(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 529 940 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
07.03.2007 Bulletin 2007/10

(21) Application number: **04026231.3**

(22) Date of filing: **04.11.2004**

(51) Int Cl.:
F02D 41/38 *(2006.01)* ***F02D 41/14*** *(2006.01)*
F02D 41/24 *(2006.01)* ***F02D 41/30*** *(2006.01)*
F02M 63/02 *(2006.01)* ***F02M 59/20*** *(2006.01)*
F02M 59/46 *(2006.01)*

(54) **Common rail fuel injection apparatus**

Common Rail Einspritzvorrichtung

Dispositif d'injection common rail

(84) Designated Contracting States:
DE FR GB

(30) Priority: **05.11.2003 JP 2003376085**

(43) Date of publication of application:
11.05.2005 Bulletin 2005/19

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- **PATENT ABSTRACTS OF JAPAN vol. 2000, no. 13, 5 February 2001 (2001-02-05) -& JP 2000 282929 A (DENSO CORP), 10 October 2000 (2000-10-10)**

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Description

[0001] The present invention relates to a common rail fuel injection apparatus that injects fuel into an internal combustion engine and, more particularly, includes an inlet amount control valve that controls a common rail pressure by controlling a flow amount of fuel sucked into a high pressure pump of a supply pump.

[0002] JP 2000-282929A discloses a common rail fuel injection apparatus that supplies high-pressure fuel from a supply pump to a common rail and injects the high-pressure fuel through an injector. A pressure in the common rail is controlled with an inlet control valve provided in the supply pump. The inlet control valve varies a driving current of an actuator provided in the inlet control valve.

[0003] FIG. 8 shows the relation between a driving current value (I) supplied from a control device to an inlet control valve and a discharge amount from a supply pump Q. The discharge amount from the supply pump Q will be simply referred to as a "pump discharge amount" hereinafter. In FIG. 8, as indicated with a broken line, a relationship between the pump discharge amount (Injection Amount in the Figure)and the driving current value (Driving Current in the Figure) changes due to unit differences of the supply pump and/or the inlet control valve, especially.

[0004] In the common rail fuel injection apparatus, feedback control (hereinafter abbreviated to "F/B") is provided to correct the driving current value (or the pump discharge amount prior to calculation of the driving current value) based on pressure difference between a target rail pressure and an actual rail pressure, thereby suppressing the unit differences.

[0005] In the F/B control, a proportional correction value and an integral correction value are calculated based on the pressure difference between the target rail pressure and the actual rail pressure. Additionally, the driving current value (or the pump discharge amount prior to calculation of the driving current value) is corrected based on the proportional correction value and the integral correction value.

[0006] On the other hand, in the common rail fuel injection apparatus, a learning correction process is performed on the supply pump. The learning correction process stores the integral correction value as a learned value and corrects the driving current value (or the pump discharge amount prior to calculation of the driving current value) by using the stored learned value when a learning condition is satisfied. A learning condition may be satisfied, for example, when the integral correction value has been constant for a predetermined period or longer in a stable engine status such as an idle.

[0007] However, immediately after the production of a vehicle or when a storage means in the control device has been exchanged or reset by maintenance, the variation in the supply pump cannot be corrected.

[0008] Therefore, when a learned value is not stored and the pump discharge amount to the driving current value supplied from the control device varies to the low limit side (variation low limit), the engine might stop immediately after starting.

[0009] This inconvenience will be more specifically described with reference to FIG. 9.

[0010] Note that in FIG. 9, during starting of the engine (while a starter switch is ON), the current direction control process is performed to correct the driving current value. Thereafter, during running of the engine, the discharge amount direction control process (fuel amount direction control) is performed to correct the pump discharge amount and calculate the driving current value corresponding to the pump discharge amount.

[0011] FIG. 9A shows the case of the engine starting where a learned value is not stored and the supply pump is in the status of variation low limit side. The figure shows a time series variation of the starter switch (starter SW) ON-OFF, the rail pressure (Target Pressure is indicated with an alternate long and short dash line and the Actual Pressure with a solid line), the number of engine revolutions, the integral correction value in the current direction control (Current F/B), the integral correction value in the discharge amount direction control (Fuel Amount F/B), and the driving current value for the inlet amount control valve (Inlet Amount).

[0012] When the starter switch is turned ON, as the pump discharge amount is on the variation low limit side, the pressure difference between the target rail pressure and the actual rail pressure is large on the low limit side (discharge amount shortage side). Accordingly, a proportional correction term (not shown) and an integral correction term vary to the side to increase the pump discharge amount (see j1), and the actual rail pressure is increased to the target rail pressure.

[0013] When the actual rail pressure has been increased and the starting of the engine has been completed (starter switch OFF), the current direction control process is changed to the discharge amount direction control process. This temporarily resets the integral correction value to zero. As a result, the driving current value for the inlet amount control valve is temporarily returned to the driving current value without correction (see j2).

[0014] When the engine is started, the discharge amount direction control process is started, thereby restarting calculation of the integral correction value and an increment in the integral correction value starts from zero (see j3).

[0015] In this manner, even when the pump discharge amount is on the variation low limit side and the starter switch is turned OFF, the current direction control process is changed to the discharge amount direction control process to temporarily return the integral correction value to zero. Accordingly, immediately after the turning OFF of the starter switch, the pump discharge amount might become short and the actual rail pressure might be reduced, thereby the engine might stop.

[0016] EP-1 146 218 A discloses a generic common rail fuel injection apparatus and method. This prior art apparatus comprises (a) a common rail to accumulate high-pressure fuel; (b) an injector to inject the high-pressure fuel accumulated in the common rail; (c) a supply pump including a compression chamber to suck and pressurize fuel and a high-pressure pump to supply the pressurized fuel to the common rail; (d) an inlet amount control valve including a valve to control a flow amount sucked into the compression chamber and an actuator to drive the valve, to control opening of the valve in accordance with a driving current value supplied to the actuator; (e1) feedback control means for obtaining a proportional correction value and an integral correction value based on a pressure difference between target rail pressure corresponding to a running status of an internal combustion engine and an actual rail pressure which is an actual pressure of the common rail, and obtaining a driving current value or a pump discharge amount of the supply pump by using the proportional correction value and the integral correction value; (e2) correction means for obtaining a correction value to correct variation of the pump discharge amount to the driving current value; (e3) storage means for storing the correction value obtained by the correction means as the learned value when a condition for storage of a learned value has been satisfied; and (e4) a control device including learning correction means for correcting the driving current value or the pump discharge amount based on the learned value stored in the storage means.

[0017] It is the object of the present invention, to provide a common rail fuel injection apparatus and method in which the inconvenience of engine stoppage after starting of the engine does not occur when a learned value to correct variation of pump discharge amount is not stored in a storage means of a control device immediately after the production of a vehicle or due to maintenance and even when the pump discharge amount is on the variation low limit side.

[0018] This object is solved by the apparatus having the features of claim 1 and by the method having the features of claim 6. The invention is further developed as it is defined in the dependent claims.

[0019] Other features and advantages of the present invention will be appreciated, as well as methods of operation and the function of the related parts from a study of the following detailed description, appended claims, and drawings, all of which form a part of this application. In the drawings:

FIG. 1(a) provides graphs illustrating a time series variation of various components of a first embodiment of the present invention;

FIG. 1(b) is a graph illustrating a relationship between a suction amount in an inlet amount control valve and a driving current value of the first embodiment of the present invention;

FIG. 2 is a flowchart of a determination control process of the first embodiment of the present invention;

FIG. 3 is a flowchart of a control process of the first embodiment of the present invention wherein a learned value is not stored in a storage means;

FIG. 4 is a flowchart of a current direction control process and a discharge amount direction control process of the first embodiment of the present invention wherein the learned value is stored in the storage means;

FIG. 5 is a schematic diagram of a common rail fuel injection apparatus according to the first embodiment of the present invention;

FIG. 6 is a cross-sectional view of a supply pump of the common rail fuel injection apparatus of FIG. 5;

FIG. 7 provides graphs of operational characteristics of a conventional common rail fuel injection apparatus, the first embodiment of the present invention, and a second embodiment of the present invention;

FIG. 8 is a graph showing a relationship between a driving current value and a pump discharge amount according to a conventional common rail fuel injection apparatus;

FIG. 9(a) provides graphs illustrating a time series variation of various components of a conventional common rail fuel injection apparatus; and

FIG. 9(b) is a graph illustrating a relationship between a suction amount in an inlet amount control valve and a driving current value of a conventional common rail fuel injection apparatus.

[0020] A common rail fuel injection apparatus in accordance with the principles of the present invention includes a common rail, an injector, a supply pump, an inlet amount control valve, and a control device.

[0021] The control device has an F/B control means, a correction means, storage means, and a learning correction means. The F/B control means calculates a proportional correction value and an integral correction value. The integral correction value is based on a pressure difference between a target rail pressure and an actual rail pressure. The target rail pressure corresponds to a running status of an engine. The actual rail pressure is an actual common rail pressure. The F/B control means further calculates a driving current value (or pump discharge amount from the supply pump) based on the proportional and integral correction values.

[0022] The correction means obtains a correction value to correct a variation in the pump discharge amount relative to the driving current value. The storage means stores the correction value as a learned value when a condition for storage of learned value has been satisfied. The learning correction means corrects the driving current value (or pump discharge amount) based on the learned value stored in the storage means.

[0023] Furthermore, the control device has a learned value presence/absence determination means and an integral correction value holding means. The learned value presence/absence determination means determines whether or not the learned value is stored in the storage means upon starting the engine. The integral correction value holding means holds the integral correction value calculated by the F/B control means when it is determined that the learned value is not stored in the storage means upon starting the engine without resetting the value, before the storage means stores the learned value after starting the engine.

[0024] A first embodiment of the present invention will be described with reference to Figs. 1 to 6.

[0025] First, the construction of a common rail fuel injection apparatus will be described with reference to Figs. 5 and 6.

[0026] The common rail fuel injection apparatus for injecting fuel into an engine 1, e.g. a diesel engine, has a common rail 2, an injector 3, a supply pump 4, and an ECU 5 (Engine Control Unit, corresponding to a control device).

[0027] The common rail 2 is a pressure accumulation container to accumulate high-pressure fuel supplied to the injector 3. The common rail 2 is connected to a discharge orifice of the supply pump 4 to discharge the high-pressure fuel via a fuel piping (high-pressure fuel channel) 6 such that common rail pressure corresponding to a fuel injection pressure is continuously accumulated.

[0028] Note that fuel leaked from the injector 3 is returned to a fuel tank 8 via a leak piping (fuel circulation channel) 7.

[0029] Furthermore, a pressure limiter 11 is attached to a relief piping (fuel circulation channel) 9 from the common rail 2 to the fuel tank 8. The pressure limiter 11 is a pressure valve that opens when the fuel pressure in the common rail 2 exceeds a preset pressure to suppress the fuel pressure in the common rail 2 to be equal to or lower than the preset pressure.

[0030] An injector 3 is provided in each cylinder of the engine 1 to inject fuel thereto. Each injector 3 is connected to a downstream end of one of a plurality of branch pipes from the common rail 2. The injector 3 is provided with a fuel injection nozzle and an electromagnetic valve. The fuel injection nozzle operates to inject high-pressure fuel accumulated in the common rail 2 to each cylinder. The electromagnetic valve operates to perform a lift control operation on the needle included in the fuel injection nozzle.

[0031] The supply pump 4 will now be described with reference to FIG. 6.

[0032] The supply pump 4 feeds high-pressure compressed fuel to the common rail 2 and includes a feed pump 12 (shown in a 90° rotated status in the figure), a regulator valve 13, an inlet amount control valve 14, and two high-pressure pumps 15.

[0033] The feed pump 12 is a low-pressure supply pump for sucking fuel from the fuel tank 8 and feeding the fuel to the high-pressure pumps 15. The feed pump 12 is constructed of a trochoid pump that is driven with a camshaft 16. When the feed pump 12 is driven, it supplies fuel sucked from a fuel inlet 17 to the two high-pressure pumps 15 via the inlet amount control valve 14.

[0034] Note that the camshaft 16 is a pump driving shaft. As shown in FIG. 5, the camshaft 16 is driven with a crankshaft 18 of the engine 1.

[0035] The regulator valve 13 is provided in a fuel channel 19 connecting the discharge side and the supply side of the feed pump 12. The regulator valve 13 opens when a discharge pressure of the feed pump 12 rises to a predetermined pressure to prevent the discharge pressure from exceeding the predetermined pressure.

[0036] The inlet amount control valve 14 is provided in a fuel passage 21 to introduce fuel from the feed pump 12 to the high-pressure pumps 15. The inlet control valve 14 controls the inlet amount of fuel supplied to a compression chamber 22 (plunger chamber) of the high pressure pump 15 to change and control the common rail pressure.

[0037] The inlet amount control valve 14 has a valve 23 and a linear solenoid 24. The valve 23 is operable to change an opening of the fuel passage 21 and introduce fuel from the feed pump 12 to the high-pressure pumps 15. The a linear solenoid 24 (corresponding to an actuator) is operable to control an opening of the valve 23 with a driving current supplied from the ECU 5. In the first embodiment, the inlet amount control valve 14 is a normally closed-type valve in which the valve opening is completely closed in the absence of energization to the solenoid 24.

[0038] The two high-pressure pumps 15 are plunger pumps to repeat suction and compressing of fuel at respective periods having 180° different phases. The high-pressure pumps 15 compress fuel supplied from the inlet amount control valve 14 to a high-pressure and thereafter, supply the fuel to the common rail 2. The high-pressure pumps 15 each have a plunger 25, an inlet valve, and a discharge valve 27. The plunger 25 is reciprocated with the common camshaft 16. The inlet valve 26 is operable to supply fuel to the compression chamber 22 and has a varying capacity in accordance with the reciprocation of the plunger 25. The discharge valve 27 discharges the fuel compressed in the compression chamber 22 to the common rail 2.

[0039] The plunger 25 is pressed with a spring 30 against a cam ring 29 attached around an eccentric cam 28 of the camshaft 16. When the camshaft 16 is rotated, the plunger 25 reciprocates in accordance with the eccentric motion of the cam ring 29.

[0040] When the plunger 25 moves downward and the pressure in the compression chamber 22 is reduced, the discharge valve 27 is closed and the inlet valve 26 is opened, thereby supplying an amount of fuel controlled with the inlet amount control valve 14 to the compression chamber 22.

[0041] On the other hand, when the plunger 25 moves upward and the pressure in the compression chamber 22 is increased, the inlet valve 26 is closed. Then, when the pressure in the compression chamber 22 becomes equal to the predetermined pressure, the discharge valve 27 is opened, thereby discharging the high-pressure fuel pressurized in the compression chamber 22 to the common rail 2.

[0042] The ECU 5 has functions of a CPU to perform control processing and calculation processing, storage means (a memory such as a ROM, a stand-by RAM, an EEPROM or a RAM) for storing various programs and data, an input circuit, an output circuit, a power circuit, an injector driving circuit, and a pump driving circuit. The ECU 5 performs various processes based on signals from sensors and the like read into the ECU 5. For example, the ECU 5 may read engine parameters such as a driver's driving state and a running status of the engine 1.

[0043] Note that as shown in FIG. 5, the sensors connected to the ECU 5 include an accelerator sensor 41 to detect accelerator opening, a revolution sensor 42 to detect the number of engine revolutions, a water temperature sensor 43 to detect the temperature of cooling water for the engine 1, an intake air temperature sensor 44 to detect intake air temperature sucked in the engine 1, a rail pressure sensor 45 to detect actual rail pressure, a fuel temperature sensor 46 to detect the temperature of fuel supplied to the injector 3, and other sensors 47.

[0044] Controlling the inlet amount control valve 14 by the ECU 5 will now be described.

[0045] The opening of the inlet amount control valve 14 is controlled with a driving current value supplied from the ECU 5.

[0046] The ECU 5 has a driving current value calculation means for calculating a driving current value to be supplied to the solenoid 24.

[0047] While starting the engine 1, the driving current value calculation means performs a current direction control process to calculate a driving current value and bring the actual rail pressure into correspondence with a target rail pressure appropriate to the starting. Furthermore, while the engine 1 runs subsequent to starting, the driving current value calculation means performs a discharge amount direction control process to calculate a pump discharge amount and bring the actual rail pressure into correspondence with a target rail pressure corresponding to a running status of the engine 1. Further yet, the driving current value calculation means calculates a driving current value corresponding to the pump discharge amount.

[0048] The driving current value calculation means has a feed-forward control means (hereinafter referred to as "F/F control means"), an F/B control means (also functions as correction means in the present embodiment), a storage means, and a learning correction means.

[0049] The F/F control means calculates a basic required discharge amount by adding an injection amount of injection from the injector 3 to a leak amount of leakage from the injector 3 (static leak amount + dynamic leak amount). The F/F control means also calculates a base driving current value from the basic required discharge amount.

[0050] Note that in the case of 1-pump 2-injection, i.e., the high-pressure pumps 15 make pumping once thereby cause injection from the injector 3 to the engine 1 twice, the basic required discharge amount (or base driving current value) is doubled (x2), and in the case of 1-pump 3-injection, tripled (x3).

[0051] The F/B control means calculates the driving current value and the pump discharge amount (fuel amount) in the current direction control and in the discharge amount direction control.

[0052] In the current direction control process, a proportional correction value (current value) and an integral correction value (current value) are obtained based on a pressure difference ΔPC between the target rail pressure and the actual rail pressure. Additionally, the driving current value is based on the proportional correction value and the integral correction value.

[0053] On the other hand, in the discharge amount direction control process, a proportional correction value (pump discharge amount) and an integral correction value (pump discharge amount) are calculated based on the pressure difference ΔPC between the target rail pressure and the actual rail pressure. The pump discharge amount is then calculated by using the proportional correction value and the integral correction value. Additionally, the driving current value is obtained from the pump discharge amount.

[0054] The correction means obtains a correction value to correct a variation of the pump discharge amount to the driving current value. In the present embodiment, the integral correction value (current value) obtained by the F/B control means is used as the correction value for correction of the variation.

[0055] Note that in the present embodiment, the integral correction value (current value) obtained by the F/B control means is used as the correction value for correcting the variation. However, it may be arranged such that, when a predetermined learning condition such as idling is satisfied, a predetermined variation amount detection running process is conducted and the correction value is obtained based on a variation amount obtained in the running process. As an example of variation amount detection means different from the present embodiment, it may be arranged such that upon idling or the like, the opening of the inlet amount control valve 14 is gradually increased to ensure zero inlet amount. Additionally, a driving current value is obtained when the change amount of rail pressure is equal to or greater than a predetermined value (inlet start driving current value) and the correction value is obtained based on the inlet start driving current value.

[0056] When a condition for storage of a learned value has been satisfied (in the present embodiment, in a stabled running status such as idling, and upon running stoppage of the engine 1), the storage means stores a correction value (in the present embodiment, the integral correction value) as a learned value. In a case where the learned value storage condition is repeatedly satisfied, the learned value is updated based on a previous learned value and current correction value. That is, when a previous learned value is +5 and a current correction value is +1, the learned value is to be updated with +6. Note that as the storage means for storing the learned value, a memory (a stand-by RAM, an EEPROM or the like) in which the stored learned value is not deleted even upon stoppage of the ECU 5 is employed.

[0057] The learning correction means corrects the driving current value based on the learned value (current value) stored in the storage means. Note that in the present embodiment, the driving current value is corrected based on the learned value (current value). However, it may be arranged such that the learned value is obtained as a value corresponding to a discharge amount. The pump discharge amount is then corrected and the driving current value is calculated from the corrected pump discharge amount.

[0058] In the above construction, immediately after production of a vehicle or when the storage means of the ECU 5 has been exchanged or reset by maintenance or the like, the variation of the supply pump 4 is not corrected. Accordingly, in a case where the pump discharge amount varies to the shortage low limit side to the driving current value (variation low limit), the engine 1 might be stopped immediately after starting of the engine 1.

[0059] Accordingly, the ECU 5 of the present embodiment has a function of learned value presence/absence determination means for determining whether or not a learned value is stored in the storage means upon starting (starter ON time) of the engine 1. Furthermore, the ECU functions as an integral correction value holding means for, when it is determined that a learned value is not stored, holding the integral correction value (current value) obtained by the F/B control means without resetting the value before the storage means infallibly stores a learned value (in the present embodiment, before a learning value is stored and the engine 1 has stopped after running) even after the completion of starting of the engine 1.

[0060] More particularly, in the present embodiment, in addition to starting the engine 1, when a learned value is not stored in the storage means, the current direction control process is performed during a period from starting the engine 1 to the stoppage of running of the engine 1 where an integral correction value (current value) is stored as a learned value (referred to as a "1 trip period"). The integral correction value obtained during the starting of the engine 1 is held without any change (100%) in running.

[0061] The above-described control processes will now be described with reference to Figs. 2 to 4.

[0062] First, the determination control process undertaken by the learned value presence/absence determination means will be described with reference to FIG. 2.

[0063] When an ignition key is turned ON and it becomes timing of control of the inlet amount control valve 14 (start), it is determined whether or not a learned value is stored in the storage means of the ECU 5 (Step S1).

[0064] If the result of determination at Step S1 is YES (a learned value is not stored), the current direction control process is performed for 1 trip (Step S10: see FIG. 3).

[0065] However, when the result of determination at Step S1 is NO (a learned value is stored), normal control is performed by using the learned value (Step S20: see FIG. 4).

[0066] Next, the control process when a learned value is not stored in the storage means will be described with reference to FIG. 3.

[0067] If the result of determination at Step S1 is YES (start: a learned value is not stored upon starting the engine 1), a proportional correction value (current value) is calculated from pressure difference ΔPC between a target rail pressure (during starting, target rail pressure appropriate to the starting, or during running, target pressure calculated in correspondence with a running status) and an actual rail pressure (pressure detected by the rail pressure sensor 45)(Step S11).

[0068] Next, an integral correction value (current value) is calculated from the pressure difference ΔPC between the target rail pressure and the actual rail pressure (Step S12).

[0069] Next, a final F/B amount (current value) is calculated by adding the proportional correction value calculated at Step S11 to the integral correction value calculated at Step S12 (Step S13).

[0070] Next, a basic required discharge amount is calculated by adding an injection amount to a leak amount (static leak amount + dynamic leak amount), and a base driving current value is calculated from the basic required discharge amount (Step S14). Note that in the case of 1-pump 2-injection, the base driving current value is calculated from a doubled basic required discharge amount.

[0071] Next, a final driving current value is calculated by adding the final F/B amount (current value) calculated at Step S13 to the base driving current value calculated at Step S14 (Step S15). The driving current value is then converted to a driving duty and supplied to the inlet amount control valve 14 at timing appropriate to opening of the inlet amount control valve 14.

[0072] Next, it is determined whether or not a learning condition (e.g., when the integral correction value has been constant for a predetermined period or longer in an stabled engine status such as idling) has been satisfied (Step S16). When the result of determination at Step S16 is YES, the integral correction value (current value) is stored as a learned value in the storage means (Step S17).

[0073] After execution of Step S17 or when the result of determination at Step S16 is NO, it is determined whether or not the ignition switch has been turned OFF, i.e., whether or not the engine 1 has been stopped (Step S18).

[0074] If the result of determination at Step S18 is NO (engine is running), the process returns to Step S11 to repeat the above-described control process until the engine 1 is stopped.

[0075] If the result of determination at Step S18 is YES (engine has been stopped), the integral correction value (current value) is stored as a learned value into the storage means (Step S19). At this time, when a learned value has been stored during the running, the learned value is updated based on the integral correction value upon stoppage of the engine. Thereafter, the opening control of the inlet amount control valve 14 is terminated (end).

[0076] Next, the current direction control process (upon starting) and the discharge amount direction control process (during engine running) when a learned value is stored in the storage means will be described with reference to FIG. 4.

[0077] If the result of determination at Step S1 is NO (start: a learned value is stored upon starting of the engine 1), it is determined whether or not the starting of the engine 1 has been completed. That is, it is determined whether or not the starter switch has been turned OFF (Step S21).

[0078] If the result of determination at Step S21 is NO (during starting), the current direction control process is performed between Steps S22 to S26, while when the result of determination is YES (during running), the discharge amount direction control process is performed between Steps S27 to S31.

[0079] If the result of determination at Step S21 is NO (during starting), first, a proportional correction value (current value) is calculated from the pressure difference ΔPC between the target rail pressure (target rail pressure appropriate to starting) and the actual rail pressure (Step S22).

[0080] Next, an integral correction value (current value) is calculated from the pressure difference ΔPC (Step S23).

[0081] Next, a final F/B amount (current value) is calculated by adding the proportional correction value obtained at Step S22 to the integral correction value obtained at Step S23 (Step S24).

[0082] Next, a basic required discharge amount is calculated by adding an injection amount to a leak amount (static leak amount + dynamic leak amount), and a base driving current value is calculated from the basic required discharge amount (Step S25). Note that in the case of 1-pump 2-injection, the base driving current value is calculated from a doubled basic required discharge amount.

[0083] Next, a final driving current value is calculated by adding the final F/B amount (current value) calculated at Step S24, the base driving current value calculated at Step S25, and the learned value stored in the storage means (current value to correct the variation of the supply pump 4) (Step S26). The driving current value is converted to a driving duty and supplied to the inlet amount control valve 14 at timing appropriate to opening of the inlet amount control valve 14. The control process between the above Steps S22 to S26 is repeated until the starter switch is turned OFF.

[0084] If the result of determination at Step S21 is YES (during running), first, a proportional correction value (pump discharge amount) is calculated from the pressure difference ΔPC between the target rail pressure (target rail pressure calculated in correspondence with a running status) and the actual rail pressure (Step S27).

[0085] Next, an integral correction value (pump discharge amount) is calculated from the pressure difference ΔPC (Step S28).

[0086] Next, a final F/B amount (pump discharge amount) is calculated by adding the proportional correction value calculated at Step S27 to the integral proportional correction value (pump discharge amount) calculated at Step S28 (Step S29).

[0087] Next, a basic required discharge amount is obtained by adding an injection amount to a leak amount (static leak amount + dynamic leak amount). Then the basic required discharge amount is added to the final F/B amount (pump discharge amount) calculated at Step S29 and a base driving current value is calculated from the added value (pump discharge amount) (Step S30). Note that in the case of 1-pump 2-injection, the calculation is made with a doubled basic required discharge amount.

[0088] Next, a final driving current value is calculated by adding the base driving current value calculated at Step S30 to the learned value stored in the storage means (current value to correct the variation of the supply pump 4) (Step S31). The driving current value is then converted to a driving duty and supplied to the inlet amount control valve 14 at timing appropriate to opening of the inlet amount control valve 14. The control process during the above-described Steps S27 to S31 is repeated until the ignition switch is turned OFF.

[0089] Note that it may be arranged such that when a predetermined learning condition (e.g., a stabled status of the engine 1 such as idling) is satisfied while the engine is running, the current direction control process is temporarily performed, and at that time, when the integral correction value (current value) has been constant for a predetermined period or longer, the learned value is updated by using the integral correction value at that time (current value).

[0090] An example of the actuation when a learned value is not stored in the storage means will now be described with reference to FIG. 1.

[0091] Note that FIG. 1(a) shows a status upon starting of the engine 1 where a learned value is not stored and the supply pump 4 is in the variation low limit side status. The figure shows a time series variation of the starter switch (in the figure, starter SW) ON-OFF, the rail pressure (in the figure, the target pressure is indicated with an alternate long and short dash line, and the actual pressure, with a solid line), the number of engine revolutions, the integral correction value in the current direction control (in the figure, current F/B integral value), the integral correction value in the discharge amount direction control (in the figure, fuel amount F/B integral value), and the driving current value for the inlet amount control valve 14 (in the figure, inlet amount control valve energization current).

[0092] When the starter switch is turned ON, the pump discharge amount is on the variation low limit side, the pressure difference between the target rail pressure and the actual pressure is large to the low limit side (discharge amount shortage side). Accordingly, the proportional correction term (not shown) and the integral correction term vary to the side to increase the pump discharge amount (see a1 in the figure) and the actual rail pressure is increased to the target rail pressure.

[0093] Even when the actual rail pressure has been increased and the starting of the engine 1 has been completed (starter switch is turned OFF), the current direction control process is continued. Then the integral correction value (current value) is not reset (see a2 in the figure).

[0094] Accordingly, even when the pump discharge amount is on the variation low limit side, the integral correction value (current value) to increase the pump discharge amount during starting is held after starting the engine 1 (see a3 in the figure). As a result, the inconvenience of reduction of actual rail pressure does not occur nor does the inconvenience of the engine 1 stopping due to a shortage of actual rail pressure immediately after starting the engine 1.

[0095] As described above, in the common rail fuel injection apparatus of the present embodiment, when a learned value is not stored in the storage means of the ECU 5 immediately after production of vehicle or by maintenance or the like, the inconvenience of the engine 1 stopping does not occur immediately after starting the engine 1, even when the pump discharge amount is on the variation low limit side.

[0096] On the other hand, in the case of the conventional art, when a learned value to correct the variation is not stored and the pump discharge amount is on the variation upper limit side (excessive discharge amount side), the integral correction value is temporarily reset to zero and the actual rail pressure greatly overshoots the target rail pressure immediately after starting of the engine 1. As described herein, providing a pressure reduction valve in the common rail 2 can reduce this overshoot. However, omission of the pressure reduction valve is required for the sake of cost reduction, though the overshoot immediately after starting of the engine 1 cannot be suppressed without the pressure reduction valve. Upon the occurrence of such an overshoot, combustion noise might become worse, or in some cases, the engine 1 might stop.

[0097] Therefore, according to the first embodiment described herein, even when a learned value is not stored and the pump discharge amount is on the variation upper limit side, the integral correction value during starting (value on the side to reduce the discharge amount) is not reset immediately after starting but is held and therefore, any overshoot immediately after starting the engine can be suppressed. Thus, the inconveniences of increased combustion noise and engine stoppage due to an overshoot of the common rail pressure can be suppressed.

[0098] A second embodiment of the present invention will now be described with reference to FIG. 7. Note that FIG. 7(a) shows a variation of the integral correction value (current value: current F/B integral value in the figure) upon starting and immediately after starting the engine and the integral correction value (pump discharge amount: fuel amount F/B integral value in the figure) in the conventional art. FIG. 7(b) shows a variation of the integral correction value (current value: current F/B integral value in the figure) upon starting and immediately after starting the engine and the integral correction value (pump discharge amount: fuel amount F/B integral value in the figure) in the first embodiment described above. FIG. 7(c) shows a variation of the integral correction value (current value: current F/B integral value in the figure) upon starting and immediately after starting the engine and the integral correction value (pump discharge amount: fuel amount F/B integral value in the figure) of the second embodiment.

[0099] In the first embodiment, when starting the engine 1 has been completed (starter switch has been turned OFF), the integral correction value (current value) is held.

[0100] On the other hand, in the second embodiment, when starting the engine 1 has been completed (starter switch has been turned OFF), a predetermined ratio of the integral correction value (current value) is held.

[0101] Note that as the predetermined ratio, any ratio may be used as long as an actual rail pressure not to stop running of the engine 1 can be maintained. For example, an appropriate ratio such as 50% or 70% of the integral correction value (current value) upon completion of starting may be set in correspondence with e.g. the range of variation of the supply pump 4.

[0102] In the above embodiments, the inlet amount control valve 14 is a normally closed-type valve in which the opening becomes a full closed state in the absence of energization to the solenoid 24. However, a normally opened-type valve in which the opening becomes a full open state upon the absence of energization to the solenoid 24 may be employed as the inlet amount control valve 14. In such a case, as the opening of the inlet amount control valve 14 becomes smaller when the driving current value for the solenoid 24 is increased, increase/decrease control of the driving current value for the solenoid 24 is performed in an inversed manner to that described in the above embodiments.

Claims

1. A common rail fuel injection apparatus comprising:

    (a) a common rail (2) to accumulate high-pressure fuel;
    (b) an injector (3) to inject the high-pressure fuel accumulated in the common rail (2);
    (c) a supply pump (4) including a compression chamber (22) to suck and pressurize fuel and a high-pressure pump (15) to supply the pressu-

rized fuel to the common rail (2);
(d) an inlet amount control valve (14) including a valve (23) to control a flow amount sucked into the compression chamber (22) and an actuator (24) to drive the valve (23), to control opening of the valve (23) in accordance with a driving current value supplied to the actuator (24);
(e1) feedback control means for obtaining a proportional correction value and an integral correction value based on a pressure difference (ΔPC) between target rail pressure corresponding to a running status of an internal combustion engine (1) and an actual rail pressure which is an actual pressure of the common rail (2), and obtaining a driving current value or a pump discharge amount of the supply pump (4) by using the proportional correction value and the integral correction value;
(e2) correction means for obtaining a correction value to correct variation of the pump discharge amount to the driving current value;
(e3) storage means for storing the correction value obtained by the correction means as a learned value when a condition for storage of a learned value has been satisfied; and
(e4) a control device (5) including learning correction means for correcting the driving current value or the pump discharge amount based on the learned value stored in the storage means,

characterized in that
the correction value obtained by the correction means is at least one of a proportional correction value and an integral correction value, and
the control device (5) includes:

learned value presence/absence determination means for determining whether or not the learned value is stored in the storage means upon starting of the internal combustion engine (1); and
integral correction value holding means for holding the integral correction value obtained by the feedback control means without resetting the value before the storage means stores the learned value and after completion of starting of the internal combustion engine(1) when it is determined that the learned value is not stored in the storage means upon starting of the internal combustion engine.

2. The common rail fuel injection apparatus according to claim 1,
wherein the feedback control means also functions as the correction means, and
wherein the integral correction value obtained by the feedback control means is stored as the learned value in the storage means when the condition for storage of a learned value has been satisfied.

3. The common rail fuel injection apparatus according to claim 1 or 2,
wherein when the starting of the internal combustion engine (1) has been completed, the integral correction value holding means holds the integral correction value upon completion of starting of the internal combustion engine (1).

4. The common rail fuel injection apparatus according to claim 1 or 2,
wherein when the starting of the internal combustion engine (1) has been completed, the integral correction value holding means holds a predetermined ratio of the integral correction value upon completion of starting of the internal combustion engine (1).

5. The common rail fuel injection apparatus according to any of claims 1 to 4, wherein the feedback control means performs a current direction control process and a discharge amount direction control process,
wherein the current direction control process includes calculating the driving current value and bringing the actual rail pressure into correspondence with the target rail pressure corresponding to starting the internal combustion engine (1) or the target rail pressure corresponding to the running status of the internal combustion engine (1) when the learned value is not stored in the storage means, and
wherein the discharge amount direction control process includes calculating the pump discharge amount and bringing the actual pressure into correspondence with the target rail pressure corresponding to the running status of the internal combustion engine (1) during running of the internal combustion engine and calculating the driving current value corresponding to the pump discharge amount when the learned value is stored in the storage means.

6. A method of controlling fuel injection into an internal combustion engine (1), comprising:

accumulating high-pressure fuel in a common rail (2); injecting the high-pressure fuel;
calculating a proportional correction value and an integral correction value based on a pressure difference (ΔPC) between a target rail pressure corresponding to a running status of the engine (1) and an actual rail pressure of the common rail (2);
calculating one of a driving current value and a pump discharge amount of a supply pump (4) based on the proportional correction value and the integral correction value;
calculating a correction value to correct a variation in the pump discharge amount and the driving current value; storing the correction value as

a learned value when a condition for storage of a learned value has been satisfied; and correcting the driving current value or the pump discharge amount based on the learned value stored, **characterized by** the steps of:

determining whether or not the learned value is stored in the storage means upon starting the internal combustion engine (1); and holding the integral correction value prior to storing the learned value and after completion of starting the internal combustion engine (1).

7. The method of claim 6 further comprising:

calculating the driving current value and bringing the actual rail pressure into correspondence with the target rail pressure corresponding to the starting or the running status of the internal combustion engine (1) when the learned value is not stored; and
calculating the pump discharge amount and bringing the actual pressure into correspondence with the target rail pressure corresponding to the running status of the internal combustion engine (1) and calculating the driving current value corresponding to the pump discharge amount when the learned value is stored.

Patentansprüche

1. Common-Rail-Kraftstoffeinspritzgerät mit:

(a) einer Common-Rail (2) zum Akkumulieren eines Hochdruckkraftstoffes;
(b) einer Einspritzvorrichtung (3) zum Einspritzen des Hochdruckkraftstoffes, der in der Common-Rail (2) akkumuliert wird;
(c) einer Zuführungspumpe (4) einschließlich einer Verdichtungskammer (22) zum Ansaugen und zum Druckbeaufschlagen von Kraftstoff und einer Hochdruckpumpe (15) zum Zuführen des mit Druck beaufschlagten Kraftstoffes zu der Common-Rail (2);
(d) einem Einlassmengensteuerventil (14) einschließlich eines Ventils (23) zum Steuern einer in die Verdichtungskammer (22) angesaugten Strömungsmenge und eines Aktuators (24) zum Antreiben des Ventils (23), um eine Öffnung des Ventils (23) gemäß einer Antriebsstromstärke zu steuern, die zu dem Aktuator (24) zugeführt wird;
(e1) einer Regeleinrichtung zum Erhalten eines Proportionalkorrekturwertes und eines Integralkorrekturwertes auf der Grundlage einer Druckdifferenz (ΔPC) zwischen einem Soll-Rail-Druck entsprechend einem Fahrtstatus einer Brennkraftmaschine (1) und einem Ist-Rail-Druck, der ein Ist-Druck der Common-Rail (2) ist, und zum Erhalten einer Antriebsstromstärke oder einer Pumpenauslassmenge der Zuführungspumpe (4) unter Verwendung des Proportionalkorrekturwertes und des Integralkorrekturwertes;
(e2) einer Korrektureinrichtung zum Erhalten eines Korrekturwertes zum Korrigieren einer Änderung der Pumpenauslassmenge bezüglich der Antriebsstromstärke;
(e3) einer Speichereinrichtung zum Speichern des durch die Korrektureinrichtung erhaltenen Korrekturwertes als einen gelernten Wert, wenn eine Bedingung zum Speichern eines gelernten Wertes erfüllt ist; und
(e4) einer Steuervorrichtung (5) einschließlich einer Lernkorrektureinrichtung zum Korrigieren der Antriebsstromstärke oder der Pumpenauslassmenge auf der Grundlage des gelernten Wertes, der in der Speichereinrichtung gespeichert ist,

dadurch gekennzeichnet, dass
der durch die Korrektureinrichtung erhaltene Korrekturwert zumindest ein Proportionalkorrekturwert oder ein Integralkorrekturwert ist, und
die Steuervorrichtung (5) Folgendes aufweist:

eine Einrichtung zum Bestimmen eines Vorhandenseins/Fehlens eines gelernten Wertes, um zu bestimmen, ob der gelernte Wert in der Speichereinrichtung beim Starten der Brennkraftmaschine (1) gespeichert ist oder nicht; und
eine Einrichtung zum Halten des Integralkorrekturwertes, um den durch die Regeleinrichtung erhaltenen Integralkorrekturwert zu halten, ohne den Wert zurückzusetzen, bevor die Speichereinrichtung den gelernten Wert speichert und nach der Beendigung eines Startens der Brennkraftmaschine (1), wenn bestimmt wird, dass der gelernte Wert nicht in der Speichereinrichtung beim Starten der Brennkraftmaschine gespeichert ist.

2. Common-Rail-Kraftstoffeinspritzgerät gemäß Anspruch 1,
wobei die Regeleinrichtung außerdem als die Korrektureinrichtung dient, und
wobei der durch die Regeleinrichtung erhaltene Integralkorrekturwert als der gelernte Wert in der Speichereinrichtung gespeichert wird, wenn die Bedingung zum Speichern eines gelernten Wertes erfüllt ist.

3. Common-Rail-Kraftstoffeinspritzgerät gemäß Anspruch 1 oder 2,
wobei, wenn das Starten der Brennkraftmaschine (1)

beendet ist, die Einrichtung zum Halten des Integralkorrekturwertes den Integralkorrekturwert bei der Beendigung des Startens der Brennkraftmaschine (1) hält.

4. Common-Rail-Kraftstoffeinspritzgerät gemäß Anspruch 1 oder 2,
wobei, wenn das Starten der Brennkraftmaschine (1) beendet ist, die Einrichtung zum Halten des Integralkorrekturwertes ein vorbestimmtes Verhältnis des Integralkorrekturwertes bei der Beendigung des Startens der Brennkraftmaschine (1) hält.

5. Common-Rail-Kraftstoffeinspritzgerät gemäß einem der Ansprüche 1 bis 4, wobei die Regeleinrichtung einen Stromrichtungssteuerprozess und einen Auslassmengenrichtungssteuerprozess durchführt, wobei der Stromrichtungssteuerprozess ein Berechnen der Antriebsstromstärke und ein Einstellen des Ist-Rail-Druckes in Übereinstimmung mit dem Soll-Rail-Druck entsprechend dem Starten der Brennkraftmaschine (1) oder dem Soll-Rail-Druck entsprechend dem Fahrtstatus der Brennkraftmaschine (1) beinhaltet, wenn der gelernte Wert nicht in der Speichereinrichtung gespeichert ist, und
wobei der Auslassmengenrichtungssteuerprozess ein Berechnen der Pumpenauslassmenge und ein Einstellen des Ist-Druckes in Übereinstimmung mit dem Soll-Rail-Druck entsprechend dem Fahrtstatus der Brennkraftmaschine (1) während eines Betriebs der Brennkraftmaschine und ein Berechnen der Antriebsstromstärke entsprechend der Pumpenauslassmenge beinhaltet, wenn der gelernte Wert in der Speichereinrichtung gespeichert ist.

6. Verfahren zum Steuern einer Kraftstoffeinspritzung in eine Brennkraftmaschine (1), mit:

Akkumulieren eines Hochdruckkraftstoffes in einer Common-Rail (2);
Einspritzen des Hochdruckkraftstoffes;
Berechnen eines Proportionalkorrekturwertes und eines Integralkorrekturwertes auf der Grundlage einer Druckdifferenz (ΔPC) zwischen einem Soll-Rail-Druck entsprechend einem Fahrtstatus der Kraftmaschine (1) und einem Ist-Rail-Druck der Common-Rail (2);
Berechnen einer Antriebsstromstärke oder einer Pumpenauslassmenge einer Zuführungspumpe (4) auf der Grundlage des Proportionalkorrekturwertes und des Integralkorrekturwertes;
Berechnen eines Korrekturwertes zum Korrigieren einer Änderung der Pumpenauslassmenge und der Antriebsstromstärke;
Speichern des Korrekturwertes als einen gelernten Wert, wenn eine Bedingung zum Speichern eines gelernten Wertes erfüllt ist; und
Korrigieren der Antriebsstromstärke oder der Pumpenauslassmenge auf der Grundlage des gespeicherten, gelernten Wertes,

gekennzeichnet durch die folgenden Schritte:

Bestimmen, ob der gelernte Wert in der Speichereinrichtung beim Starten der Brennkraftmaschine (1) gespeichert ist oder nicht; und
Halten des Integralkorrekturwertes vor dem Speichern des gelernten Wertes und nach der Beendigung des Startens der Brennkraftmaschine (1).

7. Verfahren gemäß Anspruch 6, des Weiteren mit den folgenden Schritten:

Berechnen der Antriebsstromstärke und Einstellen des Ist-Rail-Druckes in Übereinstimmung mit dem Soll-Rail-Druck entsprechend dem Starten oder dem Fahrtstatus der Brennkraftmaschine (1), wenn der gelernte Wert nicht gespeichert ist; und
Berechnen der Pumpenauslassmenge und Einstellen des Ist-Rail-Druckes in Übereinstimmung mit dem Soll-Rail-Druck entsprechend dem Fahrtstatus der Brennkraftmaschine (1) und Berechnen der Antriebsstromstärke entsprechend der Pumpenauslassmenge, wenn der gelernte Wert gespeichert ist.

Revendications

1. Un appareil d'injection de carburant à rampe commune comprenant :

(a) une rampe commune (2) pour accumuler du carburant sous haute pression;
(b) un injecteur (3) pour injecter le carburant sous haute pression accumulé dans la rampe commune (2);
(c) une pompe d'alimentation (4) incluant une chambre de compression (22) pour aspirer et mettre sous pression du carburant, et une pompe à haute pression (15) pour fournir à la rampe commune (2) le carburant mis sous pression;
(d) une vanne de commande de quantité d'entrée (14) incluant une vanne (23) pour commander un débit aspiré dans la chambre de compression (22) et un actionneur (24) pour entraîner la vanne (23), pour commander l'ouverture de la vanne (23) conformément à une valeur de courant d'attaque qui est appliquée à l'actionneur (24);
(e1) un moyen d'asservissement pour obtenir une valeur de correction proportionnelle et une valeur de correction intégrale basées sur une

différence de pression (ΔPC) entre une pression de rampe cible correspondant à un état de marche d'un moteur à combustion interne (1) et une pression de rampe réelle qui est une pression réelle de la rampe commune (2), et pour obtenir une valeur de courant d'attaque ou une quantité d'évacuation de la pompe d'alimentation (4) en utilisant la valeur de correction proportionnelle et la valeur de correction intégrale;

(e2) un moyen de correction pour obtenir une valeur de correction de la valeur de courant d'attaque, pour corriger une variation de la quantité d'évacuation de pompe;

(e3) un moyen de stockage pour stocker la valeur de correction obtenue par le moyen de correction, comme une valeur apprise lorsqu'une condition pour le stockage d'une valeur apprise a été remplie; et

(e4) un dispositif de commande (5) incluant un moyen de correction d'apprentissage pour corriger la valeur de courant d'attaque ou la quantité d'évacuation de pompe sur la base de la valeur apprise stockée dans le moyen de stockage,

caractérisé en ce que

la valeur de correction obtenue par le moyen de correction est au moins une d'une valeur de correction proportionnelle et d'une valeur de correction intégrale, et

le dispositif de commande (5) inclut :

un moyen de détermination de présence / absence de valeur apprise, pour déterminer si la valeur apprise est stockée ou non dans le moyen de stockage, au démarrage du moteur à combustion interne (1); et

un moyen de conservation de valeur de correction intégrale pour conserver la valeur de correction intégrale obtenue par le moyen d'asservissement sans restaurer la valeur avant que le moyen de stockage ne stocke la valeur apprise, et après l'achèvement du démarrage du moteur à combustion interne (1) lorsqu'il est déterminé que la valeur apprise n'est pas stockée dans le moyen de stockage au moment du démarrage du moteur à combustion interne.

2. L'appareil d'injection de carburant à rampe commune selon la revendication 1,
dans lequel le moyen d'asservissement fonctionne également comme le moyen de correction, et
dans lequel la valeur de correction intégrale obtenue par le moyen d'asservissement est stockée comme la valeur apprise, dans le moyen de stockage, lorsque la condition pour le stockage d'une valeur apprise a été remplie.

3. L'appareil d'injection de carburant à rampe commune selon la revendication 1 ou 2,
dans lequel lorsque le démarrage du moteur à combustion interne (1) a été achevé, le moyen de conservation de valeur de correction intégrale conserve la valeur de correction intégrale à l'achèvement du démarrage du moteur à combustion interne (1).

4. L'appareil d'injection de carburant à rampe commune selon la revendication 1 ou 2,
dans lequel lorsque le démarrage du moteur à combustion interne (1) a été achevé, le moyen de conservation de valeur de correction intégrale conserve un rapport prédéterminé de la valeur de correction intégrale à l'achèvement du démarrage du moteur à combustion interne (1).

5. L'appareil d'injection de carburant à rampe commune selon l'une quelconque des revendications 1 à 4,
dans lequel le moyen d'asservissement effectue un processus de commande de sens de courant et un processus de commande de sens de quantité d'évacuation,
dans lequel le processus de commande de sens de courant comprend le calcul de la valeur de courant d'attaque et l'opération consistant à amener la pression de rampe réelle en correspondance avec la pression de rampe cible correspondant au démarrage du moteur à combustion interne (1) ou la pression de rampe cible correspondant à l'état de marche du moteur à combustion interne (1), lorsque la valeur apprise n'est pas stockée dans le moyen de stockage, et
dans lequel le processus de commande de sens de quantité d'évacuation comprend le calcul de la quantité d'évacuation de pompe et l'opération consistant à amener la pression réelle en correspondance avec la pression de rampe cible correspondant à l'état de marche du moteur à combustion interne (1) pendant la marche du moteur à combustion interne, et le calcul de la valeur de courant d'attaque correspondant à la quantité d'évacuation de pompe lorsque la valeur apprise est stockée dans le moyen de stockage.

6. Un procédé de commande d'injection de carburant dans un moteur à combustion interne (1), comprenant les étapes suivantes :

accumuler du carburant sous haute pression dans une rampe commune (2);

injecter le carburant sous haute pression;

calculer une valeur de correction proportionnelle et une valeur de correction intégrale basées sur une différence de pression (ΔPC) entre une pression de rampe cible correspondant à un état de marche du moteur (1) et une pression de rampe réelle de la rampe commune (2);

calculer une d'une valeur de courant d'attaque et d'une quantité d'évacuation de pompe d'une

pompe d'alimentation (4), sur la base de la valeur de correction proportionnelle et de la valeur de correction intégrale;
calculer une valeur de correction pour corriger une variation dans la quantité d'évacuation de pompe et la valeur de courant d'attaque;
stocker la valeur de correction comme une valeur apprise lorsqu'une condition pour le stockage d'une valeur apprise a été remplie; et
corriger la valeur de courant d'attaque ou la quantité d'évacuation de pompe sur la base de la valeur apprise stockée,

caractérisé par les étapes suivantes :

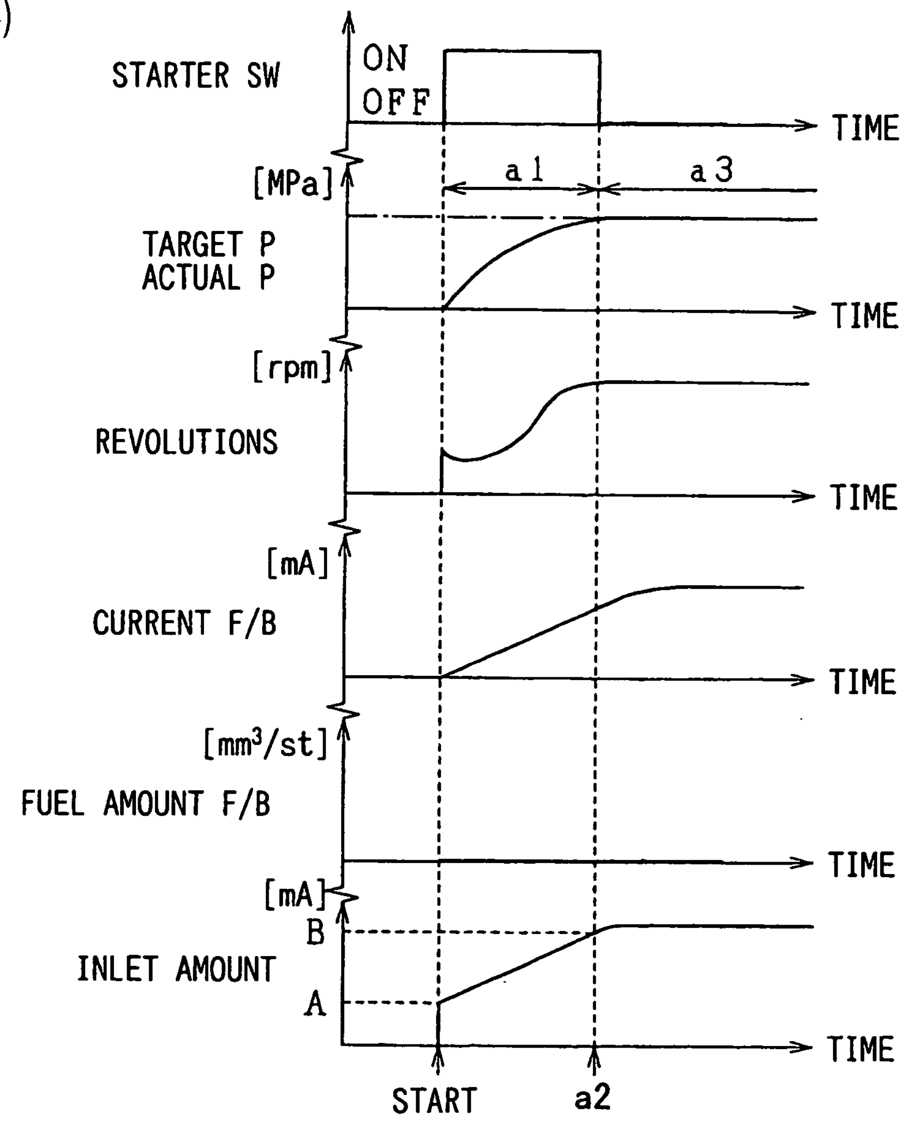
déterminer si la valeur apprise est stockée ou non dans le moyen de stockage au démarrage du moteur à combustion interne (1); et
conserver la valeur de correction intégrale avant de stocker la valeur apprise et après l'achèvement du démarrage du moteur à combustion interne (1).

7. Le procédé selon la revendication 6, comprenant en outre les étapes suivantes :

calculer la valeur de courant d'attaque et amener la pression de rampe réelle en correspondance avec la pression de rampe cible correspondant au démarrage ou à l'état de marche du moteur à combustion interne (1), lorsque la valeur apprise n'est pas stockée; et
calculer la valeur d'évacuation de pompe et amener la pression réelle en correspondance avec la pression de rampe cible correspondant à l'état de marche du moteur à combustion interne (1), et calculer la valeur de courant d'attaque correspondant à la quantité d'évacuation de pompe lorsque la valeur apprise est stockée.

FIG. 1

(a)


STARTER SW
ON
OFF
TIME
[MPa]
a 1
a 3
TARGET P
ACTUAL P
TIME
[rpm]
REVOLUTIONS
TIME
[mA]
CURRENT F/B
TIME
[mm3/st]
FUEL AMOUNT F/B
TIME
[mA]
B
INLET AMOUNT
A
TIME
START
a2

(b)

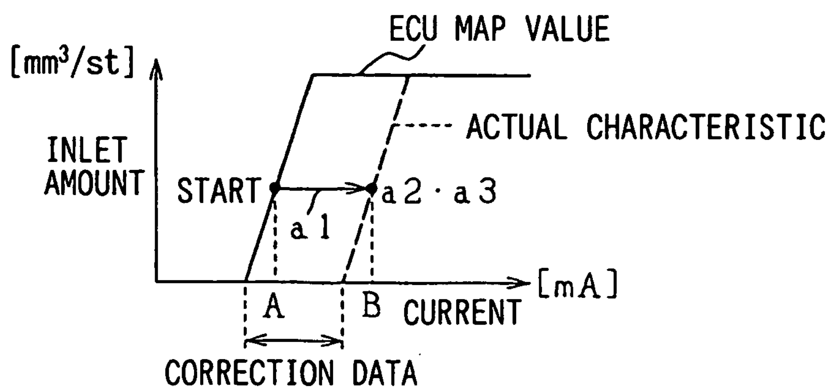

ECU MAP VALUE
[mm3/st]
ACTUAL CHARACTERISTIC
INLET
AMOUNT
START
a 2 · a 3
a 1
[mA]
A
B
CURRENT
CORRECTION DATA

FIG. 2

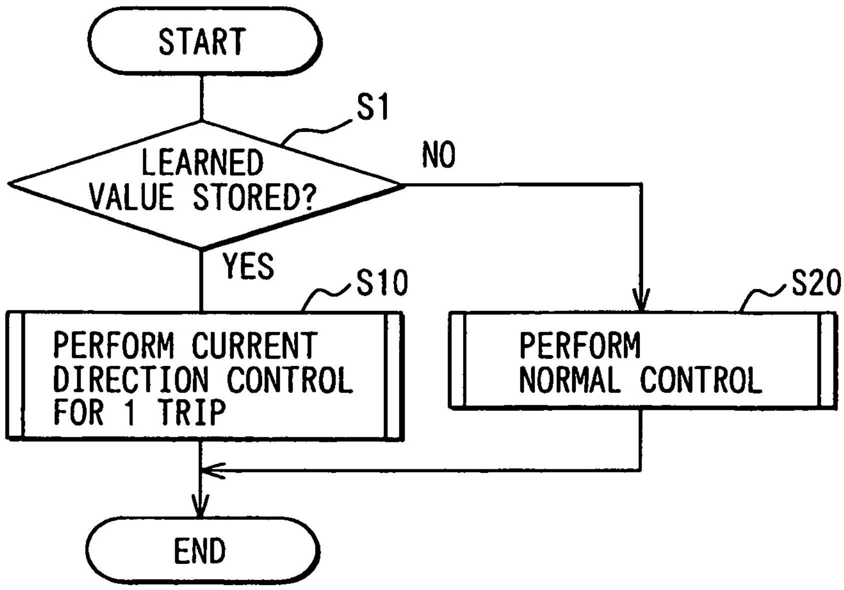

START
S1
LEARNED VALUE STORED?
NO
YES
S10
PERFORM CURRENT DIRECTION CONTROL FOR 1 TRIP
S20
PERFORM NORMAL CONTROL
END

FIG. 3

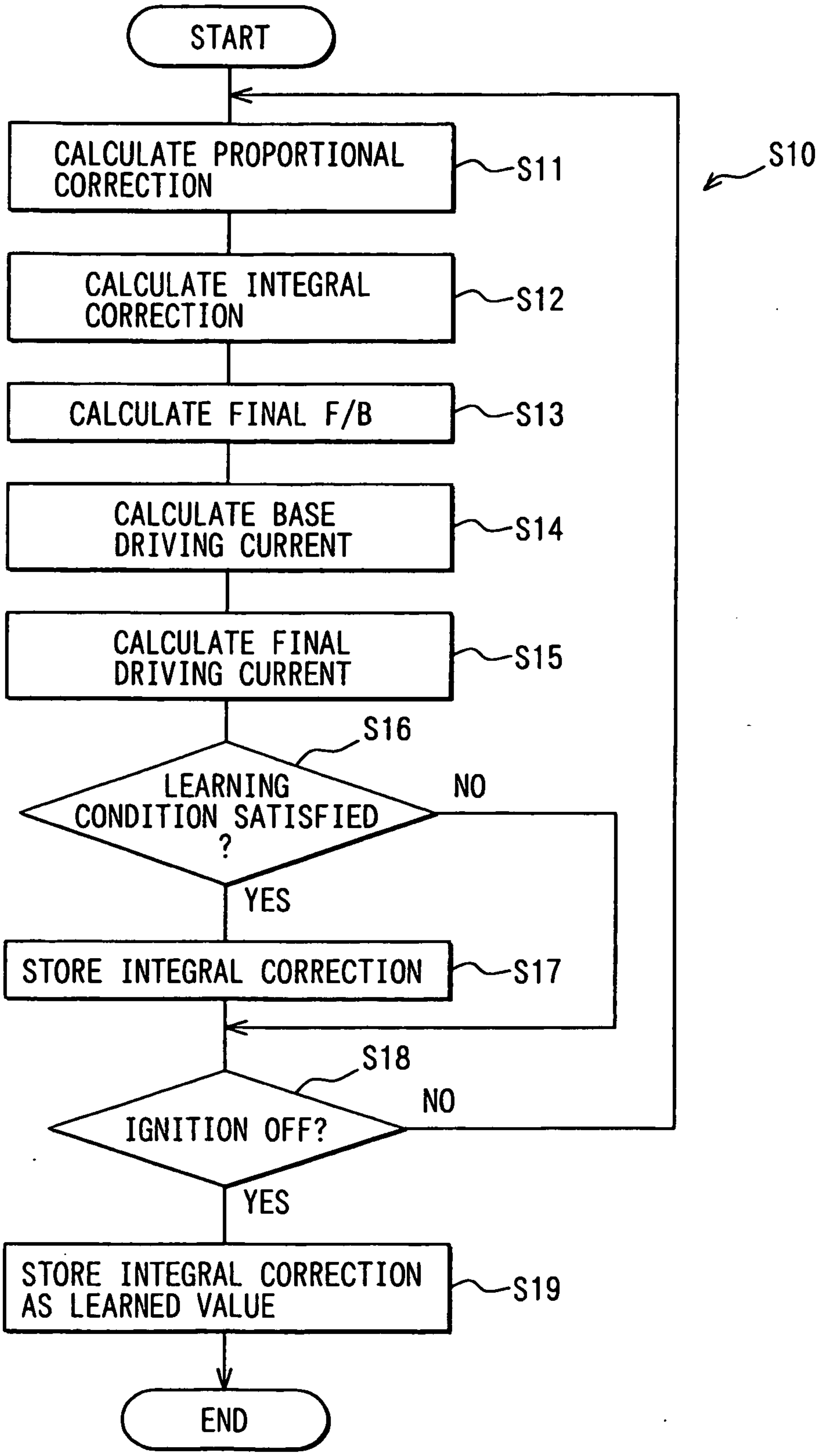

START
CALCULATE PROPORTIONAL CORRECTION
S11
CALCULATE INTEGRAL CORRECTION
S12
CALCULATE FINAL F/B
S13
CALCULATE BASE DRIVING CURRENT
S14
CALCULATE FINAL DRIVING CURRENT
S15
S10
S16
LEARNING CONDITION SATISFIED ?
NO
YES
STORE INTEGRAL CORRECTION
S17
S18
IGNITION OFF?
NO
YES
STORE INTEGRAL CORRECTION AS LEARNED VALUE
S19
END

FIG. 4

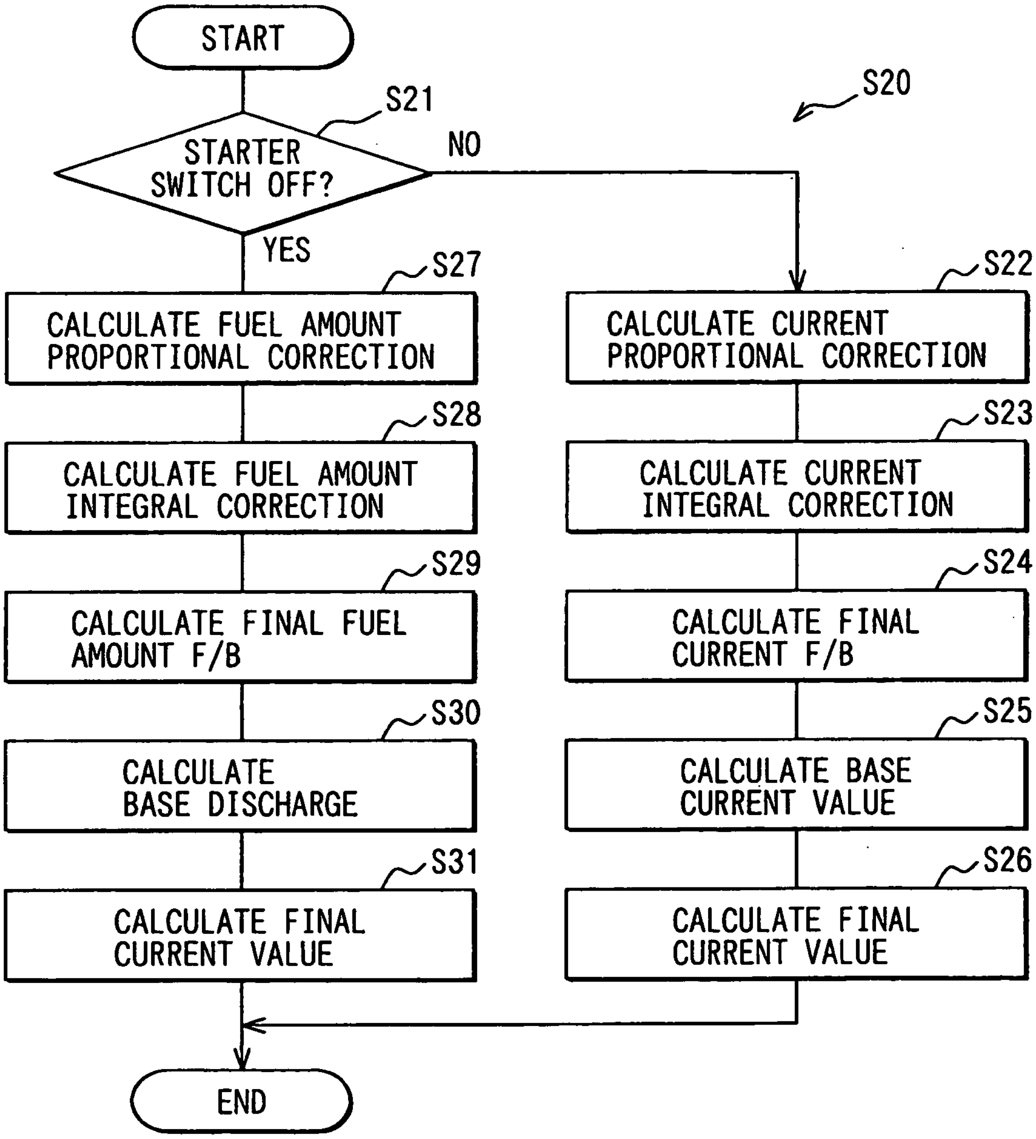

START
S21
STARTER SWITCH OFF?
NO
YES
S20
S27
CALCULATE FUEL AMOUNT PROPORTIONAL CORRECTION
S28
CALCULATE FUEL AMOUNT INTEGRAL CORRECTION
S29
CALCULATE FINAL FUEL AMOUNT F/B
S30
CALCULATE BASE DISCHARGE
S31
CALCULATE FINAL CURRENT VALUE
S22
CALCULATE CURRENT PROPORTIONAL CORRECTION
S23
CALCULATE CURRENT INTEGRAL CORRECTION
S24
CALCULATE FINAL CURRENT F/B
S25
CALCULATE BASE CURRENT VALUE
S26
CALCULATE FINAL CURRENT VALUE
END

FIG. 5

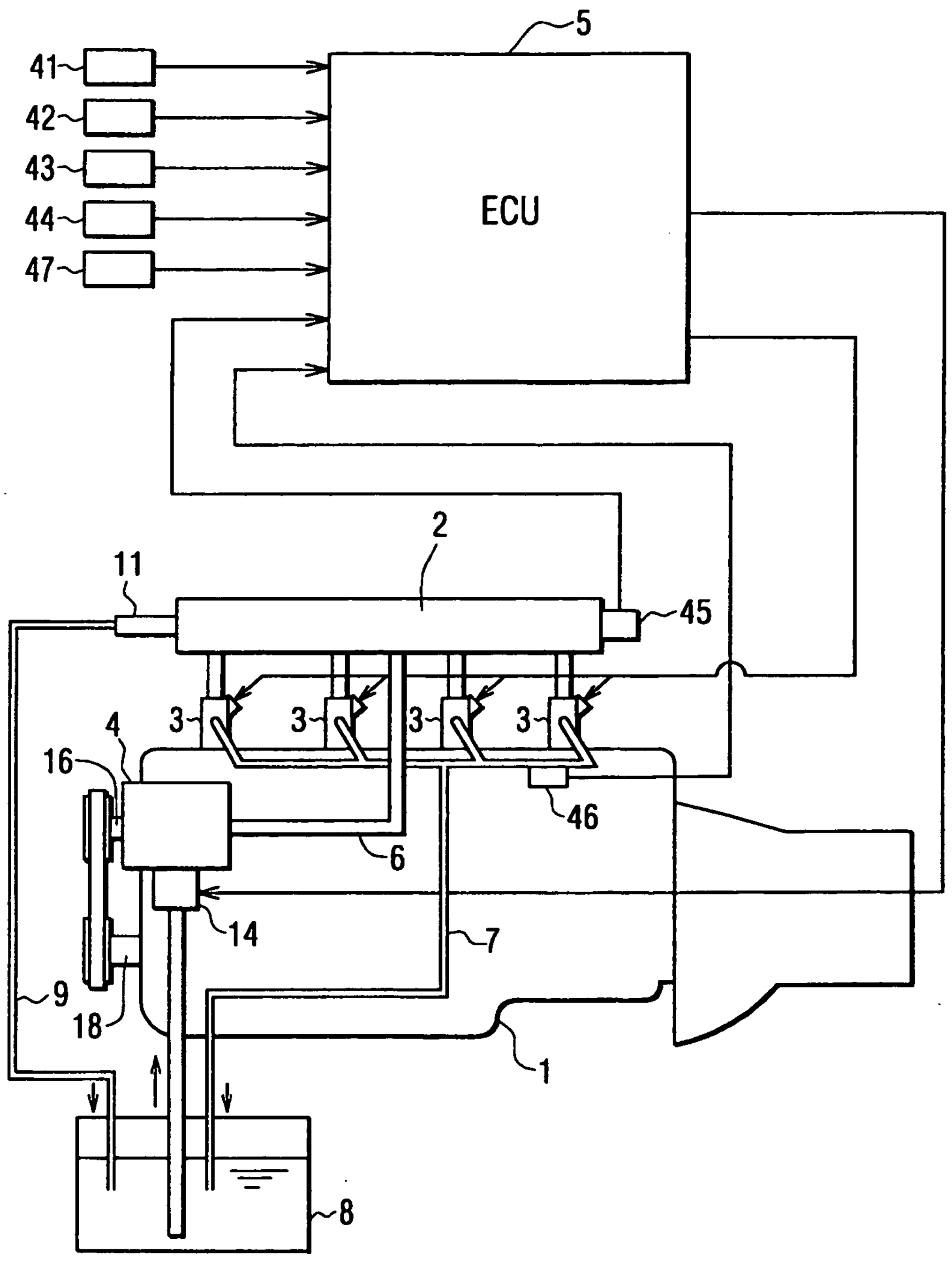
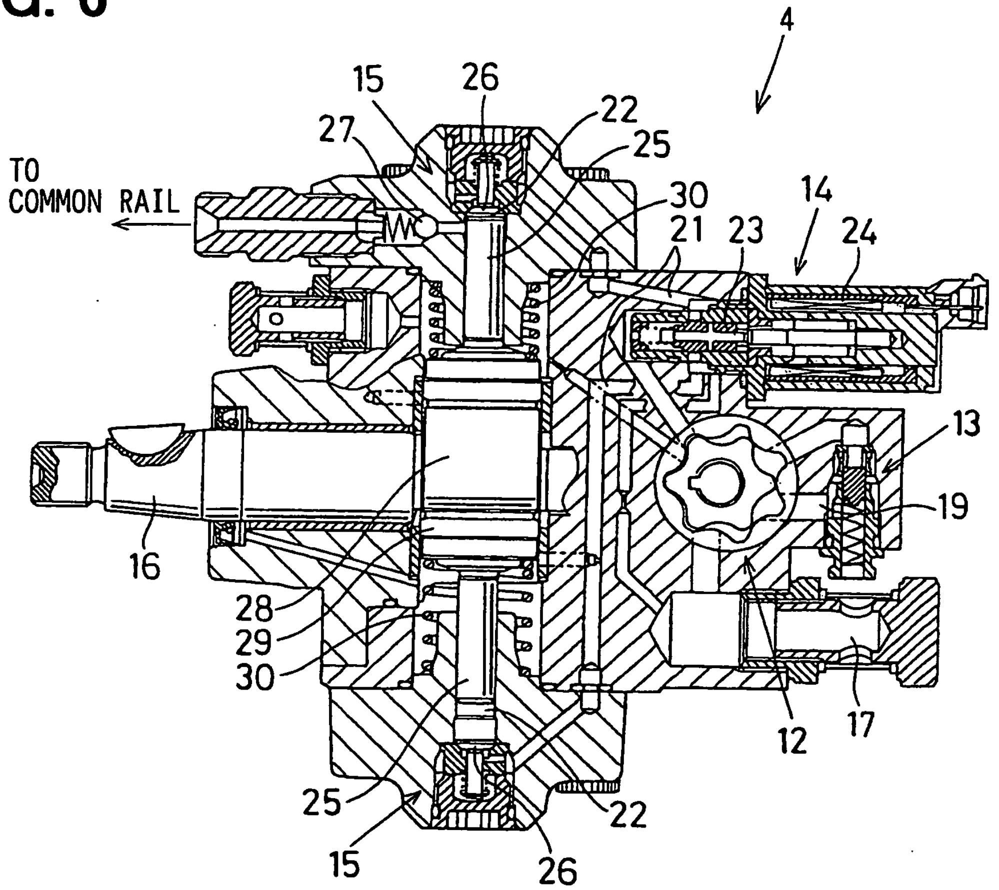


FIG. 6


4
15
26
22
27
25
TO
COMMON RAIL
30
21
23
14
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13
19
16
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29
30
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15
26

FIG. 8

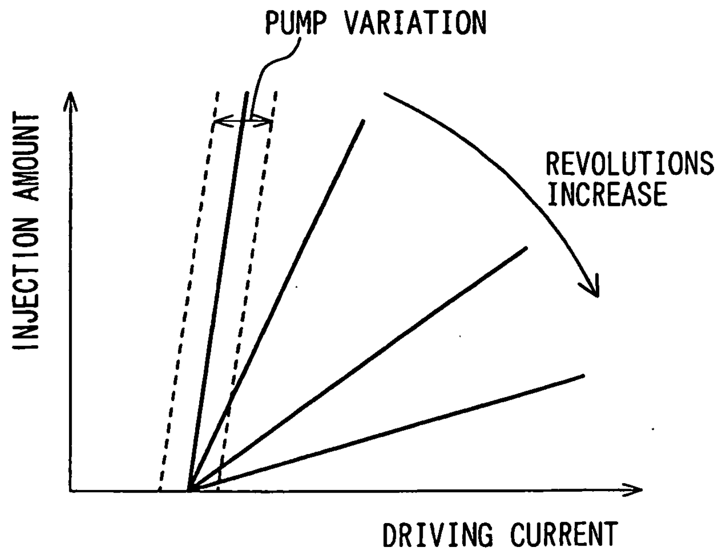

PUMP VARIATION
INJECTION AMOUNT
REVOLUTIONS
INCREASE
DRIVING CURRENT

FIG. 7

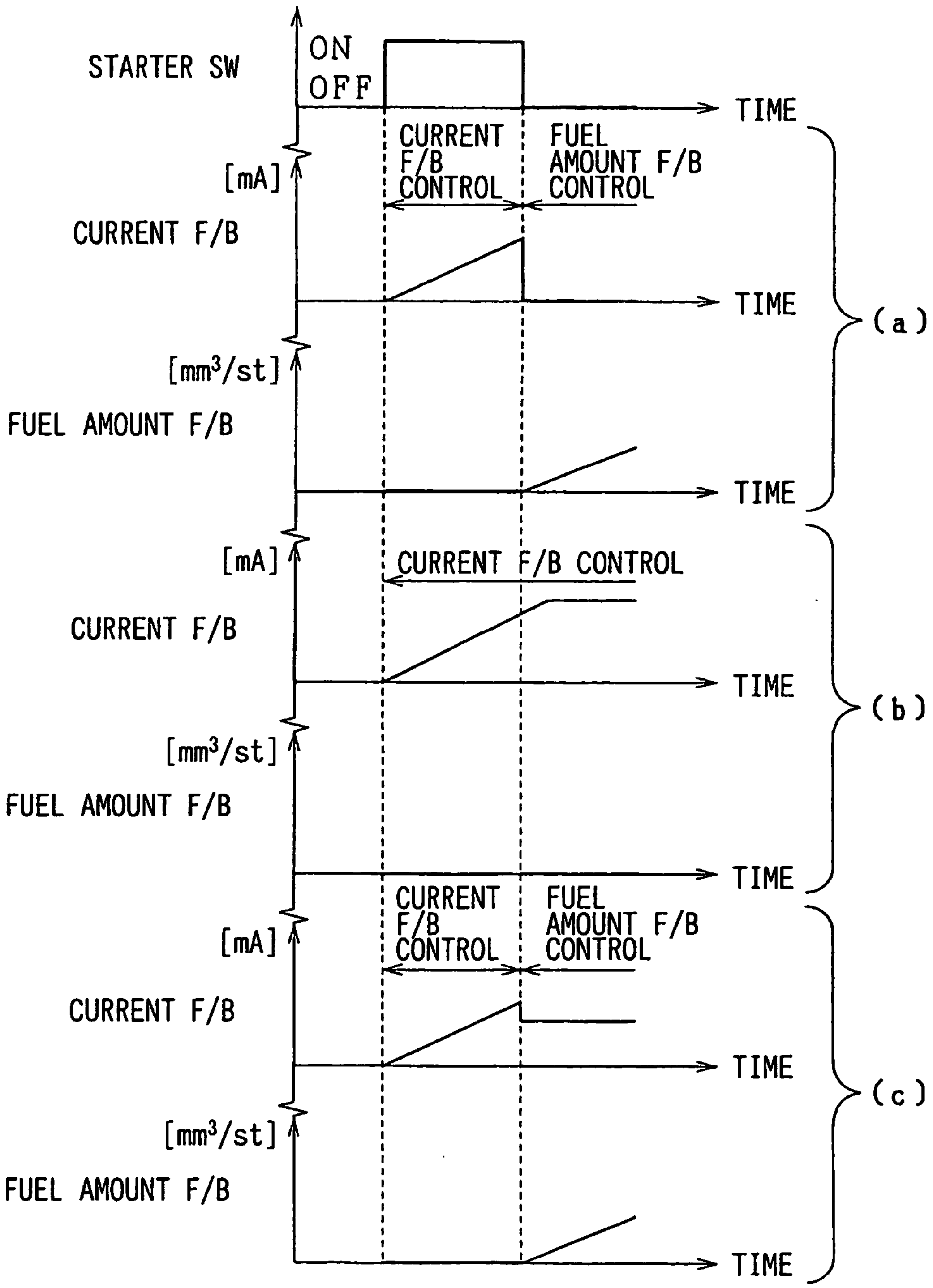
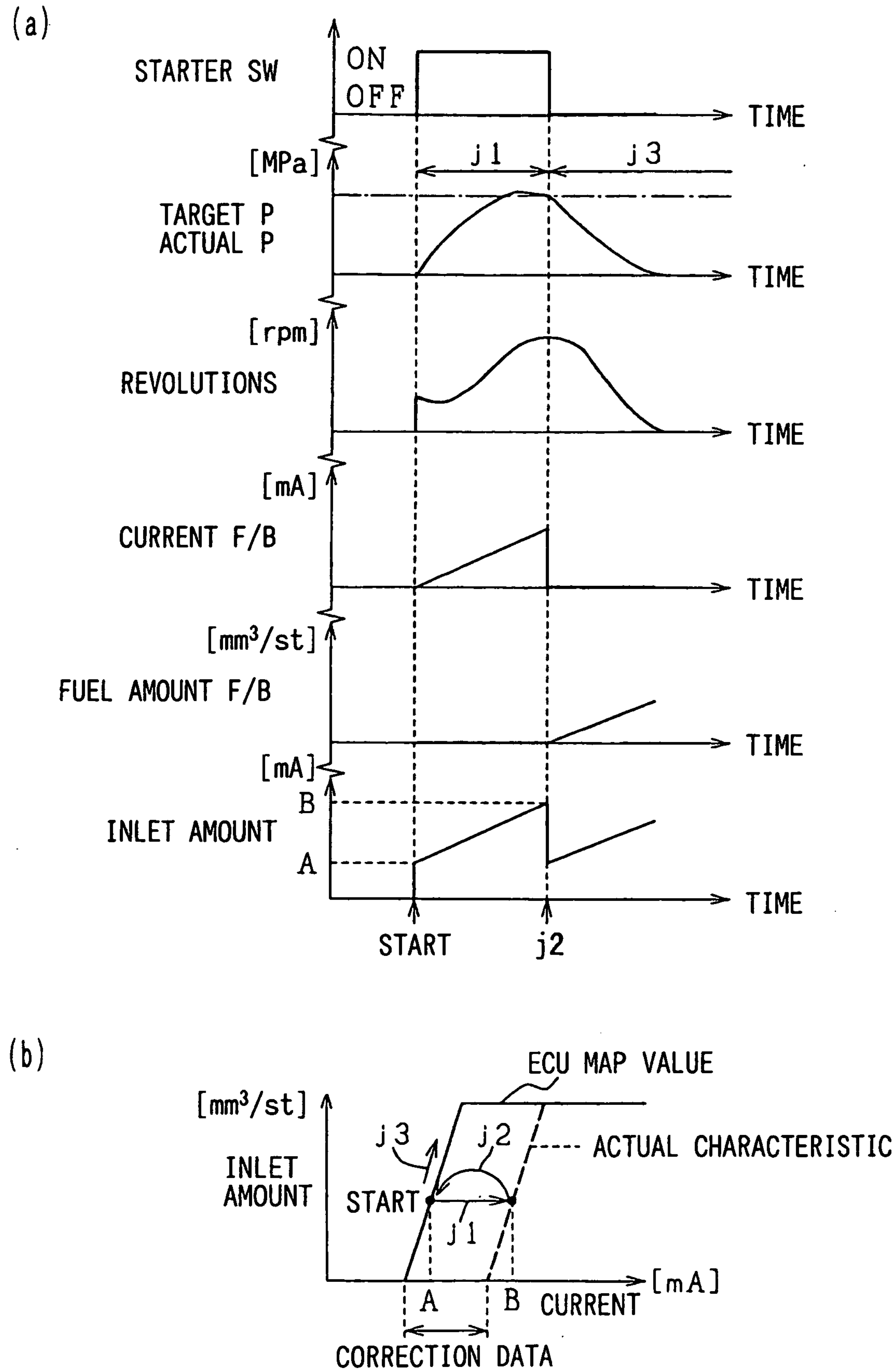

STARTER SW
ON
OFF
TIME
[mA]
CURRENT F/B
CURRENT F/B CONTROL
FUEL AMOUNT F/B CONTROL
TIME
[mm³/st]
FUEL AMOUNT F/B
TIME
(a)
[mA]
CURRENT F/B
CURRENT F/B CONTROL
TIME
[mm³/st]
FUEL AMOUNT F/B
TIME
(b)
[mA]
CURRENT F/B
CURRENT F/B CONTROL
FUEL AMOUNT F/B CONTROL
TIME
[mm³/st]
FUEL AMOUNT F/B
TIME
(c)

FIG. 9


(a)
STARTER SW
ON
OFF
TIME
[MPa]
j1
j3
TARGET P
ACTUAL P
TIME
[rpm]
REVOLUTIONS
TIME
[mA]
CURRENT F/B
TIME
[mm3/st]
FUEL AMOUNT F/B
TIME
[mA]
B
INLET AMOUNT
A
TIME
START
j2
(b)
ECU MAP VALUE
[mm3/st]
j3
j2
ACTUAL CHARACTERISTIC
INLET AMOUNT
START
j1
[mA]
A
B
CURRENT
CORRECTION DATA