of a fuel injection control apparatus of an accumulator type diesel engine (common-rail diesel engine) 1, to which the present invention is applied. The accumulator type diesel engine 1 is mounted on a vehicle and used as a driving power source for driving the vehicle.

[0042] The diesel engine 1 has a plurality of cylinders (four cylinders in this embodiment) #1, #2, #3, #4. An injector 2 constituting fuel injection means is disposed for a fuel chamber of each of the cylinders #1-#4. Injection of fuel from the injector 2 to each of the cylinders #1-#4 of the diesel engine 1 is controlled by ON/OFF of an electromagnetic valve 3 for injection control.

[0043] The injector 2 is connected to a common rail 4 serving as an accumulator pipe common to the respective cylinders such that the fuel in the common rail 4 is injected to each of the cylinders #1-#4 through the injector 2 while the electromagnetic valve 3 for injection control is opened. In the common rail 4, a relative a high pressure equivalent to fuel injection pressure is continuously accumulated. To achieve this accumulation, the common rail 4 is connected to an outlet port 6a of a supply pump 6 through a supply pipe 5. A check valve 7 is provided at an intermediate section of the supply pipe 5. This check valve 7 allows the fuel to be supplied from the supply pump 6 to the common rail 4 and restricts the counter flow from the common rail 4 to the supply pump 6.

[0044] The aforementioned supply pump 6 is connected to the fuel tank 8 through the intake port 6b and a filter 9 is provided at the intermediate section thereof. The supply pump 6 admits the fuel from the fuel tank 8 through the filter 9. At the same time, the supply pump 6 reciprocates the plunger by a cam (not shown) synchronizing with a rotation of the diesel engine 1 so as to raise the fuel pressure to a requested predetermined pressure. Then, the supply pump 6 supplies high pressure fuel to the common rail 4.

[0045] A pressure control valve 10 is provided in the vicinity of the outlet port 6a of the supply pump 6. This pressure control valve 10 controls the fuel pressure (or discharge quantity) discharged from the outlet port 6a to the common rail 4. If the pressure control valve 10 is opened, excessive fuel that has not been discharged from the outlet port 6a is returned to the fuel tank 18 from a return port 6c provided in the supply pump 6 through a return pipe 11.

[0046] An intake path 13 and an emission path 14 are connected to a combustion chamber of the diesel engine 1. A throttle valve (not shown) is provided in the intake path 13 and the flow rate of intake air introduced to the combustion chamber is adjusted by opening or closing the throttle valve depending on an operating condition.

[0047] A glow plug 16 is disposed in the combustion chamber of the diesel engine 1. The glow plug 16 is an auxiliary starting device for accelerating fuel combustion, which is heated by applying a current to a glow relay 16a just before starting of the diesel engine 1 and spraying a part of injected fuel thereto for ignition and combustion.

[0048] The diesel engine 1 contains various sensors for detecting the condition, for example, an operating condition of the diesel engine 1 of this embodiment. That is, as shown in FIG. 1, an accelerator sensor 21 for detecting an accelerator opening degree ACCPF is provided in the vicinity of the accelerator pedal 15 and a full-close switch 22 for outputting a full-close signal when a depression quantity of the accelerator pedal 15 is zero is provided in the vicinity of the accelerator sensor 21.

[0049] An intake pressure sensor 23 is provided in the intake path 13 via a filter 17 and a vacuum switching valve (VSV) 18. This intake pressure sensor 23 detects the intake pressure PM inside the intake path 13.

[0050] A water temperature sensor 24 for detecting a temperature of cooling water (cooling water temperature THW) is provided in the cylinder block of the diesel engine 1.

[0051] Further, provided in the diesel engine 1 is a starter 19 for starting. The starter 19 contains a starter switch 25 for detecting the operating condition. The starter switch 25 is operated by a driver from OFF to start position of an ignition switch (not shown) when starting the diesel engine 1. When the starter is operated (when it is in a cranking state), a starter signal STA is output as "ON".

[0052] If, after completion of the start of the diesel engine 1 (in complete combustion state), the ignition switch is returned from the start position to the ON position, the starter switch 25 outputs the starter signal STA as "OFF".

[0053] Additionally, the aforementioned return pipe 11 is provided with a fuel temperature sensor 26 for detecting a fuel temperature THF.

[0054] The common rail 4 contains a fuel pressure sensor 27 as fuel pressure detecting means for detecting the pressure of the fuel (fuel pressure PC) within the common rail 4.

[0055] In this embodiment, an NE sensor 28 is provided in the vicinity of a pulser provided on a crank shaft (not shown) of the diesel engine 1. A rotation of the crank shaft is transmitted to a cam shaft (not shown) for opening or closing an intake valve 31 and exhaust valve 32 via a timing belt or the like. The cam shaft is set to rotate at a revolution 1/2 of that of the crank shaft. A G sensor 29 is provided in the vicinity of the pulser provided on this cam shaft. According to this embodiment, revolution NE, crank angle CA and top dead center (TDC) of each of the cylinders #1-#4 are calculated according to the pulse signal output from both the sensors 28, 29.

[0056] In this embodiment, an electronic control unit (ECU) 51 for performing various controls of the diesel engine 1 is provided. The ECU 51 executes processing for controlling the diesel engine 1 such as fuel injection quantity control.

[0057] An electrical configuration of the ECU 51 will be described referring to a block diagram of FIG. 2.

[0058] The ECU 51 includes a central processing unit (CPU) 52, a read-only memory (ROM) 53 for memorizing a predetermined program, map or the like, a random access memory (RAM) 54 for temporarily memorizing a result of computation of the CPU 52, a backup RAM 55 for storing the preliminarily memorized data, a timer counter 56, and an input interface 57 and an output interface 58. Each of the respective components 52-56 is connected to the input interface 57 and the output interface 58 through a bus 59.

[0059] The aforementioned accelerator sensor 21, intake pressure sensor 23, water temperature sensor 24, fuel temperature sensor 26, fuel pressure sensor 27 and the like are connected to the input interface 57 through a buffer, multiplexer and A/D converter (not shown). Further, the NE sensor 28 and G sensor 29 are connected the input interface 57 through a waveform shaping circuit (not shown). The full-close switch 22 and starter switch 25 are directly connected to the input interface 57.

[0060] The CPU 52 reads a signal of each of the aforementioned sensors 21 to 29 through the input interface 57.

[0061] The electromagnetic valve 3, pressure control valve 10 and VSV 18 are connected to the output interface 58 through the respective driving circuit (not shown). The CPU 52 controls the electromagnetic valve 3, pressure control valve 10, VSV 18, and the like based on input values that have been read through the input interface 57 in a preferred manner via the output interface 58.

[0062] Among the controls executed by the ECU 51 in this embodiment, the fuel injection control processing will be described. FIGs. 3,4 are flow charts showing a basic injection quantity calculation routine to be executed by the ECU 51. This routine is executed by interruption at every crank angle of 180° (each combustion stroke). A step in the flow chart corresponding to each processing is expressed by "S-"

[0063] Upon start of the basic injection quantity calculation routine processing, first, a governor injection quantity QGOV is obtained (S100). This governor injection quantity QGOV can be obtained by the revolution NE of the diesel engine 1 detected by the NE sensor 28 and accelerator opening degree ACCPF detected by the accelerator sensor 21. For example, the governor injection quantity QGOV is derived from the following equation (1).

$$QGOV = A + B \times ACCPF - C \times NE \qquad (1)$$

where A and B are constants, and C is a value derived from Table shown in FIG. 5A depending on the accelerator opening degree ACCPF. Meanwhile, like FIG. 5A, the value of C may be obtained by the accelerator opening degree ACCPF using an equation for calculating the value C.

[0064] Then it is determined whether or not the first acceleration smoothing execution flag XQSMA1 is off (OFF)(S102). It is assumed that by initial setting processing of the ECU 51 at a time of turning the power ON, the first acceleration smoothing execution flag XQSMA1 and the second acceleration smoothing execution flag XQSMA2 (described alter) are set to OFF, respectively.

[0065] If the smoothing processing for acceleration is not executed, for example, at a time of deceleration, the first acceleration smoothing execution flag XQSMA1 is turned OFF ("YES" in S102). The process proceeds to step S110 where it is determined whether or not a value of the governor injection quantity QGOV obtained in step S100 is equal to or more than the last basic fuel injection quantity QBASEOL (S110). For example, if it is detected that the accelerator pedal 15 is released for deceleration operation by the accelerator sensor 21 and the governor injection quantity is reduced to attain the relationship of QGOV<QBASEOL ("NO" in S110), decelerating processing is executed (S120). Although in this decelerating processing, a processing for decreasing the basic fuel injection quantity QBASE (equivalent to the actual fuel injection quantity) is carried out, this matter is not important in this embodiment, and therefore a description thereof in detail is omitted.

[0066] Subsequent to step S120, the first acceleration smoothing execution flag XQSMA1 for determining whether or not the acceleration time smoothing processing is being executed is turned OFF (S130). Then the basic fuel injection quantity QBASE obtained in step S120 is set to the last basic fuel injection quantity QBASEOL (S160). The basic fuel injection quantity calculation routine is temporarily terminated.

[0067] If the governor injection quantity QGOV calculated in step S100 is equal to or more than the basic fuel injection quantity QBASEOL by driver's depression of the accelerator pedal 15 in a state where the first acceleration smoothing execution flag XQSAM1 is off ("YES" in S102 and "YES" in S110), the process proceeds to step S140. It is determined whether or not a positive value is set as the governor injection quantity QGOV (S140).

[0068] If the relationship of the governor injection quantity QGOV ≦ 0 is attained ("NO" in S140), the governor injection quantity QGOV is set as the basic fuel injection quantity QBASE (S150). Then it is determined whether or not the second acceleration smoothing execution flag XQSAM2 used for determination executed in the step S195 (described later) is OFF (S152). As the second acceleration smoothing execution flag XQSMA2 is OFF as far as the initial state is held ("YES" in S152), it is determined whether or not the governor injection quantity QGOV is less than the last basic fuel injection quantity QBASEOL (S154). Here, the relationship of the governor injection quantity QGOV ≧ last basic fuel injection quantity QBASEOL is attained ("NO" in S154), the last basic fuel injection quantity QBASEOL is set as the basic fuel injection quantity QBASE (S160). The processing is temporarily terminated. If the relationship of the governor injection quantity QGOV < last basic fuel injection quantity QBASEOL is attained ("YES" in S154), the first acceleration smoothing execution flag XQSMA1 is set to OFF (S156). Then the last basic fuel injection quantity QBASEOL is set as the basic fuel injection quantity QBASE (S160) and the processing is temporarily terminated.

[0069] In case of the governor injection quantity QGOV ≦ 0 as described above, a negative value or 0 is set as the basic fuel injection quantity QBASE, and actually, no fuel injection is executed. That is, in case of the governor injection quantity QGOV ≦ 0, a driver's request for acceleration cannot be assumed. If the processing of steps S230-S250 described later are executed in case of the governor injection quantity QGOV ≦ 0, the road load injection quantity lower limit QRLMIN is set as the basic fuel injection quantity QBASE for fuel injection against the driver's intention to accelerate. The aforementioned process is executed to eliminate unnecessary fuel injection.

[0070] Meanwhile, the road load injection quantity lower limit QRLMIN is a road load injection quantity for the diesel engine having a minimum friction allowed in the same type of the diesel engine. The relationship of the road load injection quantity upper limit QRLMAX > average road load injection quantity QRL > road load injection quantity lower limit QRLMIN > 0 can be attained.

[0071] If the is determined QGOV > 0 in step S140 ("YES" in S140), that is, an acceleration request is assumed, the road load injection quantity lower limit QRLMIN is set as the smoothed injection quantity QSMA (S230).

[0072] Next, the first acceleration smoothing execution flag XQSMA1 is set to ON (S240) and the second acceleration smoothing execution flag XQSMA2 is set to ON (S245). Then, the smoothed injection quantity QSMA is set as the basic fuel injection quantity QBASE (S250). Finally the last basic fuel injection quantity QBASEOL is set as the basic fuel injection quantity QBASE (S160). The processing is temporarily terminated.

[0073] If acceleration is requested by executing these sequential processing (S100, S102, S110, S140, S230, S240, S245, S250, S160), the actual fuel injection quantity is increased stepwise to reach the road load injection quantity lower limit value QRLMIN.

[0074] The road load injection quantity lower limit value QRLMIN is set depending on the revolution NE of the diesel engine 1 as a road load injection quantity for the diesel engine having a possible minimum friction as shown by a solid line of FIG. 6, which is smaller than the average road load injection quantity QRL (indicated by a chain line of FIG. 6). For reference, the road load injection quantity upper limit value QRLMAX for a diesel engine having a possible maximum friction is shown by a broken line of FIG. 6.

[0075] In the basic injection quantity calculation routine subsequent to step S240 where the first acceleration smoothing execution flag XQSMA1 is turned ON, it is determined "NO" in step S102 subsequent to step S100, and it is determined whether or not the governor injection quantity QGOV is equal to or less than 0 (S172). If the acceleration is requested, the relationship of the governor injection quantity QGOV > 0 is attained ("NO" in S172). It is determined whether or not the governor injection quantity QGOV is equal to or less than the last basic fuel injection quantity QBASEOL (S174).

[0076] If the basic fuel injection quantity QBASEOL has been increased stepwise to reach the road load injection quantity lower limit value QRLMIN and the governor injection quantity QGOV has not become equal to or more than the last basic fuel injection quantity QBASEOL ("NO" in S174), a smoothing quantity △Q is calculated (S180).

[0077] In step S180, the smoothing quantity △Q is a positive injection quantity for addition derived from a map using the accelerator opening degree ACCPF and revolution NE as the parameter. In this map, as shown by a contour line of

FIG. 5B, the smoothing quantity △Q is set to be larger as the increase both in the accelerator opening degree ACCPF and the revolution NE. Meanwhile like Fig. 5B, the smoothing quantity △Q may be obtained according to the equation for calculating the same smoothing quantity △Q using the accelerator opening degree ACCPF and the revolution NE.

[0078] Subsequent to step S180, the smoothed injection quantity QSMA can be derived from the following equation (2) (S190).

$$QSMA = QBASEOL + \triangle Q \qquad (2)$$

[0079] In order to determine whether or not the acceleration smoothing processing using the smoothing quantity △Q can be reflected on the basic fuel injection quantity QBASE with precedence, it is determined whether or not the second acceleration smoothing execution flag XQSMA2 is set to OFF(S195). As the second acceleration smoothing execution flag XQSMA2 has been set to ON in the last step S245 ("NO" in S195), the smoothed injection quantity QSMA is set as the basic fuel injection quantity QBASE immediately to reflect the acceleration smoothing processing using the smoothing quantity △Q on the basic fuel injection quantity QBASE with precedence (S210). Then as the second acceleration execution flag XQSMA2 has been set to ON ("NO" in S152), the last basic fuel injection quantity QBASEOL is set as the basic fuel injection quantity QBASE (S160). The processing is temporarily terminated.

[0080] As aforementioned, as far as in a period when the first acceleration smoothing execution flag XQSAM1 is set to ON ("NO" in S102), the governor injection quantity QGOV is rising in the positive region ("NO" in S172) and the governor injection quantity QGOV has not reached the last basic fuel injection quantity QBASEOL yet ("NO" in S174), the second acceleration smoothing execution flag XQSMA2 keeps ON state and therefore, each time when this basic injection quantity calculation routine is repeated, the smoothing quantity △Q is added to the basic fuel injection quantity QBASE (S190,S210). The rising gradient of the basic fuel injection quantity QBASE is restricted to △Q/180° CA That is, the acceleration time smoothing processing is executed.

[0081] If the governor injection quantity QGOV becomes equal to or more than the last basic fuel injection quantity QBASEOL after repeating steps S100,S102,S172, S174, S180, S190, S195, S210, S152, S160, it is determined "YES" in step S174 subsequent to steps S100, S102, and S172. Then the second acceleration smoothing execution flag XQSMA2 is set to OFF (S178). Then the smoothing quantity △Q is calculated (S180) and the smoothed injection quantity QSMA is derived from the aforementioned equation (2) (S190).

[0082] As step S195 determines that the second acceleration smoothing execution flag XQSMA2 has been set to OFF ("YES" in S195), the process proceeds to step S200 where it is determined whether or not the governor injection quantity QGOV exceeds the smoothed injection quantity QSMA.

[0083] For example, if the relationship of the governor injection quantity QGOV > smoothed injection quantity QSMA is attained ("YES" in S200) as the accelerating operation is continued, the smoothed injection quantity QSMA is set as the basic fuel injection quantity QBASE to continue the smoothing processing (S210). If the relationship of the governor injection quantity QGOV ≦ smoothed injection quantity QSMA is attained ("NO" in S200) as accelerating operation is stopped, the governor injection quantity QGOV is set as the basic fuel injection quantity QBASE (S150).

[0084] If execution in step S210 or step S150 is terminated, it is determined whether or not the second acceleration smoothing execution flag XQSMA2 is set to OFF in step S152. As the second acceleration smoothing execution flag XQSMA2 is set to OFF in step S178 ("YES" in S152), it is determined whether or not the governor injection quantity QGOV is less than the last basic fuel injection quantity QBASEOL (S154). As the relationship at this time is attained as the governor injection quantity QGOV ≧ last basic fuel injection quantity QBASEOL ("NO" in S154), the last basic fuel injection quantity QBASEOL is set as the basic fuel injection quantity QBASE (S160). The processing is temporarily terminated.

[0085] If the last basic fuel injection quantity QBASEOL exceeds the stable governor injection quantity QGOV after executing the processing of steps S100, S102, S172, S174, S178, S180, S190, S195, S200, S210 (or S150), S152, S154, S160 repeatedly, the relationship of the governor injection quantity QGOV < last basic fuel injection quantity QBASEOL is attained. Therefore, after executing the processing of steps S100, S102, S172, it is determined "NO" in step S174. Further, as the second acceleration smoothing execution flag XQSMA2 has been set to OFF after executing the steps S180, S190, S195, S200, S210, (or S150), it is determined "YES" in step S152. Then in step S154, as a relation of the governor injection quantity QGOV < last basic fuel injection quantity QBASEOL is attained, it is determined "YES".

[0086] Therefore, the first acceleration smoothing execution flag XQSMA1 is returned to OFF (S156). Then, the last basic fuel injection quantity QBASEOL is set as the basic fuel injection quantity QBASE (S160) and the processing is temporarily terminated. Therefore, appropriate fuel injection quantity control in response to the driver's acceleration request or deceleration request can be realized by returning to the initial state, that is, "first acceleration smoothing execution flag XQSMA1 = OFF" and "second acceleration smoothing execution flag XQSMA2 = OFF".

[0087] At a time when the basic fuel injection quantity QBASE has been changed to the road load injection quantity lower limit QRLMIN stepwise by executing the sequential processing of steps S230-S250, S160 and before the governor injection quantity QGOV reaches the last basic fuel injection quantity QBASEOL, if the governor injection quantity QGOV is decreased to 0 or negative value accompanied with deceleration ("YES" in S172), the first acceleration smoothing execution flag XQSMA1 is returned to OFF (S173). This process makes it possible to engage in the deceleration process (S120) by allowing the next basic injection quantity calculation routine to determine "YES" in step S102 and "NO" in step S110.

[0088] According to the above embodiment, the following operation and effect are obtained. Referring to a timing chart of FIG. 7, when the driver depresses the accelerator pedal 15 to start acceleration (time T0), "YES" is determined in steps S102, S110, S140 of the subsequent basic injection quantity calculation routine executed at a timing of 180°CA and in step S230, the road load injection quantity lower limit value QRLMIN is set as the basic fuel injection quantity QBASE. As a result, the actual fuel injection quantity increases stepwise. At this time T0 onward, the governor injection quantity QGOV rising sharply exceeds the basic fuel injection quantity QBASE ("YES" in S174: at time T1 in FIG. 7). Until the basic fuel injection quantity QBASE reaches a stabilized governor injection quantity QGOV ("YES" in S154), fuel injection is executed by the smoothing quantity $\triangle Q$ derived from calculation of the smoothing quantity $\triangle Q$ (S180) according to the smoothed injection quantity (S190) increased at every 180° CA (S210).

[0089] As this road load injection quantity QRLMIN is identical to the one corresponding to a minimum friction allowed in the diesel engine 1 as shown in FIG. 6, the road load injection quantity lower limit QRLMIN is the smallest road load injection quantity among those of the diesel engine of the same type.

[0090] Therefore, even if the fuel injection quantity control is carried out by the aforementioned basic injection quantity calculation routine for all the same diesel engines, the fuel is always increased according to the road load injection quantity lower limit QRLMIN which is lower than or equal to the actual quantity. Thus, even if the diesel engine 1 to be controlled has a lower friction than the average friction, it is possible to prevent sharp increase in the fuel injection quantity far beyond the actual road load injection quantity, thus restricting deterioration of drivability owing to suppressed acceleration shock. Further, stepwise fuel increase for acceleration is maintained at the start of smoothing processing, acceleration performance in response to the accelerator operation can be satisfied.

[0091] In the basic injection quantity calculation routine, as compared to the conventional art, the acceleration shock can be controlled by simply using the road load injection quantity lower limit QRLMIN instead of the average road load injection quantity QRL. It can be achieved easily by using existing hardware and software, thereby maintaining a control processing speed without complicating the program.

[0092] The smoothing processing is carried out after the stepwise fuel increase by setting the road load injection quantity lower limit QRLMIN as the basic fuel injection quantity QBASE. If the smoothing processing is started in a state where the basic fuel injection quantity QBASE = 0 without stepwise increase, the smoothing processing must be started by controlling such a minute injection quantity as $\triangle Q$ at its initial stage. In such a minute quantity injection control, as an injection quantity adjustment error takes a large ratio, the accuracy of the injection quantity is not stabilized and the revolution of the diesel engine becomes unstable, which may give an adverse effect to drivability. However, according to this embodiment, the road load injection quantity lower limit QRLMIN which is a large value enough to execute high accuracy fuel injection is set as the basic fuel injection quantity QBASE, thus preventing unstable rotation of the diesel engine 1.

[0093] A second embodiment of the present invention is different from the first embodiment in that a road load injection quantity calculation routine shown in FIG. 8 is executed as a processing for calculating the road load injection quantity lower limit QRLMIN set as the smoothed injection quantity QSMA in step S230 in addition to the processing of the basic injection quantity calculation routine as shown in FIGs. 3,4. This road load injection quantity calculating routine is executed at every 180°CA.

[0094] Its hardware is formed by adding an air conditioner driven by the diesel engine 1 to the structure of the first embodiment. An ON/OFF signal XAC for turning ON/OFF the air conditioner and an ON/OFF signal XEUP for turning ON/OFF a device as an electrical load, for example, a headlamp (not shown) are input to the input interface 57 of the ECU 51 shown in FIG. 2 and the ECU 51 is allowed to detect an air conditioner load and an electrical load.

[0095] Upon start of this road load injection quantity calculation routine, first of all, determination on acceleration is executed (S300). In step S300, the same processing as aforementioned step S110 is executed, that is, it is determined whether or not the governor injection quantity QGOV is equal to or more than the last basic fuel injection quantity QBASEOL. In case of QGOV $\geqq$ QBASEOL ("YES" in S300), a reference injection quantity lower limit QRLABMN at the acceleration side is calculated (S310). The reference injection quantity lower limit QRLABMN is obtained from the revolution NE of the diesel engine 1 based on the Table. The reference injection quantity lower limit QRLABMN is set to be larger as the increase in the revolution NE. Specifically, referring to the road load injection quantity lower limit QRLMIN table among those shown in FIG. 6, the road load injection quantity lower limit QRLMIN derived from the revolution NE is used as the reference injection quantity lower limit QRLABMN.

[0096] Next, a reference injection quantity upper limit QRLABMX at the acceleration side is calculated (S320). The reference injection quantity upper limit QRLABMX is obtained from the revolution NE of the diesel engine 1 according to the table. The reference injection quantity upper limit QRLABMX is set to be larger as the increase in the revolution

NE. Specifically referring to the road load injection quantity upper limit QRLMAX table among tables shown in FIG. 6, the road load injection quantity upper limit QRLMAX derived from the revolution NE is used as the reference injection quantity upper limit QRLMAX.

[0097] Next, the reference injection quantity lower limit QRLDBMN at the deceleration side is cleared (S330) and the reference injection quantity upper limit QRLDBMX at the deceleration side is cleared (S340).

[0098] In case of QGOV < QBASEOL ("NO" in S300), the reference injection quantity lower limit QRLDBMN at the deceleration side is calculated (S350). The reference injection quantity lower limit QRLDBMN is obtained from the revolution NE of the diesel engine 1 according to the table. The reference injection quantity lower limit QRLDBMN is set to be larger as the increase in the revolution NE. Specifically referring to the road load injection quantity lower limit QRLMIN of tables shown in FIG. 6, the road load injection quantity lower limit QRLMIN derived from the revolution NE is used as the reference injection quantity lower limit QRLABMN.

[0099] Next, a reference injection quantity upper limit QRLBBMX of the acceleration side is calculated (S360). The reference injection quantity upper limit QRLABMX is obtained from the engine speed NE of the diesel engine 1 according to the table. The reference injection quantity upper limit QRLABMX is set to be larger as the increase in the revolution NE. Specifically referring to the road load injection quantity upper limit QRLMAX of tables shown in FIG. 6, the road load injection quantity upper limit QRLMAX obtained from the revolution NE is used as the reference injection quantity upper limit QRLDBMX.

[0100] Then, the reference injection quantity lower limit QRLABMN at the acceleration side is cleared (S370) and the reference injection quantity upper limit ORLABMX at the acceleration side is cleared (S380).

[0101] Subsequent to step S340 or step S380, it is determined whether or not the air conditioner ON/OFF Signal XAC is ON (S390). If the ON/OFF signal XAC is ON ("YES" in S390), air conditioner corrective injection quantity KACQRL is calculated (S400). A predetermined positive value is set as the air conditioner corrective injection quantity KACQRL. If the ON/OFF signal XAC is OFF ("NO" in S390), the air conditioner corrective injection quantity KACQRL is cleared (S410).

[0102] Subsequent to step S400 or step S410, it is determined whether or not the ON/OFF signal XEUP for turning ON/OFF the device as the electrical load is ON (S420). If the ON/OFF signal XEUP is ON ("YES" in S420), the electrical load corrective injection quantity KEQRL is calculated (S430). A positive value corresponding to total electrical load of the device turned ON is set as the electrical load corrective injection quantity KEQRL. If no device is turned ON ("NO" in S420), the electrical load corrective injection quantity KEQRL is cleared (S440).

[0103] Subsequent to step S430 or step S440, a temperature corrective injection quantity KTHWQRL is calculated (S450). This temperature corrective injection quantity KTHWQRL is set depending on a cooling water temperature THW detected by the water temperature sensor 24 according to the table shown in FIG. 9. If the cooling water temperature THW increases, that is, the diesel engine temperature increases, engine oil viscosity decreases to lower the friction. Therefore, as shown in FIG. 9, the temperature corrective injection quantity KTHWQRL decreases with the increase of the cooling water temperature THW. Finally the value 0 is set.

[0104] Then, the road load injection quantity lower limit QRLMIN and the road load injection quantity upper limit QRLMAX are calculated using the following equations (3), (4) (S460).

$$QRLMIN = QRLBMN + QRLDBMN + KTHWQRL + KACQRL + KEQRL \quad (3)$$

$$QRLMAX = QRLBMX + QRLDBMX + KTHWQRL + KACQRL + KEQRL \quad (4)$$

[0105] The thus obtained road load injection quantity lower limit QRLMIN is set as the smoothed injection quantity QSMA in step S230 shown in FIG. 3 where the basic injection quantity calculation routine is executed.

[0106] As the road load injection quantity upper limit QRLMAX is not used in the basic injection quantity calculation routine shown in FIGs. 3, 4, a processing for obtaining the road load injection quantity upper limit QRLMAX does not have to be carried out in the road load injection quantity calculation routine in FIG.8. However, the road load injection quantity upper limit QRLMAX can be used in the basic injection quantity calculation routine of the other embodiment to be described later. Further, if "NO" is determined in step S300 and steps S350-S380 are executed, the road load injection quantity lower limit QRLMIN and road load injection upper limit QRLMAX calculated in step S460 are used for deceleration. Although they are not directly used in the basic injection quantity calculation routine shown in FIGs. 3, 4, they can be used for deceleration smoothing processing in the similar way to the acceleration smoothing processing.

[0107] According to this embodiment, as described above, the following operation and effect are attained in addition to those obtained by the first embodiment. Referring to the timing chart of FIG. 7 used in the first embodiment, if a driver starts acceleration by depressing the accelerator pedal 15 (time T0), the road load injection quantity lower limit QRLMIN is set at the basic fuel injection quantity QBASE at a subsequent timing of 180° CA, such that the actual fuel injection quantity is increased stepwise.

[0108] The road load injection quantity lower limit QRLMIN located at a stepwise increased position is reflected by deflection of friction of the diesel engine 1 based on variation of the cooling water temperature THW, deflection of rotational resistance of the diesel engine 1 accompanied with ON/OFF of the air conditioner and deflection of the rotational resistance of the diesel engine 1 due to change in electrical load accompanied by ON/OFF of the headlamp. That is, the road load injection quantity to be set as the smoothed injection quantity is made smaller as the total rotational resistance of the diesel engine 1 including the friction decreases. And the road load injection quantity to be set as the smoothed injection quantity QSMA is made larger as the total rotational resistance increases. By this procedure, if the friction or rotational resistance changes, a torque corresponding to that change is reflected on the increase in the stepwise fuel injection quantity executed at the initial stage of the smoothing processing.

[0109] Therefore, even if the friction or rotational resistance of the diesel engine 1 changes to be at a lower level depending on the operating condition, a value of the road load injection quantity QRLMIN used for controlling fuel injection for the stepwise increase can be decreased. This makes it possible to prevent sharp increase in the fuel injection quantity far beyond the actual road load injection quantity lower limit QRLMIN. Thus, deterioration of drivability can be prevented by suppressing the acceleration shock.

[0110] The road load injection quantity lower limit QRLMIN used for the control can be increased in the case where the friction or other rotational resistance of the diesel engine 1 changes to be at a higher level. Therefore it is possible to prevent the start of smoothing processing for increasing the fuel injection quantity by $\triangle Q$ at every 180° CA without reaching the actual road load injection quantity lower limit QRLMIN. Therefore, acceleration response is maintained thus preventing deterioration of drivability.

[0111] Particularly, as the physical quantity corresponding to the faction of the diesel engine 1, cooling water temperature of the diesel engine 1 is detected. The road load injection quantity lower limit QRLMIN is set to be larger as the cooling water temperature becomes lower. Accordingly even in the cold state of the diesel engine, it is possible to cope with high friction owing to high engine oil viscosity. The start of smoothing processing can be prevented without reaching the actual road load injection quantity lower limit QRLMIN thus can be prevented. As a result, acceleration response is maintained and deterioration of drivability is prevented. On the contrary, as the road load injection quantity lower limit QRLMIN is set to be smaller as the cooling water temperature THW becomes higher, sharp increase in the fuel injection quantity can be prevented far beyond the actual road load injection quantity lower limit QRLMIN thus preventing deterioration of drivability by suppressing the acceleration shock.

[0112] The ON/OFF state of the mechanism, for example, air conditioner, head lamp or the like which acts as the rotational resistance of the diesel engine giving the same effect as the friction increase/decrease is detected. If OFF state of the mechanism is detected, the road load injection quantity lower limit QRLMIN is set to a value smaller than that in the case at ON sate. This may prevent sharp increase in the fuel injection far beyond the actual road load injection quantity lower limit QRLMIN, thereby preventing deterioration of drivability by suppressing the acceleration shock. On the contrary, if ON state of the mechanism is detected, the road load injection quantity lower limit QRLMIN is set to a value larger than that in the case at OFF state. This may prevent the start of smoothing processing without reaching the actual road load injection quantity lower limit QRLMIN, thus preventing deterioration of drivability by maintaining the acceleration response.

[0113] In this embodiment, a switch of the instrument acting as an electrical load, for example, an air conditioner switch and a headlamp corresponds to faction detecting means.

[0114] A third embodiment of the present invention is the same as the first embodiment except that a basic injection quantity calculation routine shown in FIGs. 3, 4 is replaced by the basic injection quantity calculation routine shown in FIGs. 10, 11, 12.

[0115] Upon start of this basic injection quantity calculation routine, first of all, the governor injection quantity QGOV is calculated (S500). This governor injection quantity QGOV can be derived from the revolution NE of the diesel engine 1 detected by the NE sensor 28 and an accelerator opening degree ACCPF detected by the accelerator sensor 21. For example, this value is calculated according to the equation (1) of the first embodiment.

[0116] Next, it is determined whether or not the first acceleration smoothing execution flag XQSMA is OFF (S502). It is assumed that the first acceleration smoothing execution flag XQSMA1 and the second acceleration smoothing execution flag XQSMA2 are set to OFF by the initial setting of the ECU 51 when turning the power ON.

[0117] If the acceleration smoothing processing is not being executed, for example, duning decelerating operation, the first acceleration smoothing execution flag XQSMA1 is OFF ("YES in S502). It is determined whether or not the governor injection quantity QGOV obtained in step S500 is equal to or more than the last basic fuel injection quantity QBASEOL (S510). For example, in case of QGOV < QBASEOL ("NO" in S510) indicating that the accelerator sensor 21 detects the release of the accelerator pedal 15 at a time of deceleration operation, decelerating operation is executed (S520). Although the decelerating processing carries out the processing for reducing the basic fuel injection quantity QBASE (equivalent to the actual fuel injection quantity), this processing is not considered as being important in this embodiment, and therefore the detailed description thereof will be omitted.

[0118] Subsequent to step S520, the first acceleration smoothing execution flag XQSMA1 for determining whether or not the acceleration smoothing processing is being carried out is set to OFF (S530), the basic fuel injection quantity

QBASE obtained in step S520 is set as the last basic fuel injection quantity QBASEOL (S560) and then the basic injection quantity calculation routine is temporarily terminated.

[0119] Next, if the governor injection quantity QGOV calculated in step S500 is equal to or more than the last basic fuel injection quantity QBASEOL by driver's depression of the accelerator pedal 15 under the condition where the first acceleration smoothing execution flag XQSMA1 is set to OFF ("YES " in step S502 and "YES" in S510), it is determined whether or not a positive value is set as the governor injection quantity QGOV (S540).

[0120] In case of the governor injection quantity QGOV ≦ 0 ("NO" in S540), the governor injection quantity QGOV is set as the basic fuel injection quantity QBASE (S550), and then it is determined whether or not the second acceleration smoothing execution flag XQSMA2 used for determination in step S595 is set to OFF (S552). As the second acceleration smoothing execution flag XQSMA2 is OFF if the initial state is continued ("YES" in S552), it is determined whether or not the governor injection quantity QGOV is less than the last basic fuel injection quantity QBASEOL (S554). As the relationship of the governor injection quantity QGOV < last basic fuel injection quantity QBASEOL is attained ("NO" in S554), the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S560). Then the processing is temporarily terminated. In case of the governor injection quantity QGOV < last basic fuel injection quantity QBASEOL ("YES" in S554), the first acceleration smoothing execution flag XQSMA1 is set to OFF (S556), the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S560). The processing is temporarily terminated.

[0121] In this case, as the relationship of the governor injection quantity ≦ 0 is attained, a negative value or 0 is set as the basic fuel injection quantity QBASE in step S550, and actually, no fuel injection is carried out. That is, in case of the governor injection quantity QGOV < 0, it is assumed that no driver's request for acceleration has been issued. If the processing of steps S630-S650 described later are carried out in case of the governor injection quantity QGOV <0, the road load injection quantity lower limit QRLMIN is set as the basic fuel injection quantity QBASE without the driver's request for acceleration, resulting in waste fuel injection. The above procedure intends to eliminate such waste fuel injection.

[0122] Meanwhile, the road load injection quantity lower limit QRLMIN is a road load injection quantity for the diesel engine having a minimum faction allowed in the same type of the diesel engine as described in the first embodiment. The relation of road load injection quantity upper limit QRLMAX > average road load injection quantity QRL > road load injection quantity lower limit QRLMIN > 0 is provided.

[0123] If QGOV > 0 is determined in step S540 ("YES" in S540), that is, acceleration request is assumed to be issued, the road load injection quantity lower limit QRLMIN is set as the smoothed injection quantity QSMA (S630).

[0124] Next, the first acceleration smoothing execution flag XQSMA1 is set to ON (S640) and the second acceleration smoothing execution flag XQSMA2 is set to ON (S645). Then, the smoothed injection quantity QSMA is set as the basic fuel injection quantity QBASE (S650), finally the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S560). Then the processing is temporarily terminated.

[0125] If acceleration is requested by these sequential processing S500, S502, S510, S540, S630, S640, S645, S650, S560, the actual fuel injection quantity is increased stepwise to the road load injection quantity lower limit QRLMIN.

[0126] This road load injection quantity lower limit QRLMIN is the same as that of the first embodiment as shown in FIG. 6. The road load injection quantity upper limit QRLMAX (indicated by a broken line of FIG. 6) for the diesel engine having a maximum allowable friction is used for control in this embodiment as described later.

[0127] In the basic injection quantity calculation routine just after the first acceleration smoothing execution flag XQSAM1 is set to ON in step S640 last time, subsequent to step S500, "NO" is determined in step S502 and then it is determined whether or not the governor injection quantity QGOV is 0 or less (S572). If the acceleration request has been issued, as the relation of the governor injection quantity QGOV > 0 ("NO" in S572), it is determined whether or not the governor injection quantity QGOV is equal to or more than the last basic fuel injection quantity QBASEOL (S574).

[0128] If the governor injection quantity QGOV has not become equal to or more than the last basic fuel injection quantity QBASEOL yet immediately after stepwise increase of the last basic fuel injection quantity QBASEOL to the road load injection quantity lower limit QRLMIN ("NO" in S574), it is determined whether or not the last basic fuel injection quantity QBASEOL exceeds the road load injection quantity upper limit QRLMAX obtained from the revolution NE according to a table of FIG. 6 (S580). In case of the road load injection quantity upper limit QRLMAX ≧ last basic fuel injection quantity QBASEOL ("NO" in S580), the first smoothing quantity QSMA1 is calculated (S582). This first smoothing quantity QSMA1 is a positive injection quantity for addition, which is obtained from a table using the revolution NE of the diesel engine 1 as the parameter. In this table, the first smoothing quantity QSMA1 is set to be larger as the revolution NE becomes higher as shown in FIG. 13(a). The first smoothing quantity QSMA1 may be obtained according to the revolution NE using the equation having increased revolution NE.

[0129] Next, using the first smoothing quantity QSMA1 calculated in this manner, the smoothed injection quantity QSMA is obtained by the following equation(5) (S588).

$$QSMA = QBASEOL + QSMA1 \quad (5)$$

[0130] To determine whether or not the acceleration smoothing processing is reflected on the basic fuel injection quantity QBASE with precedence, it is determined whether or not the second acceleration smoothing execution flag XQSMA2 is OFF (S595). As the second acceleration smoothing execution flag XQSMA2 has been just set to ON in the preceding step S645 ("NO" in S595), the smoothed injection quantity QSMA is set as the basic fuel injection quantity QBASE immediately (S610) so as to reflect the acceleration smoothing processing by the first smoothing quantity QSMA1 on the basic fuel injection quantity QBASE with precedence. Next, as the second acceleration smoothing execution flag XQSMA2 is set to ON ("NO" in S552), the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S560) and then the processing is temporarily terminated.

[0131] If the first acceleration smoothing execution flag XQSMA1 is set to ON ("NO" in S502) and the governor injection quantity QGOV is rising in a positive region ("NO" in S572) for the period when the governor injection quantity QGOV has not reached the last basic fuel injection quantity QBASEOL yet ("NO" in S574), the second acceleration smoothing execution flag XQSMA2 maintains its ON state. Therefore, each time when the basic injection quantity calculation routine is repeated, the first smoothing quantity QSMA1 is added to the last fuel injection quantity QBASEOL at an initial stage (S582, S588) so as to limit a rising gradient of the basic fuel injection quantity QBASE to the first smoothing quantity QSMA1/180° CA.

[0132] After repeating execution of steps S500, S502, S572, S574, S580, S582, S588, S595, S610, S552, S560, if the last basic fuel injection quantity QBASEOL exceeds the road load injection quantity upper limit QRLMAX, "YES" is determined in step S580 subsequent to steps S500, S502, S572, S574 so as to calculate the second smoothing quantity QSMA2 (S590). This second smoothing quantity QSMA2 is a positive injection quantity for addition obtained from a map using the accelerator opening degree ACCPF and revolution NE as parameters. In this map, as shown by a contour fine of FIG. 13B, the second smoothing quantity QSMA2 is set to be larger as the accelerator opening degree ACCPF and the revolution NE become higher. This second smoothing quantity QSMA2 is set to be larger than the first smoothing quantity QSMA1 under the same revolution NE irrespective of the accelerator opening degree ACCPF.

[0133] The second smoothing quantity QSMA2 may be obtained from an equation used for calculating the second smoothing quantity QSMA2 like in FIG. 13B according to the accelerator opening degree ACCPF and revolution NE.

[0134] Next, a third smoothing quantity QSMA3 is obtained using the second smoothing quantity QSMA2 calculated in this manner by the following equation (6) (S592).

$$QSMA3 = QSMA3 + QSMA1 \quad (6)$$

[0135] The third smoothing quantity QSMA3 is set to 0 by the initial setting of the ECU 51 at a time of turning the power ON.

[0136] Then, the smoothed injection quantity QSMA can be obtained using the third smoothing quantity QSMA3 calculated in this manner as shown by the formula (7) (S594).

$$QSMA = QBASEOL + MIN(QSMA3, QSMA2) \quad (7)$$

where MIN() is an operator for outputting a value which is the smallest among a plurality of described values.

[0137] If the last basic fuel injection quantity QBASOL exceeds the road load injection quantity upper limit QRLMAX, the increase rate of the basic fuel injection quantity QBASE is switched from small to large by changing the execution from the aforementioned steps S582, S588 to the sequential processing of steps S590, S592, S594.

[0138] In the smoothing processing where the injection quantity is raised by the quantity QSMA at every 180°C CA, the increase rate is relatively gentle. At a time when the last basic fuel injection quantity QBASEOL exceeds the road load injection quantity upper limit QRLMAX, the processing is switched to relatively a sharp increase of the injection quantity by a quantity QSMA2 at every 180°CA.

[0139] By rising the basic fuel injection quantity QBASE stepwise to the road load injection quantity lower limit QRLMIN at the start of the smoothing processing, the acceleration shock is prevented and the acceleration response is maintained in the same way as the first embodiment. Further, in consideration of the acceleration shock induced by the sharp increase in the injection quantity in a region close to the road load injection quantity equal to or more than the actual road load injection quantity, the injection quantity is increased at a lower increase rate and further increased at a higher increase rate, thereby preventing the acceleration shock and realizing the required acceleration performance.

[0140] The level of the actual road load injection quantity existing between the road load injection quantity lower limit QRLMIN and road load injection quantity upper limit QRLMAX cannot be identified. Therefore, the higher increase rate will be used until the injection quantity reaches the road load injection quantity upper limit QRLMAX. This is specified as the minimum condition.

[0141] Further, in the smoothing control, merely switching of the increase quantity of QSMA1 to the increase quantity of QSMA2 may cause the acceleration shock owing to the sharp change in the increase rate of injection quantity. Thus, by executing the processing of step S592, an intermediate increase rate period for changing the increase rate is provided at a transitional timing from the initial period (injection quantity rising period by an quantity of QSMA1) to the next period (increase rate rising period by a quantity of QSMA2). That is, a third smoothing quantity QSMA3 as an intermediate increase rate between the injection quantity increase rate by QSMA1 and injection quantity increase rate by QSMA2 is calculated in step S592. In step S594, the second smoothing quantity QSMA2 and the third smoothing quantity QSMA3 are compared and then a smaller value is added to the last basic fuel injection quantity QBASOL, such that the smoothed injection quantity QSMA is obtained to realize the intermediate increase rate period.

[0142] As the ON setting of the second acceleration smoothing execution flag XQSMA2 has not been changed after step S594 ("NO" in S595), the smoothed injection quantity QSMA is set as the basic fuel injection quantity QBASE immediately (S610). As the second acceleration smoothing execution flag XQSMA2 is set to ON ("NO" in S552), the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S560) and then the processing is temporarily terminated.

[0143] The processing shifts to the second stage smoothing processing and the processing of steps S500, S502, S572, S574, S580, S590, S594, S595, S610, S552, S560 are repeated. If the governor injection quantity QCOV reaches the last basic fuel injection quantity QBASEOL, "YES" is determined in step S574 subsequent to steps S500, S502, S572, and the second acceleration smoothing execution flag XQSMA2 is set to OFF (S578). Then, after execution of the processing of steps S580, S590, S592, S594, the second acceleration smoothing execution flag XQSMA2 is set to OFF in step S595 ("YES" in S595). The process proceeds to step S600 where it is determined whether or not the governor injection quantity QGOV exceeds the smoothed injection quantity QSMA.

[0144] For example, in case of the governor injection quantity QGOV > smoothed injection quantity QSMA owing to the continued accelerating operation ("YES" in S600), the smoothed injection quantity QSMA is set as the basic fuel injection quantity QBASE (S610). In case of the governor injection quantity QGOV < smoothed injection quantity QSMA ("NO" in S600) owing to suspended accelerating operation, the governor injection quantity QGOV is set as the basic fuel injection quantity QBASE (S550).

[0145] Then, if the processing in step S610 or step S550 is terminated, the process proceeds to step S552 where it is determined whether or not the second acceleration smoothing execution flag XQSMA2 is set to OFF. As the second acceleration smoothing execution flag XQSMA2 is set to OFF in step S578 ("YES" in S552), it is determined whether or not the governor injection quantity QGOV is less than the last basic fuel injection quantity QBASEOL (S554). As a relation of governor injection quantity QGOV ≧ last basic fuel injection quantity QBASEOL exists ("NO" in S554), the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S560). Then the processing is temporarily terminated.

[0146] After repetition of executing steps S500, S502, S572, S574, S578, S580, S590, S592, S594, S595, S600, S610 (or S550), S552, S554, S560, the last basic fuel injection quantity QBASEOL surpasses the stabilized governor injection quantity QGOV resulting from stopped accelerating operation to attain the relation governor injection quantity QGOC < last basic fuel injection quantity QBASEOL. Then "NO" is determined in step S574 subsequent to execution of steps S500, S502, S572. Further, subsequent to steps S580, S590, S592, S594, S595, S600, S610 (or S550), as the second acceleration smoothing execution flag XQSMA2 is set to OFF, "YES" is determined in step S552. As a relation of governor injection quantity QGOV < last basic fuel injection quantity QBASEOL is attained, "YES" is determined in step S554.

[0147] Then, the first acceleration smoothing execution flag XQSMA1 is returned to OFF (S556). Then, the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S560) and the processing is temporarily terminated. Therefore, the process returns to the initial state, that is, "first acceleration smoothing execution flag XQSMA1 = OFF" and "second acceleration smoothing execution flag XQSMA2 = OFF" such that an appropriate fuel injection quantity control corresponding to the driver's acceleration request or deceleration request can be executed.

[0148] If the basic fuel injection quantity QBASE has been changed to the road load injection quantity lower limit QRLMIN stepwise by the sequential processing of steps S630-S650, S560 and the operation is changed to deceleration to decrease the governor injection quantity QGOV to a negative value or 0 before the governor injection quantity QGOV reaches the last basic fuel injection quantity QBASEOL("YES" in S572), the first acceleration smoothing execution flag XQSMA1 to OFF (S573). In the next basic injection calculation routine, step S502 is allowed to determine "YES" and step S510 "NO" so as to engage in the deceleration processing (S520).

[0149] According to the aforementioned embodiment, as described in the first embodiment, the acceleration shock can be prevented and the acceleration response is improved by setting the road load injection quantity lower limit QRLMIN as the basic fuel injection quantity QBASE at a time of executing the smoothing processing. Additionally the following operation and effect can be obtained.

[0150] Referring to a timing chart of FIG. 14, when a driver starts acceleration by depressing the accelerator pedal 15,"YES " is determined in steps S502, S510, S540 of the basic injection quantity calculation routine, respectively and the road load injection quantity lower limit QRLMIN is set as the basic fuel injection quantity QBASE in step S630.

Therefore the actual fuel injection quantity increases stepwise (time T20). At the time T20 onward, the governor injection quantity QGOV sharply increases to surpass the basic fuel injection quantity QBASE ("NO" in S574: time T21). Then the fuel injection quantity control is carried out according to the smoothed injection quantity QAMA set in smoothing processing (S582, S588 or S590, S592, S594) until the basic fuel injection quantity QBASE reaches a stabilized governor injection quantity QGOV ("YES" in S554: time T24).

[0151] The smoothing processing period (time T20-T24) contains the first smoothing period R1, intermediate increase rate period M and second smoothing period R2. First, during the first smoothing period R1, (S582, S588: time T20-T22) will be executed and the basic fuel injection quantity QBASE is increased relatively gentrl by the first smoothing quantity QSMA1 in the range from the road load injection quantity lower limit QRLMIN to the road load injection quantity upper limit QRLMAX. Then, during the intermediate increase rate period M (time T22-T23) subsequent to the first smoothing period R1, the fuel increase rate is set such that the increase rate during the first smoothing period R1 is gradually changed to the increase rate during the second smoothing period R2 (S590, S592, S594). As a result, the increase rate changes smoothly from that of the first smoothing period R1 to that of the second smoothing period R2. After the increase rate is changed to that of the second smoothing period R2, a relatively sharp increase (S590, S592, S594) as the second smoothing period R2(time T23-T24) is continued until the basic fuel injection quantity QBASE reaches the governor injection quantity QGOV ("YES" in S554).

[0152] A length of the intermediate increase rate period M (time T22-T23) is determined by a timing at which the MIN (QSMA3, QSMA2) value is switched from the third smoothing quantity QSMA3 to the second smoothing quantity QSMA2 as obvious from the aforementioned equation (7). That is, if the timing at which the MIN (QSMA3, QSMA2) value is switched from the third smoothing quantity QSMA3 to the second smoothing quantity QSMA2 is early, the intermediate increase rate period M is shortened. On the contrary, if the timing is late, the intermediate increase rate period M is prolonged.

[0153] This means that the intermediate increase rate period M is shortened as the third smoothing quantity QSMA 3 increases faster, and it is prolonged as the third smoothing quantity QSMA3 increases slower. An increase speed of the third smoothing quantity QSMA3 is defined by the first smoothing quantity QSMA1 as evident from a calculation of step S592 shown by the aforementioned formula (6) and if this first smoothing quantity QSMA 1 is increased, the intermediate increase rate period M is shortened. If the first smoothing quantity QSMA1 is decreased, the intermediate increase rate period M is increased.

[0154] The first smoothing quantity QSMA1 is a positive injection quantity for addition obtained from a table using the revolution NE of the diesel engine 1 as a parameter. As shown in FIG. 13A, the first smoothing quantity QSMA1 is set to be larger as the revolution NE becomes higher. Accordingly the higher the revolution NE of the diesel engine becomes, the shorter the intermediate increase rate period M becomes. The lower the revolution NE becomes, the longer the intermediate increase rate period M becomes.

[0155] As the accelerating operation is quickened, the revolution NE of the diesel engine 1 at the time T22 tends to be higher, the accelerating operation rate defines the size of the first smoothing quantity QSMA1 at the start of the intermediate increase rate period M.

[0156] Therefore, if the accelerating operation is carried out quickly, the intermediate increase rate period M is shortened and if the accelerating operation is carried out slowly, the intermediate increase rate period M is prolonged.

[0157] As described above, according to this embodiment, if the accelerating operation to the greater degree is carried out, the intermediate increase rate period M for changing the increase rate smoothly is shortened at a time when the processing shuts from the initial smoothing processing (first smoothing period R1) to the next smoothing processing for increasing the fuel at higher increase rate (second smoothing period R2). If the accelerating operation to smaller degree is carried out, the intermediate increase rate period M is prolonged. Thus, if the accelerator operating quantity becomes constant, namely smaller degree of the accelerating operation, at the time of terminating the initial smoothing processing (e.g., time Ts in FIG. 14), the intermediate increase rate period M is prolonged. Consequently, if the governor injection quantity QGOV has a greater difference with respect to the basic fuel injection quantity QBASE, and the basic fuel injection quantity QBASE (the first smoothing period) becomes substantially smaller than the governor injection quantity QGOV set by the initial smoothing processing (first smoothing period R1), the second stage smoothing control (second smoothing period R2) is not started. Instead the second smoothing control is executed afier an elapse of a relatively long intermediate increase rate period M. Therefore, the fuel increase against the intention of a driver is not carried out, thereby suppressing the acceleration shock. If the driver carries out a quick accelerating operation, the intermediate increase rate period M becomes shorter or the intermediate increase rate period M is eliminated, such that the processing can shift from the initial smoothing processing (first smoothing period R1) to the second smoothing control (second smoothing period R2) at an earlier state, thereby achieving sufficient acceleration. In this case, although the acceleration shock occurs between the initial smoothing processing (first smoothing period R1) and the second smoothing control (second smoothing period R2), the driver may not have uncomfortable feeling as he/she requires acceleration.

[0158] Therefore, in the second smoothing processing, prevention of the acceleration shock and establishment of the acceleration response can be attained, thus preventing deterioration of drivability.

[0159] According to this embodiment, step S582 corresponds to a processing of the accelerating operation detecting means and steps S592, S594 correspond to a processing of the intermediate increase rate setting means.

[0160] A fourth embodiment of the present invention is different from the first embodiment in that a basic injection quantity calculation routine shown in FIGs. 3 and 4 is replaced by the basic injection quantity calculation routine shown in FIGs. 15, 16, 17. Further, a transmission (not shown) is provided with a shut position sensor for detecting a shut position and inputting a transmission shut position signal to the input interface 57 of the ECU 51. Thus, the ECU 51, capable of determining a shut position state, can be used for control. The other structure is the same as that of the first embodiment.

[0161] Upon start of this basic injection quantity calculation routine, first of all, the governor injection quantity QGOV is calculated (S700). This governor injection quantity QGOV can be obtained from the revolution NE of the diesel engine 1 detected by the NE sensor 28 and an accelerator opening degree ACCPF detected by the accelerator sensor 21. For example, this value is calculated according to the equation (1) described in the first embodiment.

[0162] Next, it is determined whether or not the first acceleration smoothing execution flag XQSMA1 is set to OFF (S702). It is assumed that the first acceleration smoothing execution flag XQSMA1 and the second acceleration smoothing execution flag XQSMA2 to be described later are at to OFF by the initial setting of the ECU 51 at the time of turning the power ON.

[0163] If the acceleration smoothing processing is not being executed, for example, deceleration is being operated, the first acceleration smoothing execution flag XQSMA1 is set to OFF ("YES in S702). Then it is determined whether or not the governor injection quantity QGOV obtained in step S700 is equal to or more than the last basic fuel injection quantity QBASEOL (S710). For example, if a relation QGOV < QBASEOL is attained ("NO" in S710) as in the case where the accelerator sensor 21 detects the release of the accelerator pedal 15 at a time of deceleration operation, decelerating operation is carried out (S720). Although this decelerating processing carries out to reduce the basic fuel injection quantity QBASE (equivalent to the actual fuel injection quantity), this is not an important factor in this embodiment. The detailed description thereof is omitted.

[0164] Subsequent to Step S720, it is determined whether or not the current revolution NE of the diesel engine 1 is less than a minimum revolution NEMIN during deceleration (S724). In case of NEMIN > NE ("YES" in S724), the current revolution NE is set as a latest minimum revolution NEMIN during deceleration (S726). In case of NEMIN < NE ("NO" in S724), the minimum revolution NEMIN is kept as it is. Steps S724, S726 executes the processing for obtaining the minimum revolution under no load, namely, for memorizing the revolution of the diesel engine 1 using the actual road load injection quantity.

[0165] After determination of "NO" in step S726 or S724, the first acceleration smoothing execution flag XQSMA1 for determining whether or not the acceleration smoothing processing is being executed is set to OFF (S730), the basic fuel injection quantity QBASE obtained in step S720 is set as the last basic fuel injection quantity QBASEOL (S760). Then the basic injection quantity calculation routine is temporarily terminated.

[0166] Next, for example, if the first acceleration smoothing execution flag XQSMA1 is OFF or the governor injection quantity QGOV calculated in step S700 is equal to or more than the last basic fuel injection quantity QBASEOL by driver's depression of the accelerator pedal 15 ("YES" in step S702 and "YES "in S710), it is determined whether or not a positive value is set at the governor injection quantity QGOV (S740).

[0167] In case of the governor injection quantity QGOV $\leqq 0$ ("NO" in S740), the governor injection quantity QGOV is set as the basic fuel injection quantity QBASE (S750), and then it is determined whether or not the second acceleration smoothing execution flag XQSMA2 used for determination in step S795 is set to OFF (S752). As the second acceleration smoothing execution flag XQSMA2 is OFF if the initial state is continued ("YES" in S752), it is determined whether or not the governor injection quantity QGOV is less than the last basic fuel injection quantity QBASEOL (S754). Here, as the relation governor injection quantity QGOV < last basic fuel injection quantity QBASEOL is attained ("NO" in S754), the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S760) and then the processing is temporarily terminated. If governor injection quantity QGOV $\geqq$ last basic fuel injection quantity QBASEOL ("YES "in S754), the first acceleration smoothing execution flag XQSMA1 is set to OFF (S756), the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S760) and the processing is temporarily terminated.

[0168] If governor injection quantity $\leqq 0$, a negative value or 0 is set as the basic fuel injection quantity QBASE in step S750, and actually, no fuel injection is carried out. If governor injection quantity QGOV $\leqq 0$, it is assumed to have no driver's request for acceleration. Upon execution of steps S830-S850 described later in case of governor injection quantity QGOV $\leqq 0$, the road load injection quantity lower limit QRLMIN is set as the basic fuel injection quantity QBASE against the driver's intention for acceleration, resulting in waste fuel injection. The above procedure intends to prevent the waste fuel injection.

[0169] Meanwhile, as described in the first embodiment, the road load injection quantity lower limit QRLMIN is a road load injection quantity for the diesel engine having a minimum faction allowed in the same type of the diesel engine. A relation of road load injection quantity upper limit QRLMAX > average road load injection quantity QRL > road load injection quantity lower limit QRLMIN > 0 is attained.

[0170] If it is determined QGOV > 0 in step S740 ("YES "in S740), that is, it is estimated to have an acceleration request, the road load injection quantity lower limit QRLMIN is set as the smoothed injection quantity QSMA (S830).

[0171] Next, the first acceleration smoothing execution flag XQSMA1 is set to ON (S840) and the second acceleration smoothing execution flag XQSMA2 is set to ON (S845). Then, the smoothed injection quantity QSMA is set as the basic fuel injection quantity QBASE (S850). Finally the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S760) and the processing is temporarily terminated.

[0172] If acceleration is requested by execution of sequential steps S700, S702, S710, S740, S830, S840, S845, S850, S760, the actual fuel injection quantity is increased stepwise to reach the road load injection quantity lower limit QRLMIN.

[0173] This road load injection quantity lower limit QRLMIN is as shown in FIG. 6 in the first embodiment. The road load injection quantity upper limit QRLMAX (indicated by a broken line of FIG. 6) for the diesel engine having a maximum allowable friction is used for control in this embodiment as described later.

[0174] In the basic injection quantity calculation routine just after the first acceleration smoothing execution flag XQSAM1 is set to ON in step S840, subsequent to step S700, "NO" is determined in step S702 and then it is determined whether or not the governor injection quantity QGOV is equal to or less than 0 (S772). If an acceleration request is issued, as the relation of the governor injection quantity QGOV > 0 is attained ("NO" in S772), it is determined whether or not the governor injection quantity QGOV is equal to or more than the last basic fuel injection quantity QBASEOL (S774).

[0175] If the governor injection quantity QGOV has not been equal to or more than the last basic fuel injection quantity QBASEOL that has been increased stepwise to the road load injection quantity lower limit QRLMIN ("NO" in S774), it is determined whether or not the last basic fuel injection quantity QBASEOL exceeds the road load injection quantity upper limit QRLMAX obtained from the revolution NE according to a table of FIG. 6 (S780). If road load injection quantity upper limit QRLMAX ≧ last basic fuel injection quantity QBASEOL ("NO" in S780), the first smoothing quantity QSMA1 is calculated (S782). The first smoothing quantity QSMA1 is a positive injection quantity for addition obtained from a table using the revolution NE of the diesel engine 1 as a parameter. In this table, the first smoothing quantity QSMA1 is set to be larger as the revolution NE becomes higher as shown in FIG. 13A. The first smoothing quantity QSMA1 may be obtained according to the revolution NE using the equation so as to be larger as the revolution NE becomes higher.

[0176] Next, a revolution reference value KNESF corresponding to a shift position of the transmission is calculated according to the shift position sensor detection signal (S784). This revolution reference value KNESF is a positive value which is set to be smaller as the shift position is raised and larger as it is lowered as shown by an example of 5-stage transmission in a table of FIG. 18A,.

[0177] Then it is determined whether or not the revolution NE is less than a sum of the minimum revolution NEMIN during deceleration and revolution reference value KNESF (S786).

[0178] If the revolution NE has not been equal to or more than the sum of the minimum revolution NEMIN and revolution reference value KNESF ("YES" in S786), the smoothed injection quantity QSMA is obtained using the first smoothing quantity QSMA1 calculated in step S782 by the following equation (8) (S788).

$$QSMA = QBASEOL + QSMA1 \quad (8)$$

[0179] If the revolution NE is equal to or more than the sum of the minimum revolution NEMIN and revolution reference value KNESF in spite of "NO" determined in step S780 ("NO" in step S786), the process proceeds to step S790. Step S788 is not carried out.

[0180] It is determined whether or not the second acceleration smoothing execution flag XQSMA2 is OFF (S795) to determine whether or not the acceleration smoothing processing will be reflected on the basic fuel injection quantity QBASE with precedence subsequent to step S788. Here, as the second acceleration smoothing execution flag XQSMA2 has been just set to ON in the preceding step S845 ("NO" in S795), the smoothed injection quantity QSMA is immediately set as the basic fuel injection quantity QBASE to reflect the acceleration smoothing processing by the first smoothing quantity QSMA1 on the basic fuel injection quantity QBASE with precedence (S810).

[0181] Next, as the second acceleration smoothing execution flag XQSMA 2 is set to ON ("NO" in S752), the basic fuel injection quantity QBASE is set as the last fuel injection quantity QBASEOL (S760) and the processing is temporarily terminated.

[0182] As described above, under the state where the first acceleration smoothing execution flag XQSMA1 is ON, in a period when the governor injection quantity QGOV is rising in a positive region but has not reached the last basic fuel injection quantity QBASEOL yet ("NO" in S774), the second acceleration smoothing execution flag XQSMA2 is kept ON. Therefore, each time when the basic fuel injection quantity calculation routine is repeated, the first smoothing quantity QSMA1 is added to the last basic fuel injection quantity QBASEOL at the initial stage (S782,S788) and a rising gradient of the basic fuel injection quantity QBASE is restricted to the first smoothing quantity QSMA1/180° CA.

[0183] After repetitive execution of steps S700, S702, S772, S774, S780, S782, S788, S795, S810, S752, S760 are repeated, if the last basic fuel injection quantity QBASEOL exceeds the road load injection quantity upper limit QRLMAX, "YES" is determined in step S780 subsequent to steps S700, S702, S772, S774 to calculate the second smoothing quantity QSMA2 (S790). This second smoothing quantity QSMA2 is a positive injection quantity for addition obtained from a map using the accelerator opening degree ACCPF and revolution NE as parameters. In this map, as shown by a contour line of FIG. 13B, the second smoothing quantity QSMA2 is at to be larger as the accelerator opening degree ACCPF and the revolution NE become higher. The second smoothing quantity QSMA2 is set to be larger than the first smoothing quantity QSMA1 at the same revolution NE irrespective of the accelerator opening degree ACCPF. The second smoothing quantity QSMA2 may be obtained from the equation used for calculating the second smoothing quantity QSMA2 similar to the one shown in FIG. 13B according to the accelerator opening degree ACCPF and revolution NE.

[0184] Next, a third smoothing quantity QSMA3 is obtained using the second smoothing quantity QSMA2 calculated in this way, by the following equation (9) (S792).

$$QSMA3 = QSMA3 + QSMA1 \qquad (9)$$

[0185] The third smoothing quantity QSMA3 is set to 0 by the initial setting of the ECU 51 at a time of turning the power ON.

[0186] Then, the smoothed injection quantity QSMA can be obtained using the thus calculated third smoothing quantity QSMA3 by the following equation (10) (S794).

$$QSMA = QBASEOL + MIN(QSMA3, QSMA2) \qquad (10)$$

where MIN() is an operator for outputting a value which is the smallest quantity a plurality of values described in ().

[0187] If the last basic fuel injection quantity QBASOL exceeds the road load injection quantity upper limit QRLMAX, the processing of the aforementioned steps S782, S784, S786, S788 is changed to the sequential processing of steps S790, S792, S794 such that an increase rate of the basic fuel injection quantity QBASE by smoothing processing is switched from low to high.

[0188] That is, at the initial stage of the smoothing processing, the injection quantity is increased by a quantity of QSMA1 at 180°CA at a relative gentle increase rate as described in the third embodiment. When the last basic fuel injection quantity QBASEOL exceeds the road load injection quantity upper limit QRLMAX, the processing is switched to the smoothing at a relative sharp increase rate, in which the injection quantity is increased by an quantity of QSMA2 at 180°CA.

[0189] By increasing the basic fuel injection quantity QBASE stepwise up to the road load injection quantity lower limit QRLMIN when starting the smoothing processing, the acceleration shock is prevented and the acceleration response is maintained as described in the first embodiment. Further, the acceleration shock is induced by a sharp increase in the injection quantity in a region over the actual road load injection quantity and in the vicinity of the road load injection quantity, the injection quantity is initially increased at a gentle increase rate and then further increased at the sharp increase rate, thereby preventing the acceleration shock as well as satisfying the acceleration performance.

[0190] It is not evident as to which point the actual road load injection quantity exists in the range between the road load injection quantity lower limit QRLMIN and road load injection quantity upper limit QRLMAX` Therefore, it is the minimum requirement to increase the increase rate of the fuel injection quantity after the injection quantity is increased to reach the road load injection quantity upper limit QRLMAX.

[0191] However, if the increase in the injection quantity is switched from QSMA1 to QSMA2 in the smoothing processing, the acceleration shock may be caused by a sharp change in the increase rate of the injection quantity. Thus, by executing step S792, an intermediate increase rate period is provided for switching the increase rate smoothly at a transition period from the initial period (period for increasing injection quantity by QSMA1) to the next period (period for increasing injection quantity by QSMA2). That is, a third smoothing quantity QSMA3 as an intermediate increase rate between QSMA1 and QSMA2 is calculated. In step S792, the second smoothing quantity QSMA2 and the third smoothing quantity QSMA3 are compared and either of them whichever smaller is added to the last basic fuel injection quantity QBASOL to obtain smoothed injection quantity QSMA, thus realizing the intermediate increase rate period.

[0192] Further, according to this embodiment, processing of steps S784, S786 is inserted between step S782 and step S788. Therefore, even if step S780 does not determine that the last basic fuel injection quantity QBASEOL has exceeded the road load injection quantity upper limit QRLMAX ("YES" in S780), but step S786 determines that the relation of revolution NE ≧ minimum revolution NEMIN + revolution reference value KNESF has been attained ("NO" in S786), processing of steps S790, S792, S794, namely the intermediate increase rate period and subsequent smoothing control for increasing the injection quantity by the QSMA2 are started immediately.

[0193] The minimum revolution NEMIN during deceleration is a physical quantity corresponding to the faction of the diesel engine 1. On a lower transmission stage corresponding to a shift position during acceleration, the revolution NE of the diesel engine 1 is likely to increase. Therefore, the revolution obtained by adding the revolution reference value KNESF to the minimum revolution NEMIN during deceleration is reflected on the faction of the diesel engine 1. Therefore, if the revolution NE of the diesel engine 1 is equal to or more than the NEMIN + KNESF as a reference, by changing the increase rate to higher one, it is possible to carry out two-stage smoothing control capable of switching fitted to the friction of the diesel engine 1, thus preventing the acceleration shock and achieving acceleration performance.

[0194] Subsequent to step S794, as the ON setting of the second acceleration smoothing execution flag XQSMA2 is not changed ("NO" in S795), the smoothed injection quantity QSMA is set as the basic fuel injection quantity QBASE immediately (S810). Then, as the second acceleration smoothing execution flag XQSMA2 is set to ON ("NO" in S752), the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S760) and the processing is temporarily terminated.

[0195] The smoothing processing is switched to the second stage and the processing of steps S700, S702, S772, S774, S780, S790, S792, S794, S795, S810, S752, S760 is repeated. If the governor injection quantity QCOV reaches the last basic fuel injection quantity QBASEOL, subsequent to steps S700, S702, S772, "YES" is determined in step S774 and the second acceleration smoothing execution flag XQSMA2 is set to OFF (S778). Then, after the execution of steps S780, S790, S792, S794, the second acceleration smoothing execution flag XQSMA2 is set to OFF in step S795 ("YES" in S795) and the process proceeds to step S800 where it is determined whether or not the governor injection quantity QGOV exceeds the smoothed injection quantity QSMA.

[0196] For example, as the accelerating operation is continued, if the relation of governor injection quantity QGOV > smoothed injection quantity QSMA is attained ("YES" in S800), the smoothed injection quantity QSMA is set as the basic fuel injection quantity QBASE (S810). If the accelerating operation is stopped or the relation of governor injection quantity QGOV < smoothed injection quantity QSMA is attained ("NO" in S800), the governor injection quantity QGOV is set as the basic fuel injection quantity QBASE (S750).

[0197] Then, if step S810 or step S750 is terminated, the process proceeds to step S752 where it is determined whether or not the second acceleration smoothing execution flag XQSMA2 is OFF. As the second acceleration smoothing execution flag XQSMA2 is set to OFF in step S778 ("YES" in S752), it is determined whether or not the governor injection quantity QGOV is less than the last basic fuel injection quantity QBASEOL (S754). As a relation of governor injection quantity QGOV ≧ last basic fuel injection quantity QBASEOL is attained ("NO" in S754), the basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S760) and then the processing is temporarily terminated.

[0198] After execution of steps S700, S702, S772, S774, S778, S780, S790, S792, S794, S795, S800, S810 (or S750), S752, S754, S760 are repeated, the stabilized governor injection quantity QGOV surpasses the last basic fuel injection quantity QBASEOL owing to stopped accelerating operation, and "NO" is determined in step S774 after execution of steps S700, S702, S772 as the relation of governor injection quantity QGOV < last basic fuel injection quantity QBASEO1 is attained. Further, subsequent to steps S780, S790, S792, S794, S795, S800, S810(or S750), "YES" is determined in step S752 as the second acceleration smoothing execution flag XQSMA2 has been set to OFF and "YES" determined in step S754 as the relation of governor injection quantity QGOV < last basic fuel injection quantity QBASEOL is attained.

[0199] Then, the first acceleration smoothing execution flag XQSMA1 is returned to OFF (S756). The basic fuel injection quantity QBASE is set as the last basic fuel injection quantity QBASEOL (S760) and the processing is temporarily terminated. Therefore, it is possible to return to the initial state, that is, "first acceleration smoothing execution flag XQSMA1 = OFF" and "second acceleration smoothing execution flag XQSMA2 = OFF" and carry out an appropriate fuel injection quantity control corresponding to the driver's acceleration request or deceleration request as described later.

[0200] In step 772, if the basic fuel injection quantity QBASE has been changed to the road load injection quantity lower limit QRLMIN stepwise by the sequential processing of steps S830-S850, S760 and the governor injection quantity QGOV is switched to a negative value or 0 owing to deceleration before the governor injection quantity QGOV reaches the last basic fuel injection quantity QBASEOL ("YES "in S772), step S772 returns the first acceleration smoothing execution flag XQSMA1 to OFF (S773) and in the next basic injection calculation routine causes step S702 to determine "YES" and step S710 to determine "NO" for starting the deceleration processing (S720).

[0201] According to this embodiment described above, the following operation and effect are obtained in addition to those of the first and third embodiments.

[0202] According to this embodiment, in the case where the processing of steps S784, S786 exist in a flow of the first stage smoothing processing even if it is not determined that the last basic fuel injection quantity QBASEOL has exceeded the road load injection quantity upper limit QRLMAX as shown by a timing chart of FIG. 19C ("YES" in S780), that is, the time T34 is not reached, and it is determined that a relation of revolution NE ≧ minimum revolution NEMIN

+ revolution reference value KNESF has been reached as shown in FIG. 19A ("NO" in S786: time T32), the second stage smoothing processing (S790, S792, S794) is started immediately.

[0203] As described above, the minimum revolution NEMIN during deceleration is a physical quantity corresponding to friction of the diesel engine 1. As the transmission stage becomes lower depending on a shift position during acceleration, the revolution NE of the diesel engine 1 is likely to increase. Therefore, by adding the revolution reference value KNESF to the minimum revolution NEMIN during deceleration, the friction of the diesel engine 1 is reflected on the resultant revolution. That is, as shown in FIG. 19B, an engine having a smaller friction (shown by a solid line of FIGs. 19A-19C), despite the same fuel injection quantity, has a higher engine torque TE than the engine having a larger friction (shown by a chain line of FIGs. 19A-19C). In FIG. 19B, TE0 indicates that the level of engine torque is 0 in a diesel engine having an average friction, TE0 + β indicates that the level of engine torque is 0 in the diesel engine having the highest friction, and TE0-a indicates the level of engine torque is 0 in a diesel engine to be actually controlled. Meanwhile, the diesel engine 1 to be actually controlled has a lower friction level than the average.

[0204] If the friction of the diesel engine 1 to be actually controlled is small, the revolution NE of the diesel engine reaches the NEMIN + KNESF position earlier than the diesel engine having a large friction (T32) because of high increase rate of the revolution NE of the diesel engine during acceleration. If this timing T32 is realized before the last basic fuel injection quantity QBASEOL reaches the road load injection quantity upper limit QRLMAX, the diesel engine of the actual control object is assumed to have a smaller friction compared with a diesel engine having the largest friction. Even if the second smoothing processing is started immediately, the acceleration response of the aforementioned diesel engine can be satisfied without causing an acceleration shock.

[0205] Therefore, if the revolution NE of the diesel engine 1 is equal to or more than NEMIN + KNESF ("NO" in S786), by transferring to a sharp increase injection quantity(S790, S792, S794), the second smoothing control of the diesel engine 1 that can cope with an actual friction can be executed, thus preventing the acceleration shock and satisfying the acceleration response more effectively.

[0206] Although in FIG. 19, the intermediate increase rate period M is omitted for an easy understanding, actually it is set in the same way as in the third embodiment.

[0207] A substantial smoothing processing for preventing the acceleration shock is executed as a first smoothing processing and the second smoothing processing is executed for linking the basic fuel injection quantity QBASE set to be lower than the governor injection quantity QGOV to the governor injection quantity QGOV smoothly after suppressing the acceleration shock sufficiently. Therefore, determination of step S786 of this embodiment causes the period for actual smoothing to match the actual friction such that the actual smoothing processsing is continued until a timing at which no acceleration shock is generated.

[0208] That is, since the increase rate of the revolution NE of the diesel engine 1 becomes higher as the friction gets smaller, "NO" is determined in step S786 at an elapse of a short period from the accelerating operation. Since the increase rate of the revolution NE of the diesel engine 1 become lower as the friction gets larger, "NO" is determined in step S786 at an elapse of long time from the accelerating operation.

[0209] As described above, the larger the rotational resistance by friction becomes, the longer time for the smoothing period is taken. In the case where the diesel engine 1 has a friction larger than the average friction, the smoothing processing is executed for the period corresponding to the actual road load injection quantity to increase the engine torque sufficiently, and then the smoothing processing for increasing the injection quantity sharply is executed. As a result, it is possible to prevent the acceleration shock caused by a gear backlash in a mechanism for transmitting a driving power from the diesel engine 1. On the contrary, in the case where the diesel engine 1 has a smaller friction than the average friction, if the engine torque is increased sufficiently by the smoothing processing executed for a period corresponding to the actual road load injection quantity, it is possible to proceed to a smoothing processing for executing an ordinary quantity of injection or increasing the injection quantity sharply. This may prevent continuation of the smoothing processing in spite of sufficient increase in the engine torque by the smoothing processing, thus keeping the acceleration response.

[0210] As a result, the acceleration shock can be prevented and at the same time, acceleration response can be satisfied, thus improving drivability.

[0211] According to this embodiment, steps S784 and S786 correspond to the processing performed by the friction detecting means.

[0212] In the above respective embodiments, it is determined whether or not the governor injection quantity QGOV is equal to or more than 0 in steps S140, S540, S740 respectively. This procedure serves to estimate the acceleration request. Thus, an arbitrary numerical value approximate to "0" can be used to be compared with the governor injection quantity instead of using "0" as far as the estimation of acceleration request can be executed. Alternatively, instead of determining the governor injection quantity QGOV, the increase rate thereof can be determined. In this case, if the increase rate becomes larger than the reference increase rate, based on which the acceleration request is assumed, it is determined "YES" in step S140, S540 and S740.

[0213] Although in the above respective embodiments, the road load injection quantity lower limit QRLMIN is set as the road load injection quantity to be set as a first actual fuel injection quantity for increasing the fuel quantity, it is permissible to use a value smaller than an average road load injection quantity QRL instead of using the road load injection quantity lower limit QRLMIN. For example, it is also permissible to use a road load injection quantity which is smaller than the average road load injection quantity QRL but larger than the road load injection quantity lower limit QRLMIN. In the case where the fuel quantity is increased by a road load injection quantity lower than the average road load injection quantity, if the diesel engine to be controlled has a smaller friction than the average friction,it is possible to prevent the fuel injection quantity from increasing sharply far beyond the actual road load injection quantity, thus suppressing the acceleration shock and a drop of drivability.

[0214] In the respective embodiments, estimation of the accelerating operation is conducted based on the governor injection quantity QGOV, it is permissible to determine the accelerating operation based on a depressing quantity of the accelerator pedal 15 or accelerator opening degree. For example, as the accelerator opening degree ACCPF has been already read in steps S100, S500, S700, the accelerator opening degree ACCPF and the last accelerator opening degree ACCPFOL are compared with each other in steps S110, S510, S710. Then, if ACCPF ≧ ACCPFOL, the steps S140, S540, S740 may be executed, and if ACCPF < ACCPFOL, the steps S120, S520, S720 may be executed. In steps S160, S560, S760, a processing for setting the last accelerator opening degree ACCPFOL as the accelerator opening degree ACCPF is carried out. By determining the accelerating operation based on the accelerator opening degree, it is possible to directly grasp a driver's accelerating operation, thereby enabling a further accurate control.

[0215] In the third and fourth embodiments, it is permissible to execute the road load injection quantity calculation routine shown in FIG. 8 of the second embodiment and adjust the road load injection quantity upper limit QRLMAX and road load injection quantity lower limit QRLMIN corresponding to the friction or rotational resistance of the diesel engine. As a result, an appropriate road load injection quantity upper limit QRLMAX and road load injection quantity lower limit QRLMIN corresponding to diesel engine condition are set, thus preventing the acceleration shock and satisfying acceleration response further effectively so as to suppress deterioration of drivability.

[0216] In steps S100, S500, S700 of the respective embodiments, the governor injection quantity QGOV is obtained by calculating the equation 1 based on the revolution NE of the diesel engine 1 and accelerator opening degree ACCPF. It is permissible to obtain the governor injection quantity QGOV based on the map corresponding to the revolution NE and accelerator opening degree ACCPF.

[0217] In the third and fourth embodiments, the revolution NE of the diesel engine is used as a physical quantity corresponding to a degree of the accelerating operation. It is permissible to detect an increase in an operating quantity of the accelerator pedal 15 or accelerator opening degree ACCPF as a physical quantity corresponding to the degree of the accelerating operation. In this case, as the acceleration operating quantity increases, the first smoothing quantity QSMA1 used in steps S592, S792 is increased so as to set the intermediate increase rate period M to be short at the transition of the processing from the initial smoothing processing (first smoothing period R1) to the second stage smoothing control (second smoothing period R2). As the accelerator operating quantity is reflected directly by the driver's intention, a control satisfying the driver's intention can be achieved.

[0218] In a processing of step S784 of the fourth embodiment, it is permissible to use the map of FIG. 18B instead of the table of FIG. 18A. That is, it is permissible to set the revolution reference value KNESF to a larger value if it becomes a small value as the shift position is high and the minimum revolution NEMIN is lowered during deceleration and it becomes a large value as the shift position is low and the minimum revolution NEMIN is enlarged during deceleration.

[0219] In a step S390, 420 of the second embodiment, instead of directly receiving ON/OFF signal XAC of an air conditioner or an ON/OFF signal XEUP of a switch of an apparatus of an electric load such as a headlamp, it is permissible to detect a revolution increase rate of the diesel engine as the physical quantity corresponding to the rotational resistance of the diesel engine. The road load injection quantity upper limit QRLMAX and road load injection quantity lower limit QRLMIN may be lowered as the revolution increase rate increases. This is on the ground that if the revolution increase rate of the diesel engine is high, the rotational resistance of the diesel engine can be estimated as low and if the revolution increase rate is low, the rotational resistance of the diesel engine can be estimated as high.

[0220] Further, it is permissible to detect a compression ratio as the physical quantity corresponding to the rotational resistance of the diesel engine.

[0221] The first smoothing quantity QSMA1 used in steps S588, S788 or steps S592, S792 according to the third and fourth embodiments may be a constant instead of the value corresponding to the revolution NE of the diesel engine.

[0222] In the third and fourth embodiments, the basic fuel injection quantity QBASE is increased stepwise to the road load injection quantity lower limit QRLMIN when increasing fuel quantity for acceleration (S630, S830). It is permissible to carry out the smoothing processing without increasing to the road load injection quantity lower limit QRLMIN stepwise. Further, it is permissible to add the road load injection quantity calculation routine as shown in the second embodiment.

[0223] The diesel engine injection quantity control apparatus of the present invention can be applied not only to the common rail type diesel engine, but also to all diesel engines capable of controlling the fuel injection quantity, for example, distribution type and the like.

[0224] It does not limit the claimed invention and that the discussed combination of features might not be absolutely necessary for the inventive solution.

[0225] In fuel injection quantity control of a diesel engine, to suppress deterioration of drivability caused by smoothing processing during increase in the fuel injection for acceleration, a road load injection quantity lower limit is set as a basic fuel injection quantity QBASE at start of the smoothing processing for acceleration. This road load injection quantity lower limit is the one corresponding to a minimum friction allowed in the diesel engine. Thus, if a diesel engine to be controlled has a fraction smaller than the average friction, the fuel injection quantity can be prevented from being increased sharply far beyond an actual road load injection quantity, thus suppressing the acceleration shock to prevent deterioration of drivability. Further, the stepwise increase in the fuel injection quantity for acceleration at the start of smoothing processing is maintained, thus satisfying the acceleration performance.

Claims

1. An injection quantity control apparatus of a diesel engine which is adapted, upon increasing an actual fuel injection quantity for acceleration of a diesel engine(1) corresponding to an operating condition thereof, to set a road load injection quantity as an initial value for increasing the fuel quantity for acceleration and to set the actual fuel injection quantity to be continuously increased subsequently by smoothing processing, characterized in that said road load injection quantity set as said initial value for increasing the fuel quantity for acceleration is set to be smaller than the road load injection quantity corresponding to friction at an average level of said diesel engine(1).

2. An injection quantity control apparatus of a diesel engine according to claim 1, characterized in that said road load injection quantity is set to be smaller than a road load injection quantity corresponding to a minimum level friction allowed in said diesel engine(1).

3. An injection quantity control apparatus of a diesel engine which is adapted, upon increasing an actual fuel injection quantity for acceleration of a diesel engine(1) corresponding to an operating condition thereof, to set an actual fuel injection quantity to be continuously increased subsequent to the increase to a road load injection quantity by smoothing processing, characterized by comprising friction detecting means(28, 29, 51) for detecting a rotational resistance including faction of the diesel engine(1), wherein said road load injection quantity is enlarged as the rotational resistance increases depending on the rotational resistance detected by said friction detecting means(28, 29, 51).

4. An injection quantity control apparatus of a diesel engine according to claim 3, characterized in that said friction detecting means is adapted to detects a cooling water temperature of the diesel engine(1) as a physical quantity corresponding to friction of the diesel engine(1) such that said road load injection quantity is enlarged as the cooling water temperature becomes lower.

5. An injection quantity control apparatus of a diesel engine according to claim 3, characterized in that said friction detecting means(28, 29, 51) is adapted to detect an ON/OFF state of a mechanism driven by an output of the diesel engine(1) as a rotational resistance thereof, wherein said road load injection quantity is set to be larger when said mechanism is in ON state than in case when said mechanism is in OFF state.

6. An injection quantity control apparatus of a diesel engine which is adapted, upon increasing an actual fuel injection quantity for acceleration of a diesel engine corresponding to an operating condition thereof, to set an actual fuel injection quantity to be increased continuously subsequent to the increase to a road load injection quantity by smoothing processing, characterized by comprising friction detecting means(28, 29, 51) for detecting a rotational resistance including friction of the diesel engine(1), wherein a period for the smoothing processing is prolonged depending on the rotational resistance detected by said friction detecting means(28, 29, 51) as the rotational resistance becomes higher.

7. An injection quantity control apparatus of a diesel engine according to claim 6, characterized in that said friction detecting means(28, 29, 51) is adapted to detect a revolution increase rate of the diesel engine(1) as a physical quantity corresponding to the rotational resistance of the diesel engine(1), characterized in that a period for said smoothing processing is shortened as the revolution increase rate becomes higher.

8. An injection quantity control apparatus of a diesel engine which is adapted, upon increasing an actual fuel injection quantity for acceleration of a diesel engine corresponding to an operating condition thereof, to increase the actual fuel injection quantity by smoothing processing for a first period at which the fuel injection is increased continuously

subsequent to the increase to the road load injection quantity; the actual fuel injection quantity is increased by a higher increase rate than in the first period for a second period next thereto; and an intermediate increase rate period is provided for changing the increase rate smoothly at the transition from the first period to the second period, characterized by comprising accelerating operation detecting means(51) for detecting an acceleration state of the diesel engine(1), wherein intermediate increase rate setting means(51) are adapted to reduce the intermediate increase rate period depending on a degree of the accelerating operation detected by said accelerating operation detecting means(51) as the degree of the accelerating operation becomes larger.

9. An injection quantity control apparatus of a diesel engine according to claim 8, characterized in that said accelerating operation detecting means(51) is adapted to detect a revolution of the diesel engine as a physical quantity corresponding to a degree of the accelerating operation, wherein said intermediate increase rate setting means(51) is adapted to shorten the intermediate increase rate period as the revolution becomes higher at a transition from the first period to the second period.

10. An injection quantity control apparatus of a diesel engine according to claim 8, characterized in that said accelerating operation detecting means(51) is adapted to detect an operating quantity to an accelerator as a physical quantity corresponding to the degree of the accelerating operation(15), wherein said intermediate increase rate setting means shortens the intermediate increase rate period as the revolution becomes higher at a transition from the first period to the second period.

11. A method for controlling an injection quantity in a diesel engine by

increasing an actual fuel injection quantity for acceleration of a diesel engine (1) corresponding to an operating condition thereof, and
setting a road load injection quantity as an initial value for increasing the fuel quantity for acceleration, and setting the actual fuel road load injection quantity to be continuously increased subsequently by smoothing processing, characterized by
setting said road load injection quantity as said initial value for increasing the fuel quantity for acceleration such that it is smaller than the road load injection quantity corresponding to friction as an advantage level of said diesel engine (1).

12. A method for controlling an injection quantity in a diesel engine according to claim 11, characterized in that the load injection quantity is set smaller than a road load injection quantity corresponding to a minimum level friction allowed in said diesel engine (1).

13. A method for controlling an injection quantity in a diesel engine by

increasing an actual fuel injection quantity for acceleration of a diesel engine (1) corresponding to an operating condition thereof, and
setting an actual fuel injection quantity to be continuously increased subsequent to the increase to a road load injection quantity is set by smoothing processing characterized by
detecting a rotational resistance including friction of the diesel engine (1) by a friction detecting means (28, 29, 51), wherein said road load injection quantity is enlarged as the rotational resistance increases depending on the rotational resistance detected by said friction detecting means (28, 29, 51).

14. A method according to claim 13, characterized in that said friction detecting means detect a cooling water temperature of the diesel engine (1) as a physical quantity corresponding to friction of the diesel engine (1) such that said road load injector quantity is enlarged as the cooling water temperature because lower.

15. A method according to claim 13, characterized in that said friction detecting means detects (28, 29, 51) detects an ON/OFF state of a mechanism driven by an output of the diesel engine (1) as a rotational resistance thereof, wherein said road load injection quantity is set to be larger when said mechanism is in OFF state.

16. A method for controlling an injection quantity in a diesel engine by

increasing an actual fuel injection quantity for acceleration of a diesel engine (1) corresponding to an operating condition thereof, and
setting an actual fuel injection quantity to be continuously increased subsequent to the increase to a road load

injection quantity is set by smoothing processing characterized by

prolonging the period of smoothing processing depending on the rotational resistance detected by a friction detecting means (28, 29, 51) as the rotational resistance becomes higher.

17. A method for controlling an injection quantity in a diesel engine according to claim 16, further characterized by

detecting a revolution increase rate of the diesel engine (1) as a physical quantity corresponding to the rotational resistance of the diesel engine (1), and
shortening said smoothing processing as the revolution increase rate becomes higher.

18. A method for controlling an injection quantity in a diesel engine by increasing the actual fuel injection quantity by something processing for a first period at which the fuel injection is increased continuously subsequent to the increase to the road load injection quantity; and

increasing the actual fuel injection quantity by a higher increases rate than in the first period for a second period next thereof; and providing an intermediate increase rate period for changing the increase rate smoothly at the transition from the first period to the second period, characterized by detecting an acceleration state of the diesel engine (1) by an acceleration operation detecting means (51), wherein intermediate increase rate setting means (51) reduces the intermediate rate period depending on a degree of the accelerating operation detected by said accelerating operation detecting means (51) as the degree of the accelerating operation becomes larger.

19. A method for controlling an injection quantity in a diesel engine according to claim 18, characterized by detecting a revolution of the diesel engine as a physical quantity corresponding to a degree of the accelerating operation, by said accelerating operation detecting means (51), wherein said intermediate increase rate setting means (51) shortens the intermediate increase rate period as the revolution becomes higher at a transition from the first period to the second period.

20. A method for controlling an injection quantity in a diesel engine according to claim 18, characterized by detecting an operating quantity to an accelerator as a physical quantity corresponding to the degree of the accelerating operation (15) by said accelerating operation detecting means (51), when said intermediate increase rate setting means shortens the intermediate increase rate period as the revolution from the first period to the second period.

FIG. 1

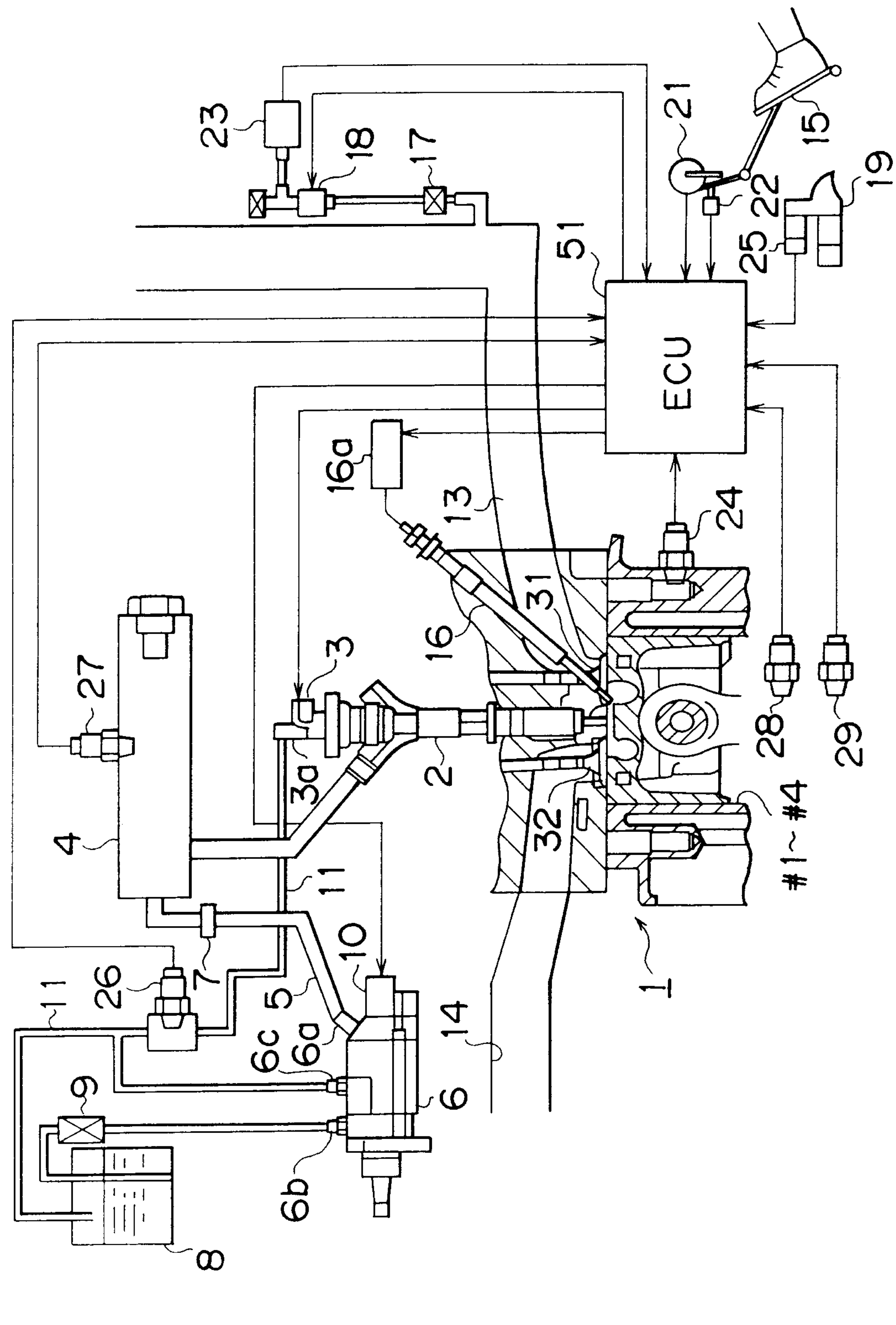


FIG. 2

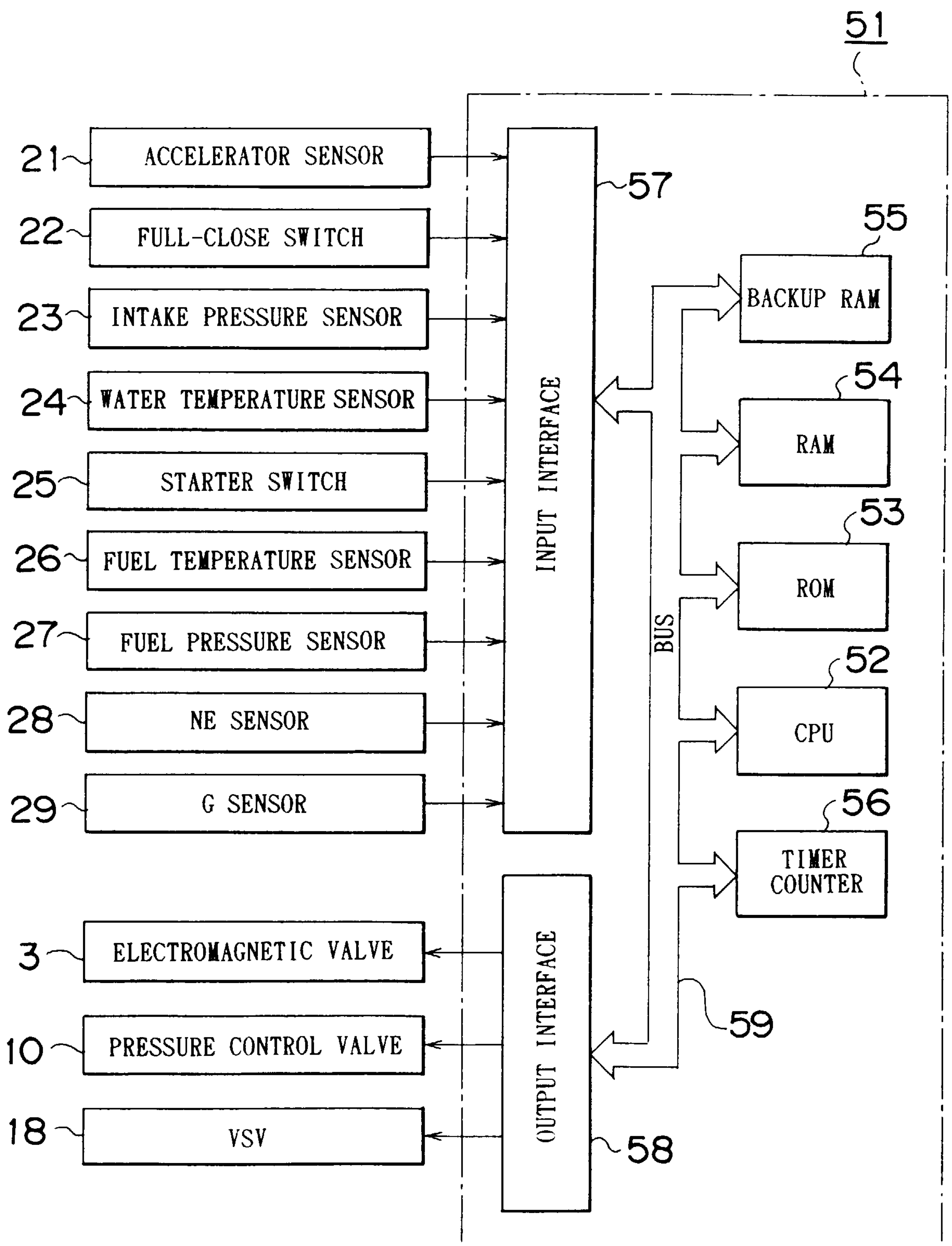

51
21
ACCELERATOR SENSOR
22
FULL-CLOSE SWITCH
23
INTAKE PRESSURE SENSOR
24
WATER TEMPERATURE SENSOR
25
STARTER SWITCH
26
FUEL TEMPERATURE SENSOR
27
FUEL PRESSURE SENSOR
28
NE SENSOR
29
G SENSOR
3
ELECTROMAGNETIC VALVE
10
PRESSURE CONTROL VALVE
18
VSV
INPUT INTERFACE
57
OUTPUT INTERFACE
58
BUS
59
BACKUP RAM
55
RAM
54
ROM
53
CPU
52
TIMER COUNTER
56

FIG. 3

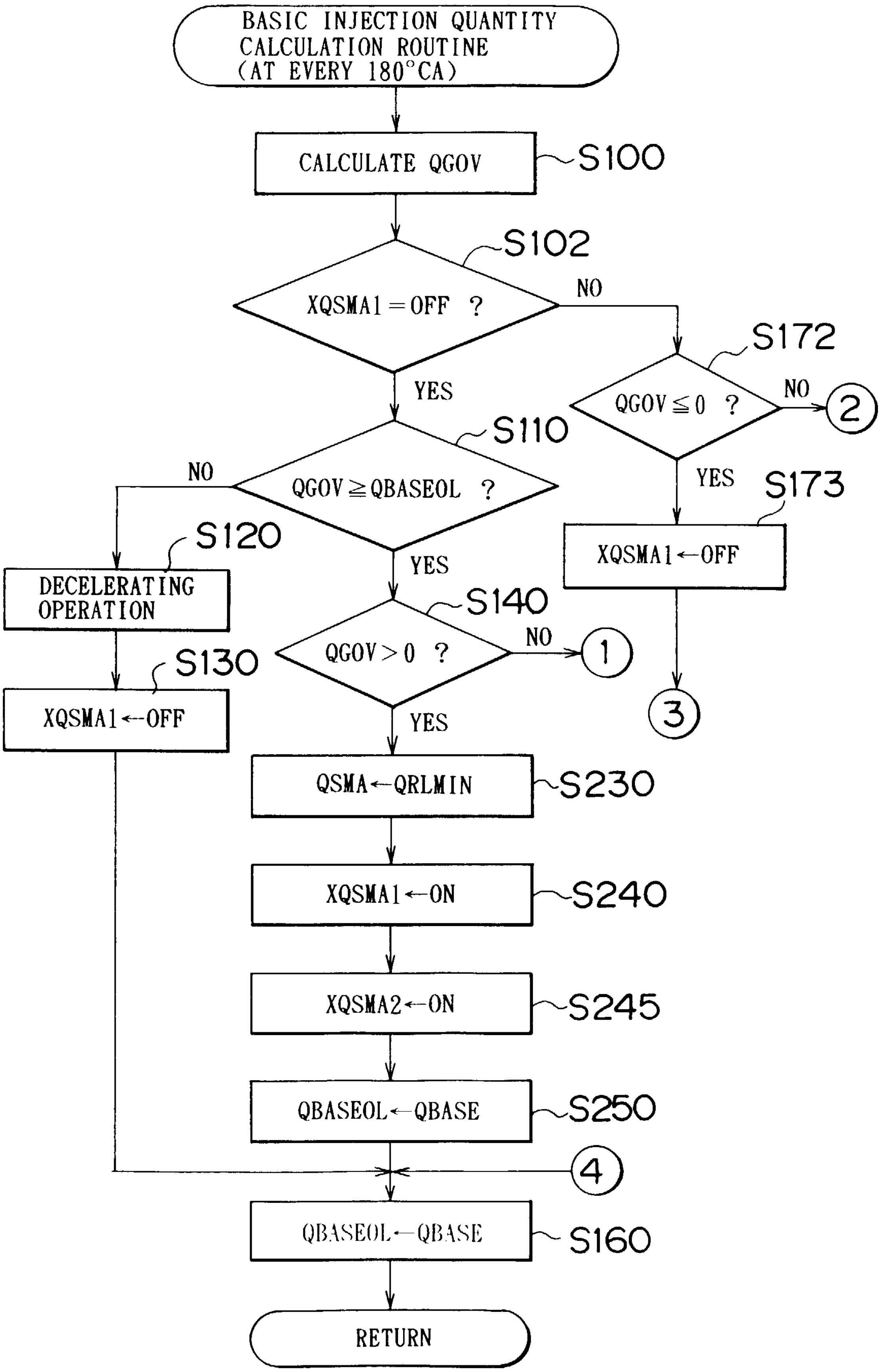

BASIC INJECTION QUANTITY CALCULATION ROUTINE (AT EVERY 180°CA)
CALCULATE QGOV
S100
S102
XQSMA1 = OFF ?
NO
YES
S172
QGOV ≦ 0 ?
NO
2
YES
S173
XQSMA1 ← OFF
3
S110
QGOV ≧ QBASEOL ?
NO
YES
S120
DECELERATING OPERATION
S130
XQSMA1 ← OFF
S140
QGOV > 0 ?
NO
1
YES
QSMA ← QRLMIN
S230
XQSMA1 ← ON
S240
XQSMA2 ← ON
S245
QBASEOL ← QBASE
S250
4
QBASEOL ← QBASE
S160
RETURN

FIG. 4

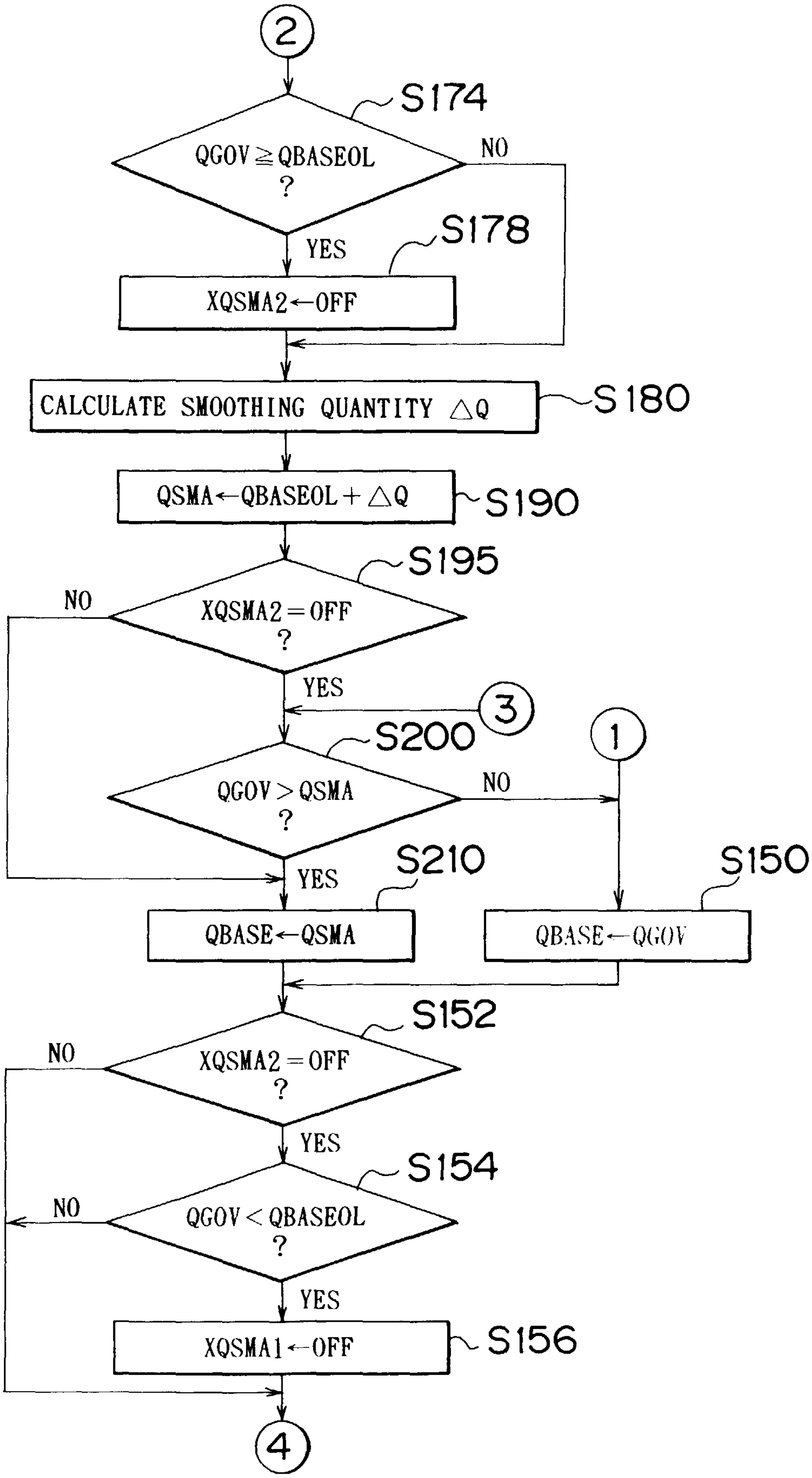

2
S174
QGOV ≧ QBASEOL ?
NO
YES
S178
XQSMA2←OFF
CALCULATE SMOOTHING QUANTITY △Q
S180
QSMA←QBASEOL + △Q
S190
S195
NO
XQSMA2 = OFF ?
YES
3
S200
1
QGOV > QSMA ?
NO
YES
S210
S150
QBASE←QSMA
QBASE←QGOV
S152
NO
XQSMA2 = OFF ?
YES
S154
NO
QGOV < QBASEOL ?
YES
XQSMA1←OFF
S156
4

FIG. 5A

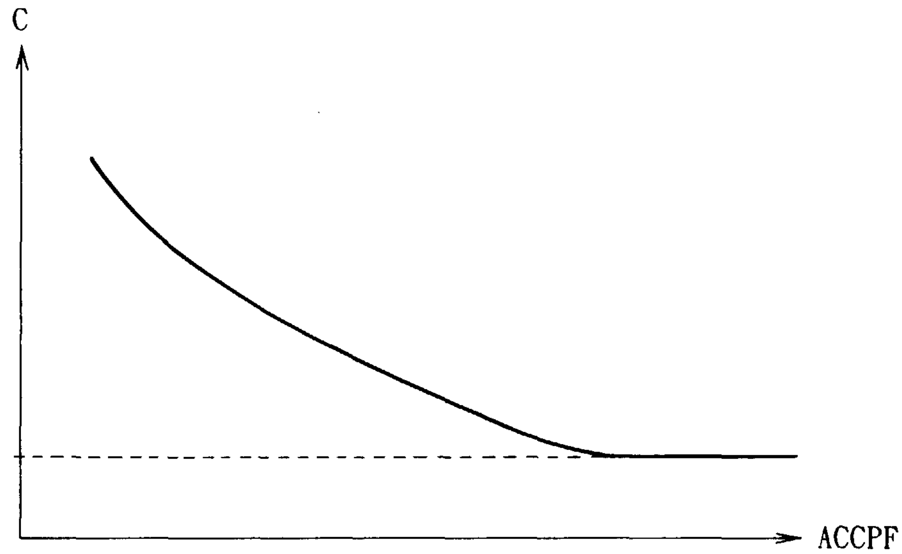


FIG. 5B

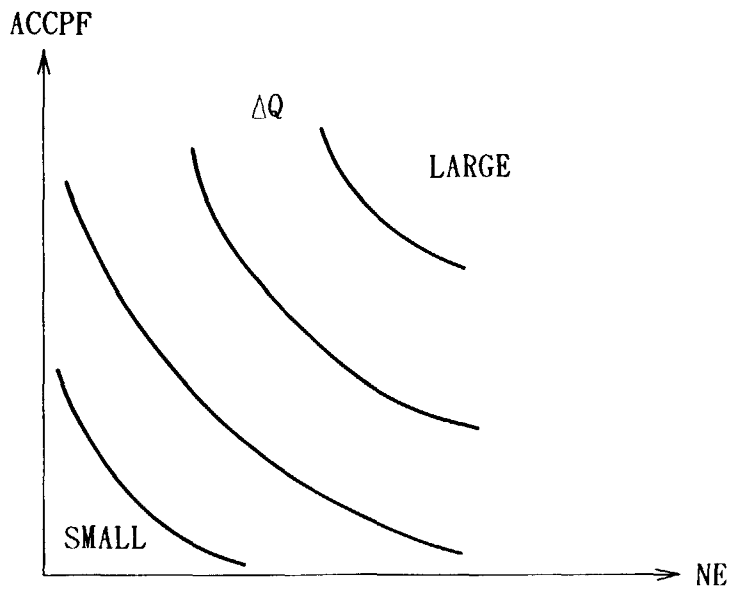


FIG. 6

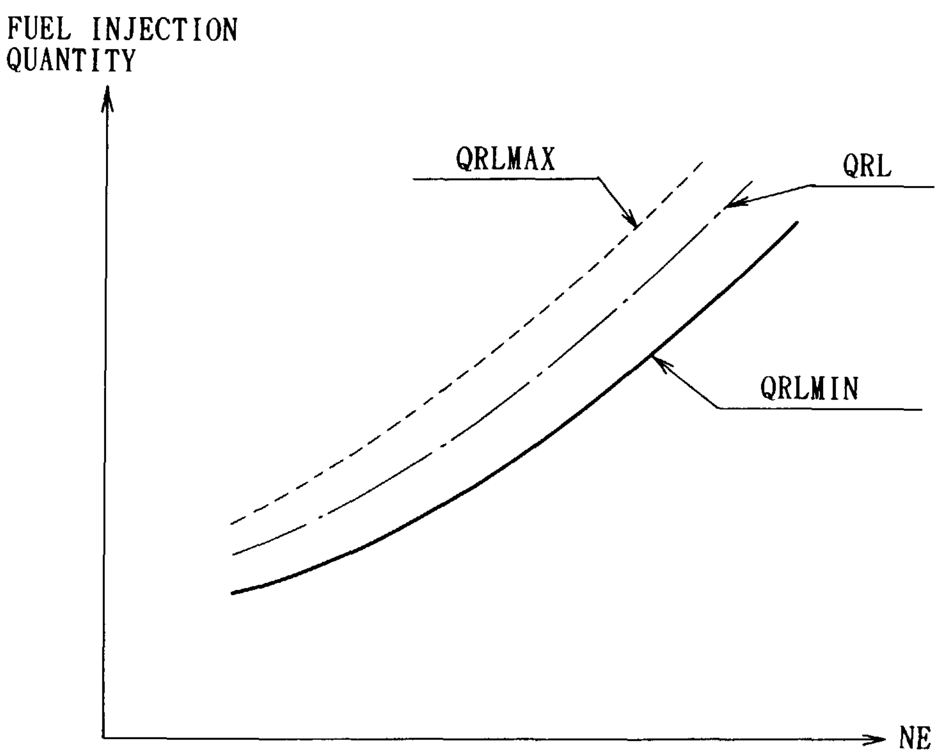


FIG. 7

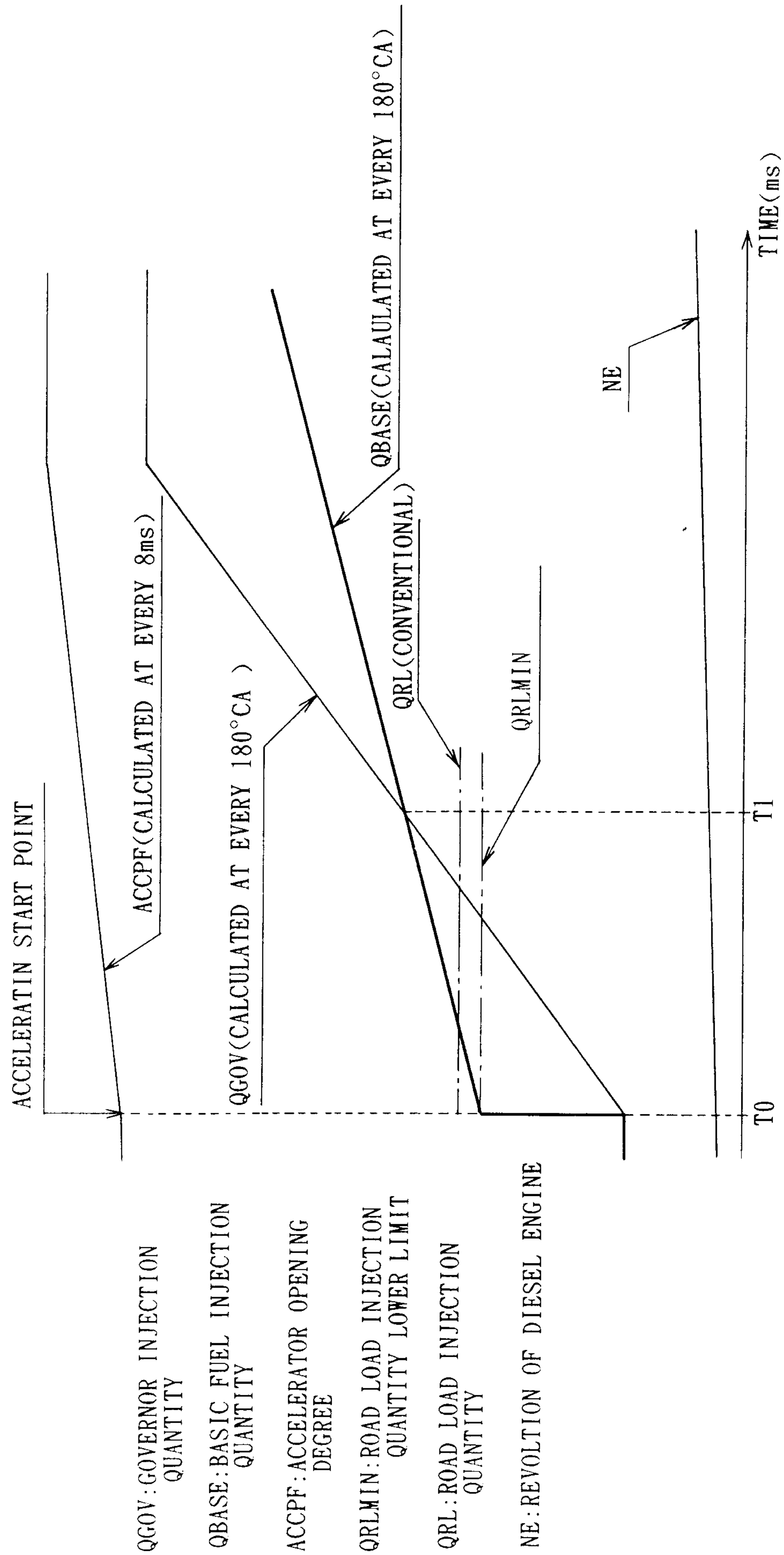

ACCELERATIN START POINT
ACCPF(CALCULATED AT EVERY 8ms)
QGOV(CALCULATED AT EVERY 180°CA)
QRL(CONVENTIONAL)
QRLMIN
QBASE(CALAULATED AT EVERY 180°CA)
NE
T0
T1
TIME(ms)
QGOV:GOVERNOR INJECTION QUANTITY
QBASE:BASIC FUEL INJECTION QUANTITY
ACCPF:ACCELERATOR OPENING DEGREE
QRLMIN:ROAD LOAD INJECTION QUANTITY LOWER LIMIT
QRL:ROAD LOAD INJECTION QUANTITY
NE:REVOLTION OF DIESEL ENGINE

FIG. 8

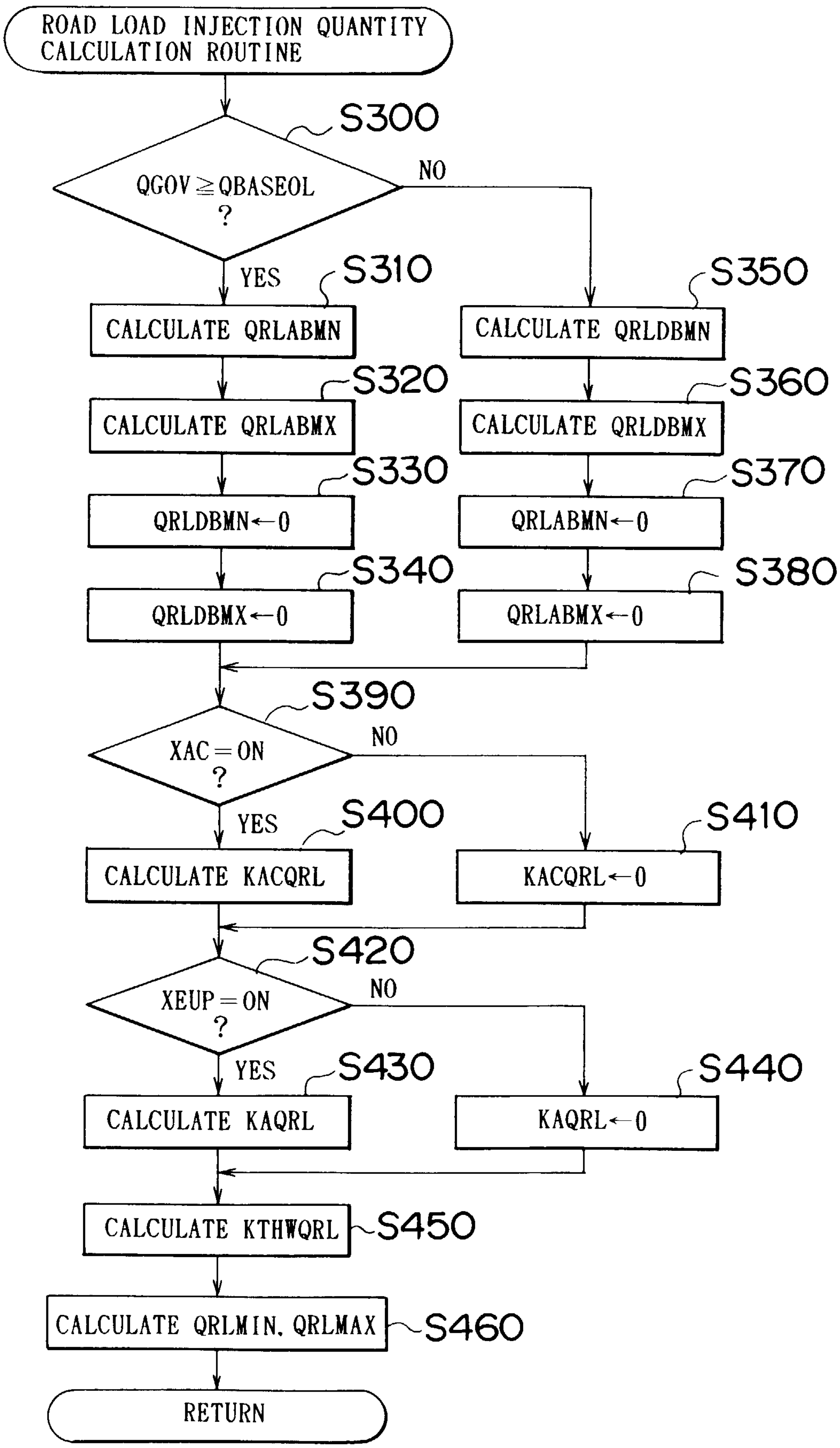

ROAD LOAD INJECTION QUANTITY CALCULATION ROUTINE
S300
QGOV ≧ QBASEOL ?
NO
YES
S310
CALCULATE QRLABMN
S320
CALCULATE QRLABMX
S330
QRLDBMN←0
S340
QRLDBMX←0
S350
CALCULATE QRLDBMN
S360
CALCULATE QRLDBMX
S370
QRLABMN←0
S380
QRLABMX←0
S390
XAC = ON ?
NO
YES
S400
CALCULATE KACQRL
S410
KACQRL←0
S420
XEUP = ON ?
NO
YES
S430
CALCULATE KAQRL
S440
KAQRL←0
S450
CALCULATE KTHWQRL
S460
CALCULATE QRLMIN, QRLMAX
RETURN

FIG. 9

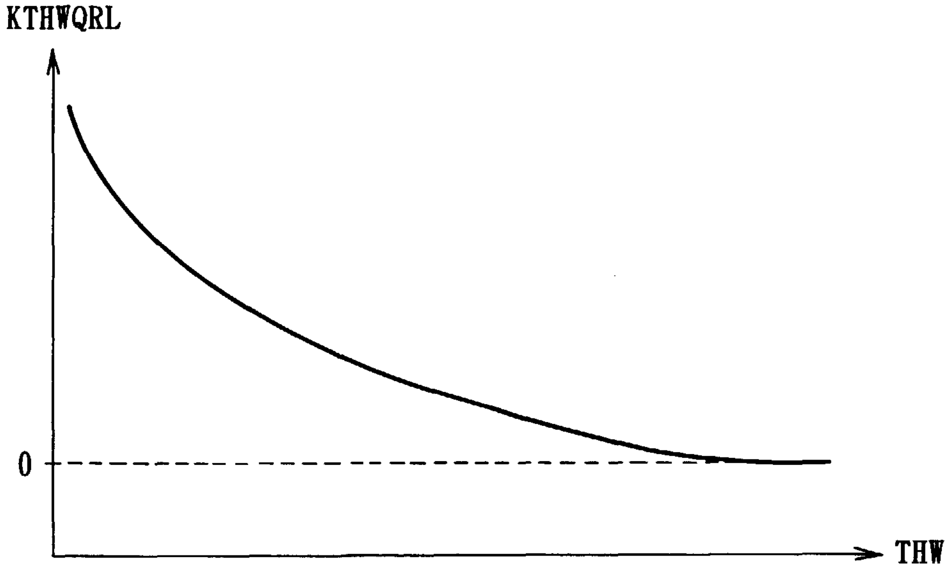


FIG.10

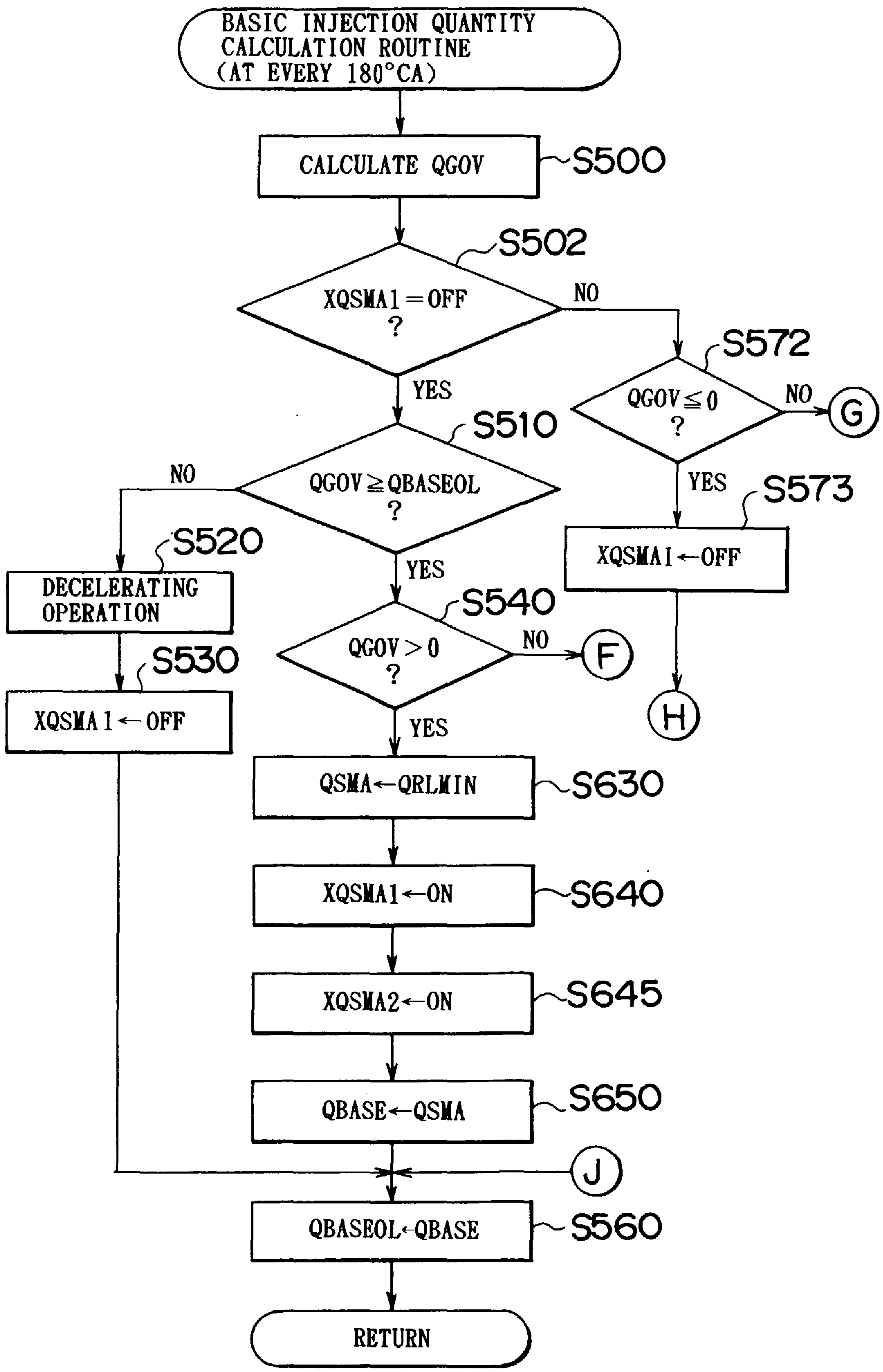

BASIC INJECTION QUANTITY CALCULATION ROUTINE (AT EVERY 180°CA)
CALCULATE QGOV
S500
S502
XQSMA1 = OFF ?
NO
YES
S572
QGOV ≦ 0 ?
NO
G
YES
S573
XQSMA1 ← OFF
H
S510
QGOV ≧ QBASEOL ?
NO
YES
S520
DECELERATING OPERATION
S530
XQSMA 1 ← OFF
S540
QGOV > 0 ?
NO
F
YES
QSMA ← QRLMIN
S630
XQSMA1 ← ON
S640
XQSMA2 ← ON
S645
QBASE ← QSMA
S650
J
QBASEOL ← QBASE
S560
RETURN

FIG. 11

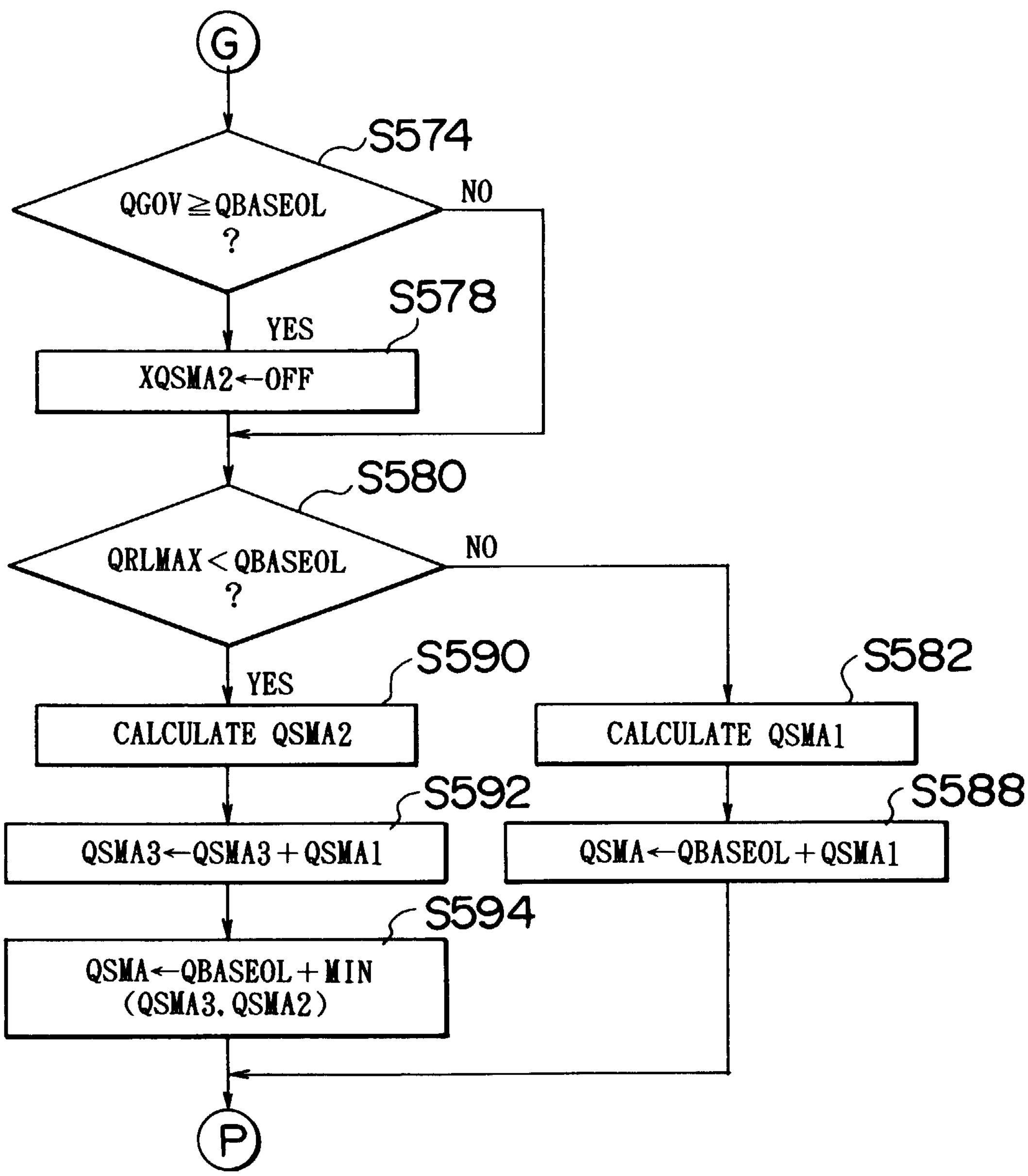

G
S574
QGOV ≧ QBASEOL ?
NO
YES
S578
XQSMA2←OFF
S580
QRLMAX < QBASEOL ?
NO
YES
S590
CALCULATE QSMA2
S582
CALCULATE QSMA1
S592
QSMA3←QSMA3 + QSMA1
S588
QSMA←QBASEOL + QSMA1
S594
QSMA←QBASEOL + MIN (QSMA3, QSMA2)
P

FIG. 12

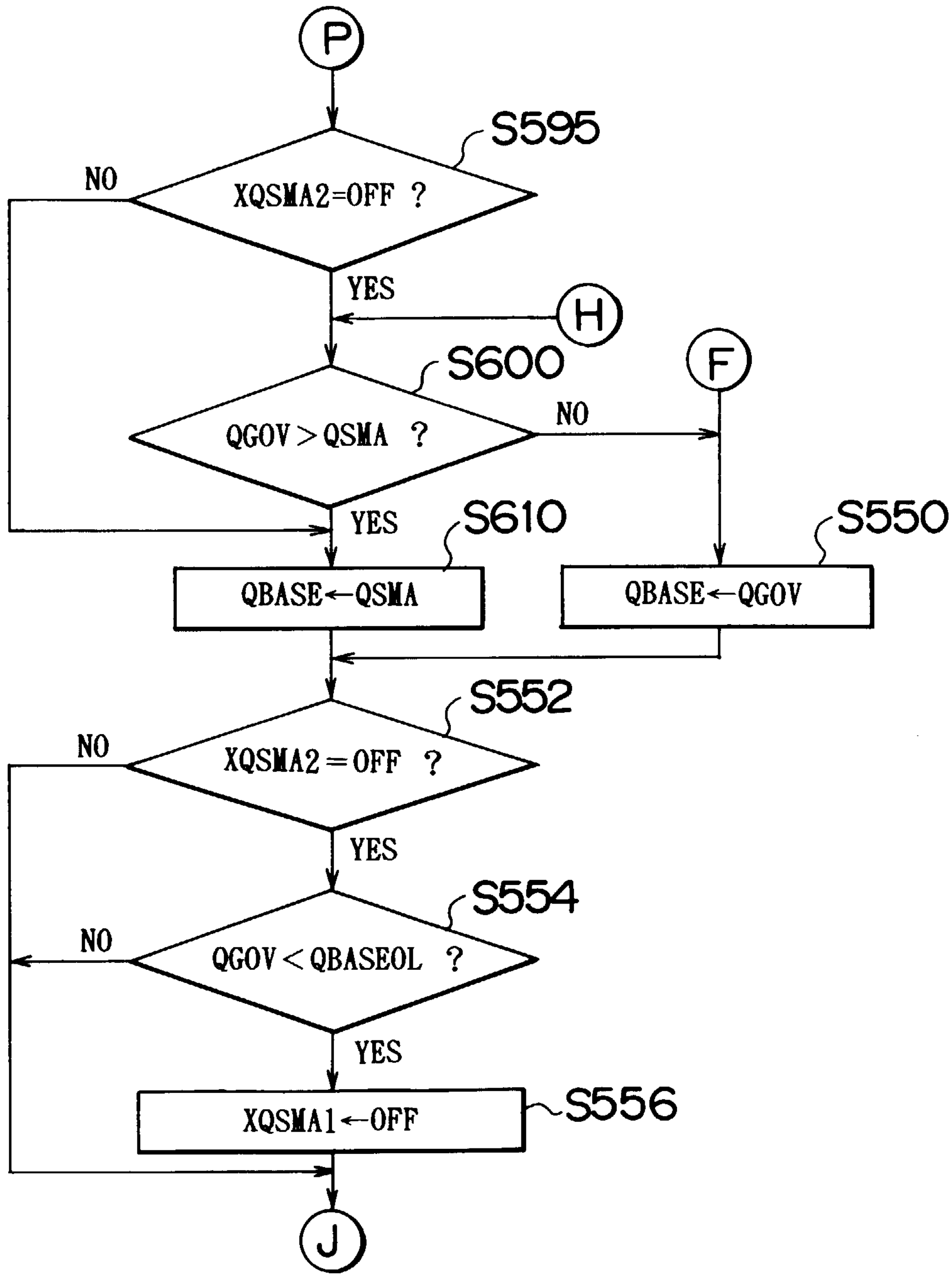

P
S595
NO
XQSMA2=OFF ?
YES
H
S600
F
QGOV > QSMA ?
NO
YES
S610
S550
QBASE←QSMA
QBASE←QGOV
S552
NO
XQSMA2 = OFF ?
YES
S554
NO
QGOV < QBASEOL ?
YES
XQSMA1←OFF
S556
J

FIG. 13A

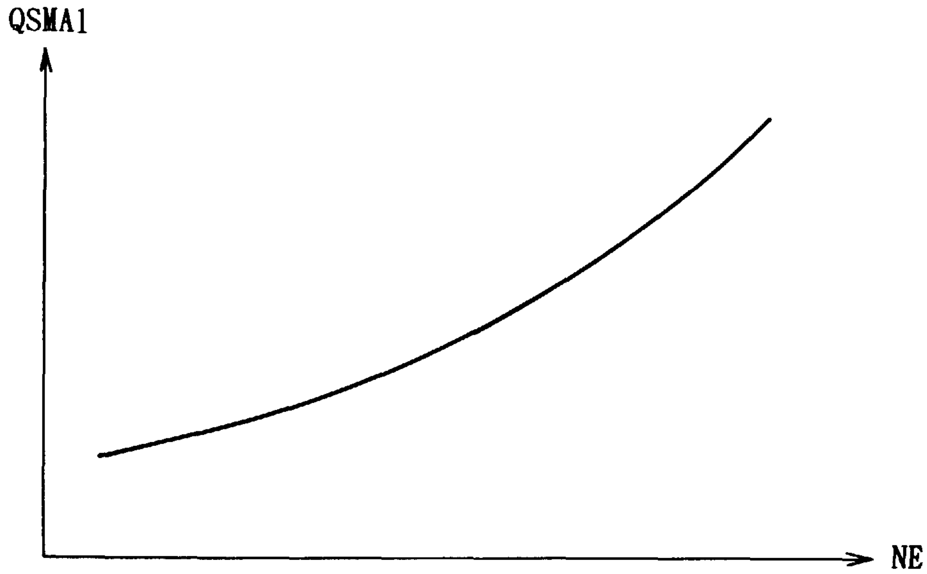


FIG. 13B

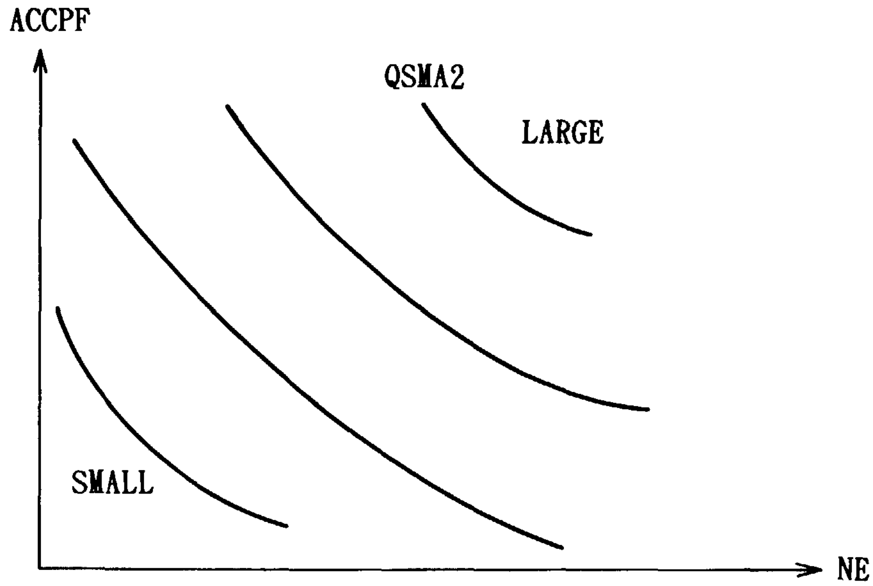


FIG. 14

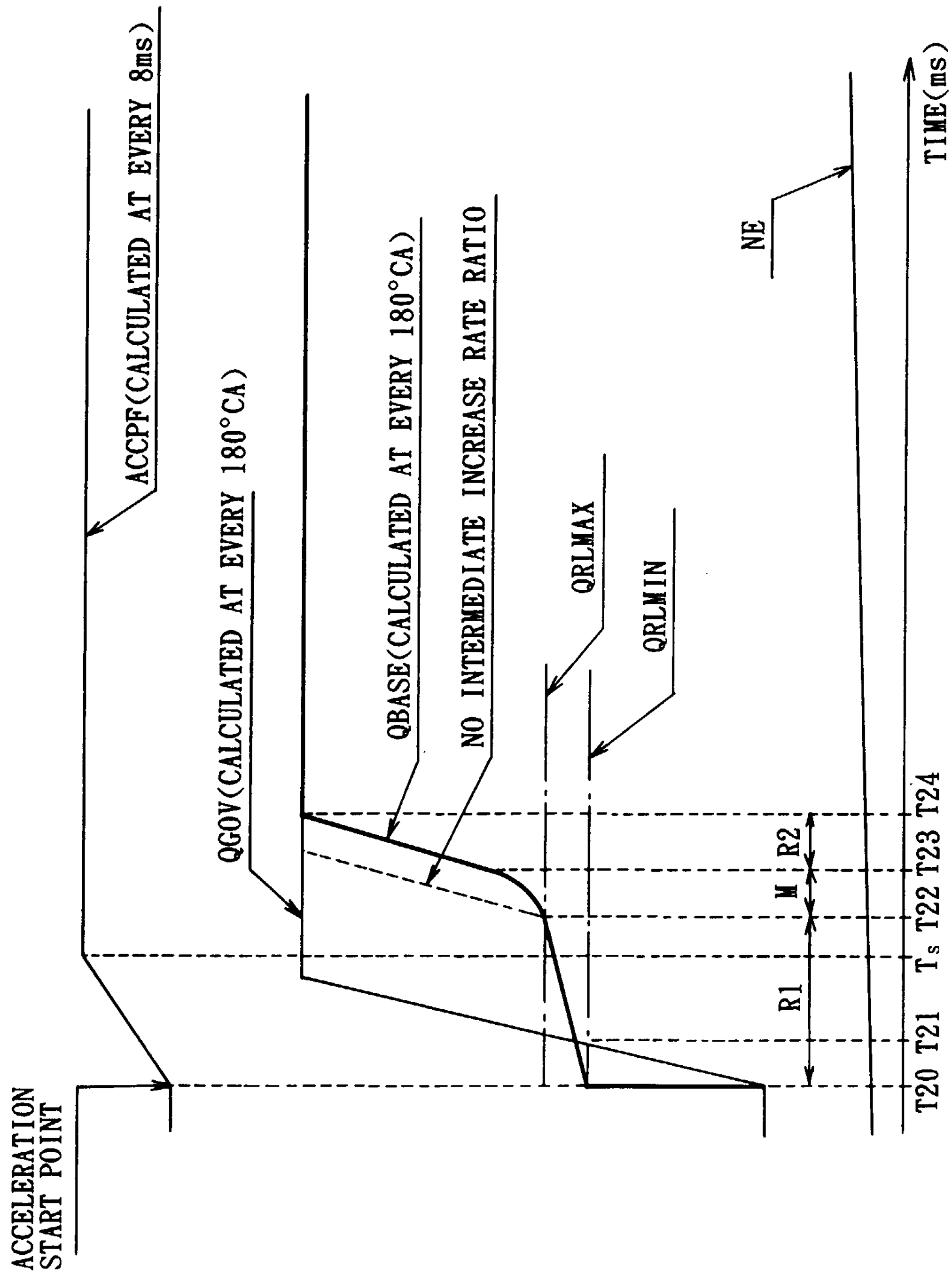

ACCELERATION START POINT
ACCPF(CALCULATED AT EVERY 8ms)
QGOV(CALCULATED AT EVERY 180°CA)
QBASE(CALCULATED AT EVERY 180°CA)
NO INTERMEDIATE INCREASE RATE RATIO
QRLMAX
QRLMIN
NE
R1
M
R2
T20
T21
Ts
T22
T23
T24
TIME(ms)

FIG. 15

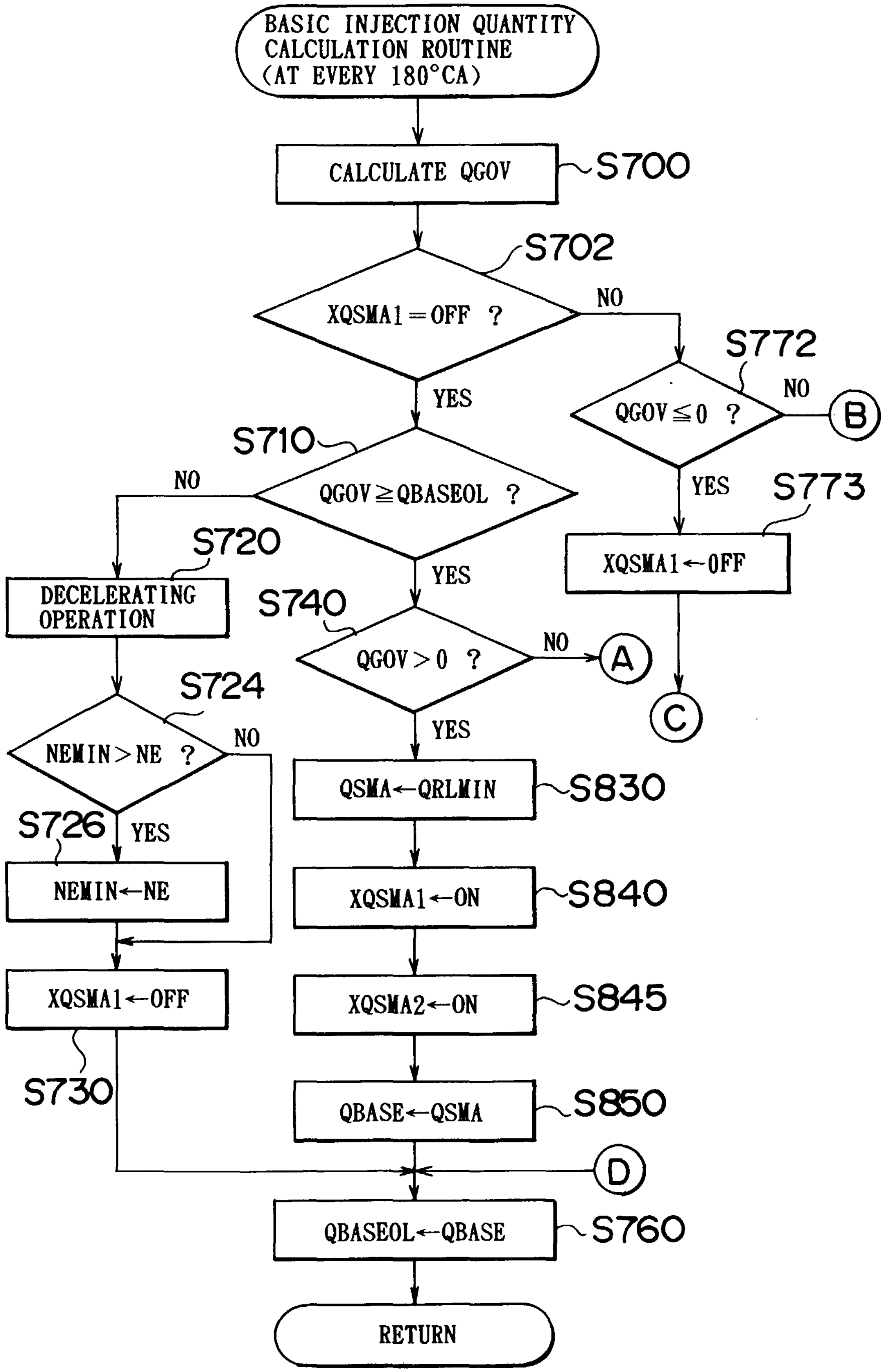

BASIC INJECTION QUANTITY CALCULATION ROUTINE (AT EVERY 180°CA)
CALCULATE QGOV
S700
S702
XQSMA1 = OFF ?
NO
YES
S772
QGOV ≦ 0 ?
NO
B
YES
S773
XQSMA1 ← OFF
C
S710
QGOV ≧ QBASEOL ?
NO
YES
S720
DECELERATING OPERATION
S740
QGOV > 0 ?
NO
A
YES
S724
NEMIN > NE ?
NO
S726
YES
NEMIN ← NE
XQSMA1 ← OFF
S730
QSMA ← QRLMIN
S830
XQSMA1 ← ON
S840
XQSMA2 ← ON
S845
QBASE ← QSMA
S850
D
QBASEOL ← QBASE
S760
RETURN

FIG. 16

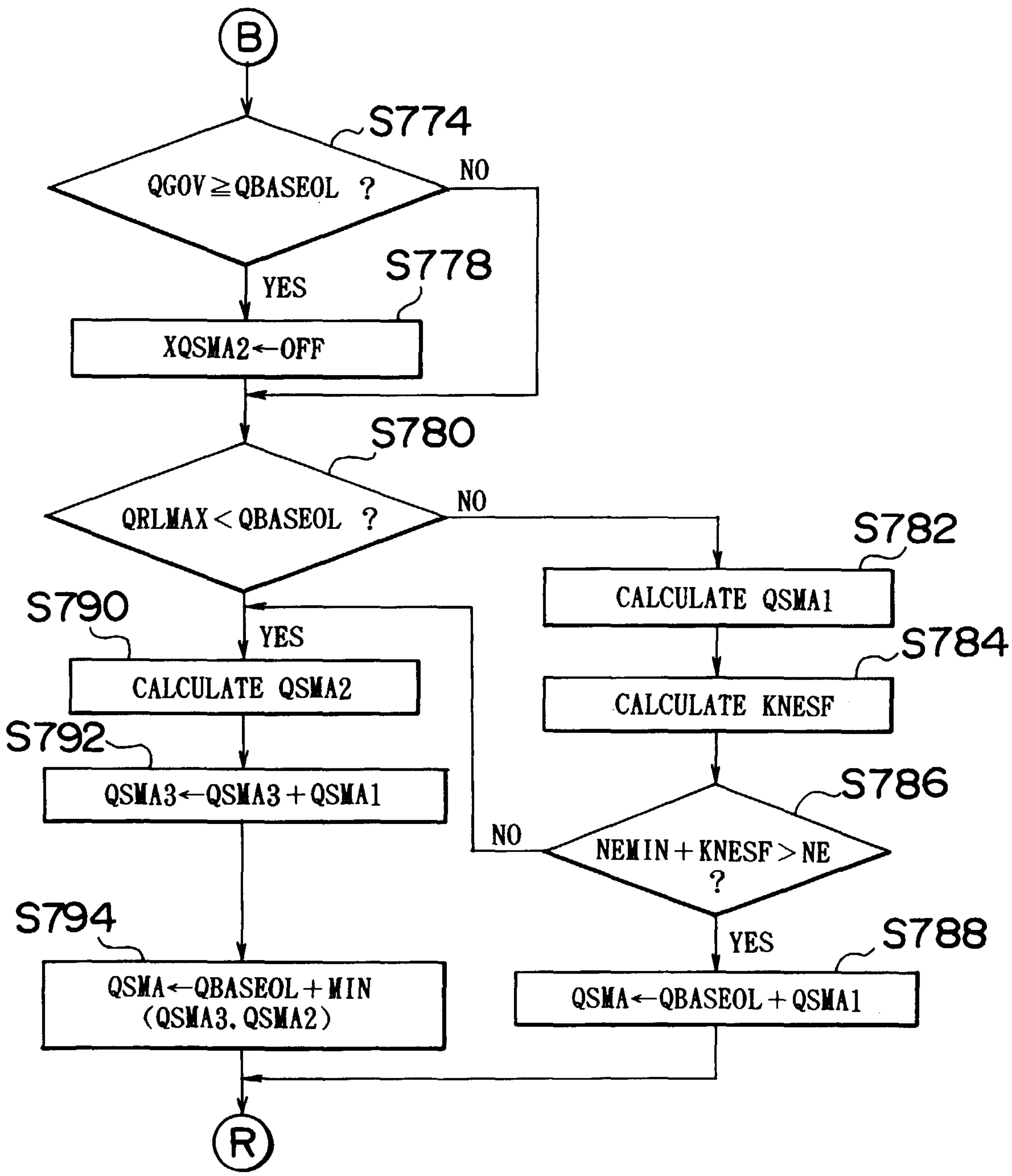

B
S774
QGOV≧QBASEOL ?
NO
YES
S778
XQSMA2←OFF
S780
QRLMAX<QBASEOL ?
NO
S782
CALCULATE QSMA1
S784
CALCULATE KNESF
S786
NEMIN+KNESF>NE ?
NO
YES
S788
QSMA←QBASEOL+QSMA1
S790
YES
CALCULATE QSMA2
S792
QSMA3←QSMA3+QSMA1
S794
QSMA←QBASEOL+MIN (QSMA3, QSMA2)
R

FIG.17

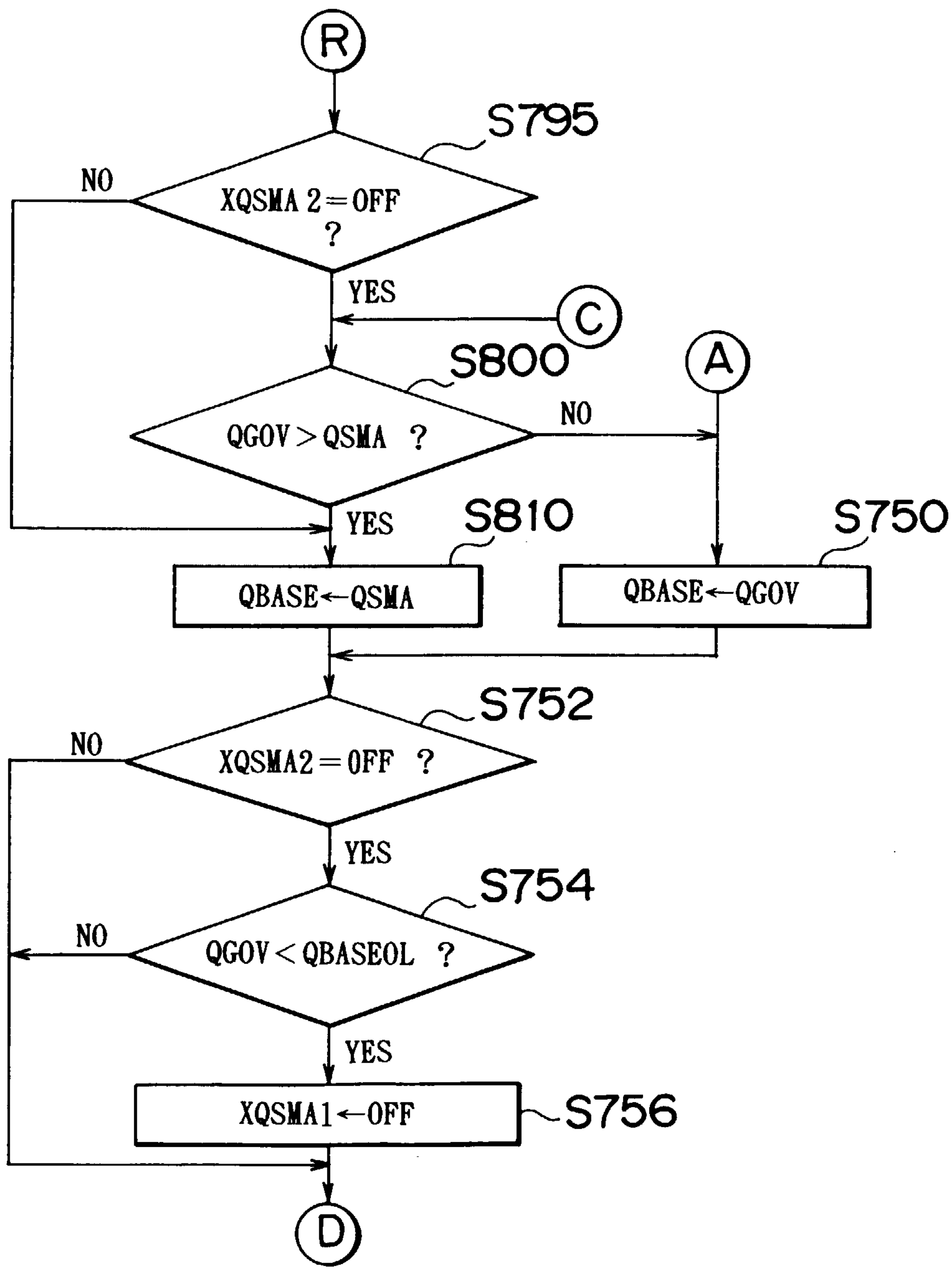
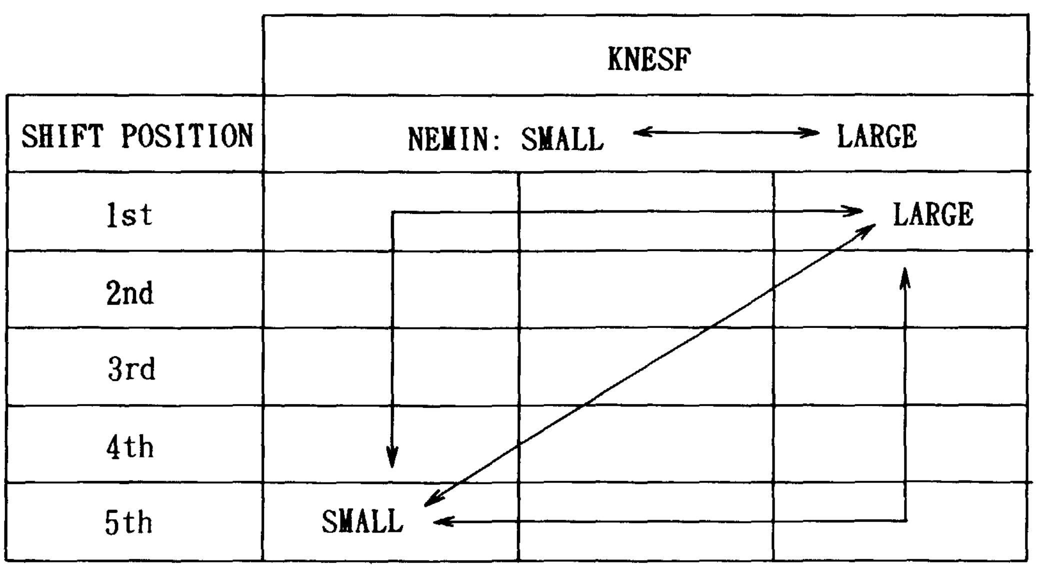

R
S795
NO
XQSMA 2 = OFF ?
YES
C
S800
A
NO
QGOV > QSMA ?
YES
S810
S750
QBASE←QSMA
QBASE←QGOV
S752
NO
XQSMA2 = OFF ?
YES
S754
NO
QGOV < QBASEOL ?
YES
XQSMA1←OFF
S756
D

FIG.18A

SHIFT POSITION	KNESF
1st	LARGE
2nd	↑
3rd	│
4th	↓
5th	SMALL

FIG.18B



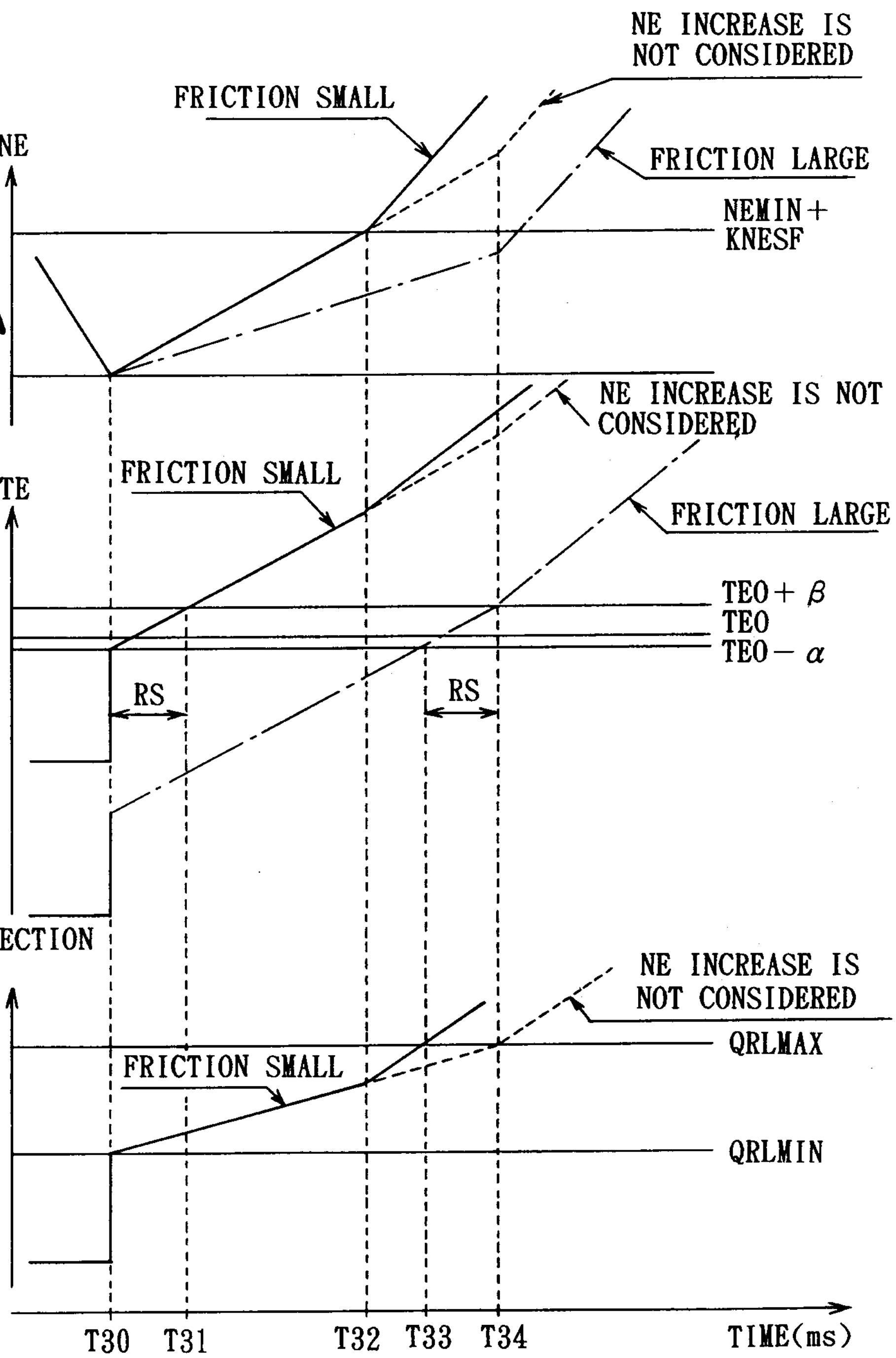


FIG.19A

FIG.19B

FIG.19C