

(19)



(11)

EP 2 116 708 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

11.11.2009 Bulletin 2009/46

(51) Int Cl.:

F02D 41/14 (2006.01)

F02D 41/24 (2006.01)

F02D 41/00 (2006.01)

(21) Application number: **09251255.7**

(22) Date of filing: **05.05.2009**

(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL
PT RO SE SI SK TR**

(72) Inventor: **Minami, Masahiro**

Toyota-shi

Aichi-ken 471-8571 (JP)

(30) Priority: **07.05.2008 JP 2008121400**

(74) Representative: **Smith, Samuel Leonard**

J.A. Kemp & Co.

14 South Square

Gray's Inn

London WC1R 5JJ (GB)

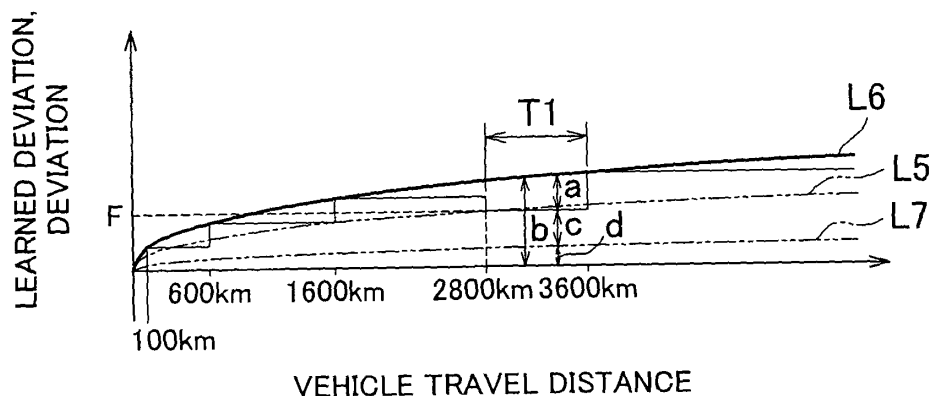
(71) Applicant: **Toyota Jidosha Kabushiki Kaisha**
Toyota-shi, Aichi-ken 471-8571 (JP)

(54) **Fuel injection amount control device and method**

(57) In an ECU that corrects an injection amount of an injector (5) based on a learned value acquired by learning a secular change in the injection amount of the injector, a temporary learned value (F) of the injection amount of the injector is calculated based on a degradation trend map (L5) indicating the secular change in the

injection amount of the injector estimated per vehicle travel distance, and a vehicle travel distance input from a terminal device (22). During the time period (T1) after the input of the vehicle travel distance until an acquisition of a new learned value is completed, the injection amount of the injector is corrected based on the temporary learned value of the injection amount of the injector.

FIG. 8



EP 2 116 708 A2

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This invention relates to a fuel injection amount control device and method for an internal combustion engine of a vehicle.

2. Description of the Related Art

[0002] An ECU (Electronic Control Unit) for an engine of a vehicle, such as an automobile, is available that learns a change in injection amount due to the degradation of an injector over time. Learned values are stored in a control memory in the ECU. When a failure occurs in the ECU, the ECU is removed and a new ECU is installed. In this case, while the injector stays in a condition degraded over time, the learned values of the injection amount of the injector that has been degraded over time is not stored in the control memory in the new ECU after the replacement. Therefore, it takes a while for the new ECU after the replacement to learn an appropriate injection amount of the injector degraded over time. Thus, it is difficult to make the injection amount of the injector optimum during the period (until the learning of the injection amount is completed).

[0003] Japanese Patent Application Publication No. 2001-65399 (JP-A-2001-65399) describes that when the ECU is replaced, the learned values stored in the control memory in the old ECU before the replacement is read out to a terminal, and the read learned value is written or stored into a control memory in a new ECU after the replacement.

[0004] Further, in an ECU system for a vehicle described in Japanese Patent Application Publication No. 2003-56398 (JP-A-2003-56398), a gateway ECU and several other ECUs are installed in the vehicle, and the gateway ECU writes a copy of data into the other ECUs in advance. When the gateway ECU is replaced, the new gateway ECU after the replacement requests the copy of data written by the old gateway ECU before the replacement from the other ECUs, and the other ECUs send the copy of data to the new gateway ECU after the replacement. By doing so, the new gateway ECU after the replacement can obtain the information same as that held by the old gateway ECU before replacement.

[0005] Japanese Patent Application Publication No. 2001-349259 (JP-A-2001-349259) describes an injection device including a piezoelectric element for an actuator. This injection device stores aging characteristics of the piezoelectric element as a function.

[0006] Japanese Patent Application Publication No. 2005-36788 (JP-A-2005-36788) describes a learning control device of a fuel injection quantity in a diesel engine. In this learning control device, a single injection with a small amount of fuel is performed during a no-injection

period in which a command injection quantity to an injector is zero or under, and a torque proportional quantity is calculated by multiplying a change amount of the engine speed increased by the single injection, by the engine speed at the time when the single injection is performed (engine speed before being increased by the single injection). In the diesel engine, because the injection quantity is proportional to the generation torque, an actual injection quantity can be estimated from the generation torque calculated from the torque proportional quantity. As a result, the difference between the estimated actual injection quantity and the command fuel injection quantity is detected as a deviation in the injection quantity, and the fuel injection quantity of the injector is corrected based on the deviation in injection quantity.

[0007] In the method described in JP-A-2001-65399, if the control memory in the old ECU before the replacement is broken, the learned values cannot be read out from the control memory in the old ECU before the replacement. In this case, the learned values stored in the control memory in the old ECU cannot be carried over to the control memory in the new ECU after the replacement.

[0008] In the ECU system for a vehicle described in JP-A-2003-56398, if a failure or the like occurs in the other ECUs and the other ECUs must be replaced together with the gateway ECU, the new gateway ECU after the replacement cannot request the copy of data from the other ECUs.

SUMMARY OF THE INVENTION

[0009] The present invention provides a fuel injection amount control device and method that quickly recover from a serious degradation of the fuel injection amount of the fuel injection valve that has been degraded over time, even if, when the ECU (a fuel injection amount control device) for a vehicle is replaced, the learned values regarding the fuel injection amount of the fuel injection valve stored in a memory in an ECU (a fuel injection amount control device) for a vehicle before the replacement is not carried over to a memory in an ECU for the vehicle after the replacement.

[0010] A first aspect of the present invention provides a fuel injection amount control device that includes: learning means for learning a secular change in an injection amount of a fuel injection valve to acquire a learned value; correcting means for correcting the injection amount of the fuel injection valve based on the learned value acquired by the learning means; and temporary learned value calculating means for calculating a temporary learned value of the injection amount of the fuel injection valve based on an input travel distance of a vehicle and an estimated secular change information indicating the secular change in the injection amount of the fuel injection valve estimated per travel distance of the vehicle. The correcting means corrects the injection amount of the fuel injection valve based on the temporary learned value

calculated by the temporary learned value calculating means instead of the learned value until the learning means completes an acquisition of the learned value after the travel distance is input.

[0011] According to the first aspect of the present invention, for example, when a failure etc. occurs in the fuel injection amount control device and the fuel injection amount control device is replaced, the fuel injection amount control device after the replacement corrects the fuel injection amount of the fuel injection valve based on the temporary learned value after the replacement until the learning means completes the acquisition of the learned value. The estimated secular change information may be, for example, a mean value of empirically acquired secular changes in the injection amount of the fuel injection valve per travel distance, and such estimated secular change information may be stored in storage means in advance. By doing so, the degradation in the fuel injection amount of the fuel injection valve degraded over time can be reduced during the time period from the replacement of the fuel injection amount control device to the completion of acquisition of the learned value by the learning means in many cases.

[0012] The fuel injection amount control device may further include fuel injection valve learning priority means for performing the learning by the learning means in priority to other learning after a command to enter a fuel injection valve learning priority mode is input until the learning by the learning means is completed and the learned value is acquired. The other learning here means learning other than the learning performed by the learning means, and is performed by learning control that shares an operation resource (CPU etc.) with the fuel injection amount control device. The command to enter a fuel injection valve learning priority mode may be the input of the travel distance.

[0013] According to this construction, the time period in which the temporary learned value is used for correcting the fuel injection amount of the fuel injection valve is reduced, compared to the case where no entry into the fuel injection valve learning priority mode exists. As a result, the fuel injection valve can quickly recover the most appropriate injection state.

[0014] A second aspect of the present invention provides a fuel injection amount control device that includes learning means for learning a secular change in an injection amount of a fuel injection valve to acquire a learned value; and correcting means for correcting the injection amount of the fuel injection valve based on the learned value acquired by the learning means. The fuel injection amount control device further includes fuel injection valve learning priority means for performing the learning by the learning means in priority to other learning after a command to enter a fuel injection valve learning priority mode is input until the learning by the learning means is completed and the learned value is acquired.

[0015] According to the second aspect of the present invention, the time period in which a default value is used

for correcting the fuel injection amount of the fuel injection valve is reduced, compared to the case where no entry into the fuel injection valve learning priority mode exists. As a result, the fuel injection valve can quickly recover the most appropriate injection state.

[0016] A third aspect of the present invention provides a fuel injection amount control method. A secular change in an injection amount of a fuel injection valve is learned to acquire a learned value. The injection amount of the fuel injection valve is corrected based on the acquired learned value. A travel distance of a vehicle is input. A temporary learned value of the injection amount of the fuel injection valve is calculated based on the input travel distance and an estimated secular change information indicating the secular change in the injection amount of the fuel injection valve estimated per travel distance of the vehicle. The injection amount of the fuel injection valve is corrected based on the calculated temporary learned value instead of the learned value until the acquisition of the learned value is completed after the travel distance is input. According to the third aspect of the present invention, the effect similar to that of the first aspect of the present invention may be obtained.

[0017] A fourth aspect of the present invention provides a fuel injection amount control method. In the method, a secular change in an injection amount of a fuel injection valve is learned to acquire a learned value. The injection amount of the fuel injection valve is corrected based on the acquired learned value. A command to enter a fuel injection valve learning priority mode is input. The learning of the secular change is performed in priority to other learning after the command to enter the fuel injection valve learning priority mode is input until the learning of the secular change is completed and the learned value is acquired. According to the fourth aspect of the present invention, the effect similar to that of the second aspect of the present invention may be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The foregoing and further objects, features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

FIG 1 is a configuration diagram illustrating a fuel injection system of a diesel engine according to an embodiment of the present invention;

FIG. 2 is a diagram showing an example of a pilot injection amount setting map;

FIG 3 is a flowchart showing a pilot injection amount learning control operation;

FIG 4 is a diagram showing an example of a deviation of the pilot injection amount of the injector of a specific cylinder with a specific rail pressure;

FIG 5 is a diagram showing an integrated value of

learned deviation and a deviation of the pilot injection amount of an injector when no correction has been performed;

FIG 6 is a diagram showing an example of a degradation trend map;

FIG 7 is a flowchart showing a control operation of the ECU according to the first embodiment of the present invention;

FIG 8 is a diagram showing an integrated value of learned deviation and a temporary learned value of the ECU according to the first embodiment of the present invention, and in particular, showing an example of a case where the ECU is replaced when the vehicle travel distance is 2800km;

FIG 9 is a flowchart showing a control operation of the ECU according to a second embodiment of the present invention;

FIG 10 is a diagram showing an integrated value of learned deviation and a temporary learned value of the ECU according to the second embodiment of the present invention, and in particular, showing an example of a case where the ECU is replaced when the vehicle travel distance is 2800km;

FIG 11 is a flowchart showing a control operation of the ECU according to a third embodiment of the present invention; and

FIG 12 is a diagram showing an integrated value of learned deviation and a temporary learned value of the ECU according to the third embodiment of the present invention, and in particular, showing an example of a case where the ECU is replaced when the vehicle travel distance is 2800km.

DETAILED DESCRIPTION OF EMBODIMENTS

[0019] A fuel injection amount control device according to a first embodiment of the present invention will be described hereinafter. In the embodiment, a fuel injection amount control device that is installed in a common-rail diesel engine (internal combustion engine) and performs learning control of a pilot injection amount (injection amount of a fuel injection valve), and a fuel injection system including the fuel injection amount control device are described as an example.

[0020] FIG. 1 is a configuration diagram illustrating a fuel injection system of a diesel engine 1 according to the embodiment. The fuel injection system shown in FIG 1 is applied to a four-cylinder diesel engine 1, for example. The fuel injection system includes a common rail 2 serving as an accumulator that stores high-pressure fuel, a high-pressure fuel pump 4 that pressurizes fuel pumped out by a feed pump 10 from a fuel tank 3 and supplies the pressurized fuel to the common rail 2, an injector (fuel injection valve) 5 that injects the high-pressure fuel supplied from the common rail 2 into a cylinder (combustion chamber 1a) in the engine 1, and an electronic control unit 6 (hereinafter, referred to as an "ECU 6"), serving as a fuel injection amount control device that

controls this fuel injection system.

[0021] The ECU 6 sets a target fuel pressure, and the common rail 2 accumulates the high-pressure fuel supplied from the high-pressure fuel pump 4 at the target fuel pressure. A pressure sensor 7 that detects an accumulated fuel pressure (hereinafter, referred to as a "rail pressure") and outputs the detected rail pressure to the ECU 6, and a pressure limiter 8 that limits the rail pressure so as not to exceed a preset upper limit are attached to the common rail 2. When the rail pressure exceeds the upper limit, the pressure limiter 8 opens to vent the excess pressure to the fuel tank 3.

[0022] The high-pressure fuel pump 4 is provided with a plunger 12 and a solenoid regulator valve 14. The plunger 12 reciprocates in a cylinder 11 in synchronization with the rotation of a camshaft 9 that is rotated by the drive force from a crankshaft of the engine 1. The solenoid regulator valve 14 regulates or adjusts the fuel amount drawn into a compression chamber 13 in the cylinder 11 from the feed pump 10. In the high-pressure fuel pump 4, when the plunger 12 moves in the cylinder 11 from the top dead point to the bottom dead point, the solenoid regulator valve 14 regulates the fuel pumped out from the feed pump 10, and the fuel pushes open an inlet valve 15 to be drawn into the compression chamber 13. Then, when the plunger 12 moves in the cylinder 11 from the bottom dead point to the top dead point, the plunger 12 pressurizes the fuel in the compression chamber 13, and the pressurized fuel pushes open a discharge valve 16 to be pumped into the common rail 2. The solenoid regulator valve 14 is controlled by a control signal from the ECU 6 to vary the (cross-sectional) passage area of a fuel supply passage. By varying the passage area, the solenoid regulator valve 14 regulates or adjusts the amount of fuel introduced into the compression chamber 13 to adjust the discharge pressure of the fuel from the high-pressure fuel pump 4, thereby adjusting the rail pressure. More specifically, when fuel is not injected (during a fuel cut operation), such as when an accelerator angle is equal to "0," the solenoid regulator valve 14 is fully closed. On the other hand, the solenoid regulator valve 14 is widely opened to increase the rail pressure.

[0023] Each cylinder in the engine 1 is provided with an injector 5. The injector 5 is connected to the common rail 2 via a high-pressure pipe 17. The injector 5 includes a solenoid valve 5a that is operated based on a command from the ECU 6, and a nozzle 5b that injects a fuel when the solenoid valve 5a is energized. The solenoid valve 5a opens and closes a low-pressure passage that connects between a pressure chamber to which the high fuel pressure in the common rail 2 is applied and a low-pressure side. When the solenoid valve is energized, the low-pressure passage is opened. When the solenoid valve is de-energized, the low-pressure passage is closed.

[0024] The nozzle 5b includes a needle that opens and closes a nozzle hole. The fuel pressure in the pressure chamber biases the needle in the valve closing direction (direction to close the nozzle hole). Therefore, when the

low-pressure passage is opened by energizing the solenoid valve 5a and thereby the fuel pressure in the pressure chamber is reduced, the needle moves upward in the nozzle 5b to open the valve (open the nozzle hole) and the high-pressure fuel supplied from the common rail 2 is injected into the cylinder through the nozzle hole. On the other hand, when the low-pressure passage is closed by de-energizing the solenoid valve 5a, and thereby the fuel pressure in the pressure chamber is increased, the needle moves downward in the nozzle 5b to close the valve (close nozzle hole) and the injection ends.

[0025] An engine speed sensor 18 (for example, an electromagnetic pick up), an accelerator angle sensor 19, a pressure sensor 7 and the like are connected to the ECU 6. The engine speed sensor 18 outputs a pulse signal to calculate an engine speed. The accelerator angle sensor 19 detects an accelerator angle (an engine load). The pressure sensor 7 detects the rail pressure. The ECU 6 calculates a target rail pressure of the common rail 2 and an injection timing, injection amount, or the like appropriate for the operating condition of the engine 1 based on the information detected by the sensors 18, 19 and 7. Then, the ECU 6 electronically controls the solenoid regulator valve 14 of the high-pressure fuel pump 4 and the solenoid valve 5a of the injector 5 in accordance with the calculation result.

[0026] Further, a neutral switch 20 sends (inputs) a neutral signal to the ECU 6 when the shift position of the transmission is N (neutral) position. Also, a clutch-off sensor 21 sends (inputs) a clutch-off signal to the ECU 6 when a vehicle driver depresses a clutch pedal. The ECU 6 further includes an interface to connect to a terminal device 22, and predetermined information (such as a vehicle travel distance described later) is input to the ECU 6 through the terminal device 22.

[0027] In the fuel injection control performed by the ECU 6, a pilot injection with a very small amount of fuel is performed prior to the main injection performed at the beginning of an expansion stroke, and pilot injection amount learning control is performed to acquire an appropriate amount of the pilot injection. By performing the pilot injection with a very small amount of fuel prior to the main injection, the temperature in the combustion chamber 1a is lowered, fuel diffusion is enhanced during the main injection, and an ignition lag from fuel injection to ignition is shortened. As a result, combustion noises are reduced and NOx emission is reduced.

[0028] The ECU 6 stores a pilot injection amount setting map as shown in FIG. 2 in a ROM. The pilot injection amount setting map defines relationships between a pilot injection amount and an energization time (valve opening time) respectively for multiple levels (six levels in FIG. 2) of common rail pressure (a - f in FIG 2 that are set such that, for example, a = 32MPa, b = 48MPa, c = 64MPa, d = 80MPa, e = 96MPa, f = 112MPa). The energization time of the injector appropriate for a certain common rail pressure is acquired in accordance with the pilot injection

amount setting map, such that a command pilot injection amount, which is determined in accordance with an engine speed or the like, is acquired or achieved.

[0029] Next, a pilot injection amount learning control operation will be described with reference to the flowchart shown in FIG. 3. In the pilot injection amount learning control, a secular change in pilot injection amount of the injector 5 is learned, and the pilot injection amount of the injector 5 is corrected based on the learned value of the secular change.

[0030] In step ST1, the ECU 6 determines whether a learning condition to perform pilot injection amount learning control during an operation of the engine 1 is satisfied. More specifically, the learning condition is satisfied if all of the following three conditions (1) - (3) are satisfied. (1) The accelerator angle is equal to "0." (2) The shift position of the transmission is N (neutral) position or the clutch is off (disconnected). (3) A predetermined rail pressure is maintained.

[0031] The ECU 6 determines the above-described conditions based on the outputs of the accelerator angle sensor 19, the neutral switch 20, the clutch-off sensor 21 and the pressure sensor 7. Note that the learning conditions for the pilot injection amount learning control are not limited to the above conditions, but may be set any other appropriate conditions.

[0032] If the determination in step ST1 is negative, this control routine is once ended. On the other hand, if the determination in step ST1 is affirmative, the process proceeds to step ST2.

[0033] In step ST2, a single injection with a very small amount of fuel (an amount same as the pilot injection amount, for example) is performed as a learning injection into a particular cylinder (a cylinder in which a piston is positioned near the top dead point). Then, in step ST3, the change in engine speed due to the single injection is detected. The change in engine speed is detected based on the output signal from the engine speed sensor 18.

[0034] In step ST4, the ECU 6 calculates the difference between a command fuel injection amount (a target injection amount determined by the ECU 6) and an actual fuel injection amount by the single injection. The difference (hereinafter, sometimes referred to as "deviation") between the command fuel injection amount and the actual fuel injection amount is set as a learned deviation (learned value). Further, the pilot injection amount of the injector 5 is corrected based on the learned deviation. In other words, the ECU 6 compares the change in engine speed when a single injection with the command fuel injection amount is assumed to be performed (this change is stored in the memory in the ECU 6 in advance) with the change in actual engine speed corresponding to the actual fuel injection amount, and calculates the learned deviation (learned value) of the fuel injection amount from the difference in the engine speed. Then, the pilot injection amount setting map (see FIG 2) described above is corrected based on the calculated learned deviation. Preferably, multiple single injections

may be performed (for example, 10 times) for each combination of a rail pressure and a cylinder to acquire multiple deviations between the command fuel injection amount and the actual fuel injection amount, and an average of the multiple deviations may be set as the learned deviation related to the combination of the rail pressure and the cylinder.

[0035] The above-described pilot injection amount learning control is performed per cylinder per rail pressure. When the steps ST1 to ST4 are performed for all cylinders and for all rail pressures (six rail pressures shown in FIG 2), the pilot injection amount learning control ends. Thereafter, the pilot injection amount learning control is preformed at appropriate times, and the deviation (secular change) of the pilot injection amount due to the degradation of the injector 5 over time is appropriately calculated.

[0036] The above-described pilot injection amount learning control is performed at such a frequency that the deviation in the pilot injection amount of the injector 5 does not exceed a predetermined injection amount correction accuracy line (for example, 0.2mm^3). In FIG. 4, the horizontal axis indicates a vehicle travel distance, and the vertical axis indicates a deviation in the pilot injection amount of the injector 5. The zigzag line L1 indicates a deviation in the pilot injection amount of the injector 5 of a specific cylinder with a specific rail pressure. This zigzag line L1 indicates a case in which the pilot injection amount learning control is performed at an appropriate timing, that is, when the difference amount matches the injection amount correction accuracy line L2. Thus, the pilot injection amount is corrected such that the deviation is equal to zero at the vehicle travel distances 100km, 600km, 1600km and 3600km.

[0037] In FIG 5, the horizontal line indicates a vehicle travel distance, and the vertical line indicates the deviation and a learned deviation of the pilot injection amount of the injector 5. More specifically, the curve L3 indicates an example of a deviation of the pilot injection amount of the injector 5 when the pilot injection amount learning control has never been performed. The line L4 indicates an integrated value of learned deviation shown in FIG 4. As shown in line L4, when the vehicle travel distances are 100km, 600km, 1600km and 3600km, the deviation of 0.2mm^3 is calculated as the learned deviation. In this case, the integrated value of the learned deviation at 100km, 600km, 1600km and 3600km are respectively 0.2mm^3 , 0.4mm^3 , 0.6mm^3 and 0.8mm^3 .

[0038] Pilot injection amount correction control of the injector 5 when the ECU is replaced will be described hereinafter.

[0039] The ECU 6 stores a degradation trend map L5 shown by a solid line in FIG 6 in the ROM. The degradation trend map L5 indicates a mean value of deviations (secular changes) in the pilot injection amount of the injector 5 estimated per vehicle travel distance when the pilot injection amount learning control has never been performed. Thus, the degradation trend map L5 indicates

a relationship between the estimated secular change and the vehicle travel distance. The degradation trend map L5 may sometimes be referred to as an "estimated secular change information," hereinafter. The curve L6 shows the fastest secular change in the pilot injection amount, and the curve L7 shows the slowest secular change in the pilot injection amount. Therefore, the deviation of the pilot injection amount of the injector 5 when the pilot injection amount has never been corrected by the pilot injection amount learning control falls between the curve L6 and the curve L7 in most cases, and results in a value close to the curve (degradation trend map) L5 with high probability. The curves L5 to L7 can be acquired in advance through experiments, or the like.

[0040] Hereinafter, an example when the secular change in the pilot injection amount progresses the most rapidly (the case of curve L6) will be described. In addition, in the following description, it is assumed that the curve L3 shown in FIG 5 indicates the case where the secular change in the pilot injection amount progresses the most rapidly.

[0041] It is assumed that, when a failure occurs in the ECU 6 installed on a vehicle and the ECU 6 is replaced, the vehicle travel distance is, for example, 2800km. In this case, as shown in FIG. 5, in the memory in the ECU 6 before the replacement, 0.6mm^3 is stored as an integrated value of learned deviation. However, in the memory of the ECU 6 after the replacement, an initial value (0mm^3) is stored as the integrated value of learned deviation. Therefore, if nothing is done, the deviation of the pilot injection amount of the degraded injector 5 is large and therefore a good pilot injection cannot be performed. In other words, because the pilot injection is performed according to a default pilot injection amount setting map corresponding to a new injector 5, the deviation increases and good pilot injection cannot be performed.

[0042] Therefore, the ECU 6 after the replacement calculates a temporary learned value of the pilot injection amount of the injector 5 in accordance with the degradation trend map L5 and a vehicle travel distance input from the terminal device 22, and corrects the pilot injection amount of the injector 5 using the temporary learned value instead of the default value until the first pilot injection amount learning control is completed after the replacement of the ECU 6. The operation for correcting the pilot injection amount will be described hereinafter with reference to FIG. 7.

[0043] In step ST11, the ECU 6 after the replacement (hereinafter, simply referred to as "ECU 6") determines whether a vehicle travel distance is input from the terminal device 22. If the determination in step ST11 is affirmative, the control process proceeds to step ST12. On the other hand, if the determination in step ST11 is negative, this control routine is once ended.

[0044] In step ST12, the ECU 6 calculates a temporary learned value of the pilot injection amount of the injector 5 (temporary integrated value of learned deviation) based on the input vehicle travel distance and the degradation

trend map (estimated secular change information) L5. In other words, the ECU 6 acquires the value (deviation) on the degradation trend map L5 shown in FIG 6 corresponding to the input vehicle travel distance, as the temporary learned value.

[0045] In step ST13, the ECU 6 sets the calculated temporary learned value as the integrated value of the learned deviation (learned value) to be used in the correction of the pilot injection amount of the injector 5, and corrects the pilot injection amount of the injector 5 based on the temporary learned value. In other words, the ECU 6 corrects the pilot injection amount setting map (see FIG 2) using the temporary learned value as the integrated value of learned deviation. The correction of the pilot injection amount using the temporary learned value continues until the first pilot injection amount learning control is completed and the learned deviation is acquired through the first pilot injection amount leaning control. Incidentally, when the first pilot injection amount learning control is completed after the replacement of the ECU, the integrated value of the learned deviation used to correct the pilot injection amount is updated from the temporary learned value to the learned value newly acquired by the first pilot injection amount learning control.

[0046] According to the ECU 6 described above, as shown in FIG 8, the temporary learned value F is used as the integrated value of the learned deviation to correct the pilot injection amount until the first pilot injection amount learning control is completed after the ECU is replaced. Thus, during this period, the deviation of the pilot injection amount of the injector 5 is difference "a" between the value on the curve L6 and the temporary learned value F. Compared to the conventional case in which the deviation of the pilot injection amount of the injector 5 after replacement of the ECU is difference "b" between the value on the curve L6 and the default value, the accuracy of the pilot injection amount improves significantly.

[0047] In the meantime, if the deviation of the pilot injection amount of the injector 5 changes over time along the curve L7, the deviation in the pilot injection amount of the injector 5 after the correction is difference "c" between the value on the curve L7 and the temporary learned value F. In this case, the deviation of the conventional way is difference "d" between the value on the curve L7 and the default value. Therefore, the accuracy of the pilot injection amount does not much improve. However, because the degradation trend map L5 indicates the mean value of the estimated deviations of the pilot injection amount of the injector 5 (for each vehicle travel distance) when the pilot injection amount learning control has never been performed, the temporary learned value F calculated based on the degradation trend map L5 and the input vehicle travel distance is highly likely to be the value close to the integrated value of the learned deviation stored in the ECU before the replacement. Therefore, according to the ECU 6, in many cases, the degradation in accuracy of the pilot injection amount after

the replacement of the ECU, which conventionally occurred, can be avoided.

[0048] A second embodiment of the present invention will be described. In the second embodiment, the difference between the first embodiment and the second embodiment will be mainly described. Like elements are denoted by the like reference numerals in the drawings, and the description thereof will be omitted hereinafter.

[0049] The ECU 6 in the first embodiment is different from the ECU 6A in the second embodiment in a portion of the pilot injection amount correction control operation performed when the ECU is replaced. The difference is described with reference to the flowchart shown in FIG 9.

[0050] In step ST21, the ECU 6A after replacement (hereinafter, simply referred to as "ECU 6A") determines whether a vehicle travel distance is input from the terminal device 22. If the determination in step ST21 is affirmative, the process proceeds to step ST22. On the other hand, if the determination in step ST21 is negative, this control routine is once ended.

[0051] In step ST22, the ECU 6A enters an injector learning priority mode. In the injector learning priority mode, the ECU 6A executes the pilot injection amount learning control described with reference to FIG. 3 in priority to other learning processes, and execution frequency of the pilot injection amount learning control increases than before entering the injector learning priority mode. The other leaning processes means learning processes other than the pilot injection amount learning control operation, but shares an operation resource (ECU etc.) with the pilot injection amount learning control operation. Incidentally, in this embodiment, the input of the vehicle travel distance from the terminal device 22 in step ST21 is used as an input of a command to enter the injector learning priority mode. However, the command to enter the injector learning priority mode may be input independently from the input of vehicle travel distance.

[0052] Step ST23 is an operation similar to that of step ST12, and step ST24 is an operation similar to that of step ST13. Therefore, description thereof will be omitted here.

[0053] In step ST25, the ECU 6A determines whether the first pilot injection amount learning control after replacement of the ECU is completed. If the determination in step ST25 is affirmative, the process proceeds to step ST26. On the contrary, if the determination in step ST25 is negative, the determination in step ST25 is performed repeatedly.

[0054] In step ST26, the ECU 6A cancels (ends) the injector learning priority mode and ends this control routine.

[0055] According to the ECU 6A, as shown in FIG 10, the time period T2 in which the temporary learned value is used to correct the pilot injection amount is reduced, compared to the same time period T1 in the case where the ECU does not enter the injector learning priority mode. Therefore, the injector 5 can recover the most suitable injection state quickly after the replacement of the

ECU.

[0056] A third embodiment of the present invention will be described hereinafter. In the following description, the difference between the first embodiment and the third embodiment will be mainly described. In the drawings, like elements will be denoted by like reference numerals, and the description thereof will be omitted.

[0057] The ECU 6 in the first embodiment is different from the ECU 6B in the third embodiment in the pilot injection amount correction control operation when the ECU is replaced. The difference is described with reference to the flowchart shown in FIG. 11.

[0058] In step ST31, the ECU 6B determines whether a predetermined command (command to enter the injector learning priority mode) is input from the terminal device 22. If the determination in step ST31 is affirmative, the process proceeds to step ST32. On the contrary, if the determination in step ST31 is negative, this control routine is once ended.

[0059] In step ST32, the ECU 6B enters the injector learning priority mode. In the injector learning priority mode, the ECU 6B executes the pilot injection amount learning control described above with reference to FIG. 3 in priority to other learning processes, and the execution frequency of the pilot injection amount learning control increases than before entering the injector learning priority mode.

[0060] Then, when the first pilot injection amount learning control after replacement of ECU is completed (step ST33: YES), the injector learning priority mode is canceled in step ST34, and this control routine ends.

[0061] According to the ECU 6B, as shown in FIG. 12, the time period T3 in which the default value (0) is used to correct the pilot injection amount is reduced, compared to the same time period T1 in the case where the ECU does not enter the injector learning priority mode. Therefore, the injector 5 can recover the most suitable injection state quickly after the replacement of the ECU.

[0062] In the above-described first to third embodiments, in-cylinder direct fuel injection engine in which fuel is directly injected into a combustion chamber from an injector is described as an example. However, an engine (a port-injection engine) in which fuel is injected into an intake pipe may be used, instead. In addition, an engine in which fuel is injected into both a combustion chamber and an intake pipe may be used. Further, the present invention is not limited to a diesel engine; rather the present invention may be applied to the fuel injection in an in-cylinder direct injection gasoline engine or a port-injection gasoline engine.

[0063] Furthermore, in the above-described first to third embodiments, the injection amount learning control is performed for pilot injection. However, the present invention is not limited to the pilot injection. Rather, the injection amount learning control may be performed for main injection or after injection, which is performed after the main injection.

[0064] In addition, the command to enter the injector

learning priority mode may not be input from the terminal device 22. For example, switches may be connected to the ECU 6A or 6B, and a predetermined switch signal input from the switches may be used as the command to enter the injector learning priority mode.

[0065] The present invention may be used, for example, in a fuel injection amount control apparatus that performs learning control to correct secular change in a pilot injection amount of a diesel engine.

[0066] While some embodiments of the invention have been illustrated above, it is to be understood that the invention is not limited to details of the illustrated embodiments, but may be embodied with various changes, modifications or improvements, which may occur to those skilled in the art, without departing from the spirit and scope of the invention.

Claims

1. A fuel injection amount control device (6, 6A) **characterized by** comprising:

learning means for learning a secular change in an injection amount of a fuel injection valve (5) to acquire a learned value;

correcting means for correcting the injection amount of the fuel injection valve based on the learned value acquired by the learning means; and

temporary learned value calculating means for calculating a temporary learned value of the injection amount of the fuel injection valve based on an input travel distance of a vehicle and an estimated secular change information (L5) indicating the secular change in the injection amount of the fuel injection valve estimated per travel distance of the vehicle,

wherein the correcting means corrects the injection amount of the fuel injection valve based on the temporary learned value calculated by the temporary learned value calculating means instead of the learned value until the learning means completes an acquisition of the learned value after the travel distance is input.

2. The fuel injection amount control device according to claim 1, further comprising fuel injection valve learning priority means for performing the learning by the learning means in priority to other learning after a command to enter a fuel injection valve learning priority mode is input until the learning by the learning means is completed and the learned value is acquired.
3. The fuel injection amount control device according to claim 1 or 2, wherein the estimated secular change

information is a mean value of empirically acquired secular changes in the injection amount of the fuel injection valve per travel distance, and the fuel injection amount control device further comprises storage means that stores the estimated secular change information in advance. 5

4. The fuel injection amount control device according to claim 2, wherein the command to enter the fuel injection valve learning priority mode is the input of the travel distance. 10

5. A fuel injection amount control device (6B) **characterized by** comprising: 15

learning means for learning a secular change in an injection amount of a fuel injection valve (5) to acquire a learned value;
correcting means for correcting the injection amount of the fuel injection valve based on the learned value acquired by the learning means; 20
and
fuel injection valve learning priority means for performing the learning by the learning means in priority to other learning after a command to enter a fuel injection valve learning priority mode is input until the learning by the learning means is completed and the learned value is acquired. 25

6. A fuel injection amount control method **characterized by** comprising the steps of: 30

learning a secular change in an injection amount of a fuel injection valve to acquire a learned value; 35
correcting the injection amount of the fuel injection valve based on the acquired learned value; inputting a travel distance of a vehicle (ST11, ST12);
calculating a temporary learned value of the injection amount of the fuel injection valve based the input travel distance and an estimated secular change information indicating the secular change in the injection amount of the fuel injection valve estimated per travel distance of the vehicle (ST12, ST23); and 40
correcting the injection amount of the fuel injection valve based on the calculated temporary learned value instead of the learned value until the acquisition of the learned value is completed after the travel distance is input (ST13, ST24). 45 50

7. A fuel injection amount control method **characterized by** comprising the steps of: 55

learning a secular change in an injection amount of a fuel injection valve to acquire a learned value;

correcting the injection amount of the fuel injection valve based on the acquired learned value; inputting a command to enter a fuel injection valve learning priority mode (ST31); and performing the learning of the secular change in priority to other learning after the command to enter the fuel injection valve learning priority mode is input until the learning of the secular change is completed and the learned value is acquired (ST32, ST33).

FIG. 1

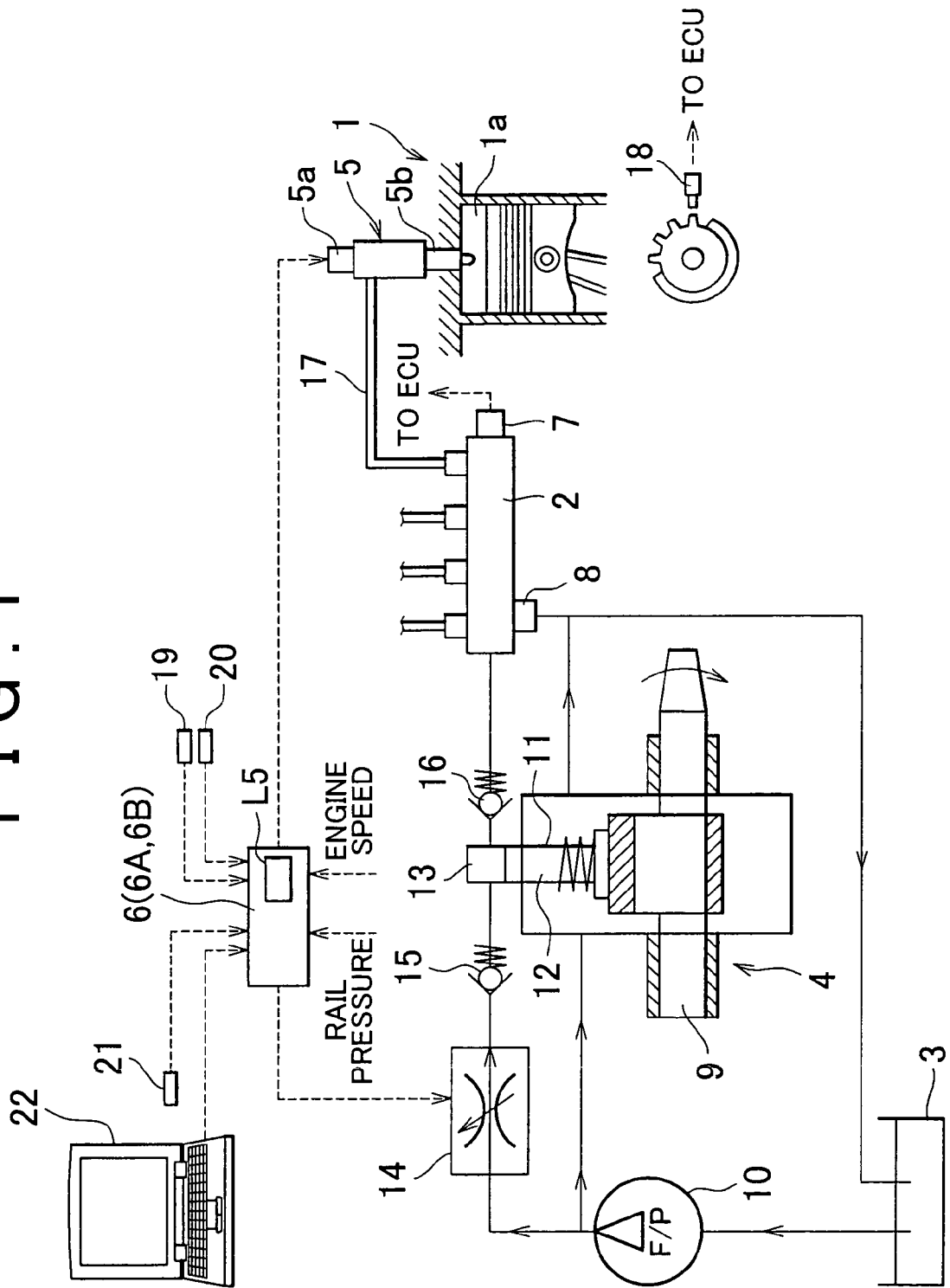


FIG. 2

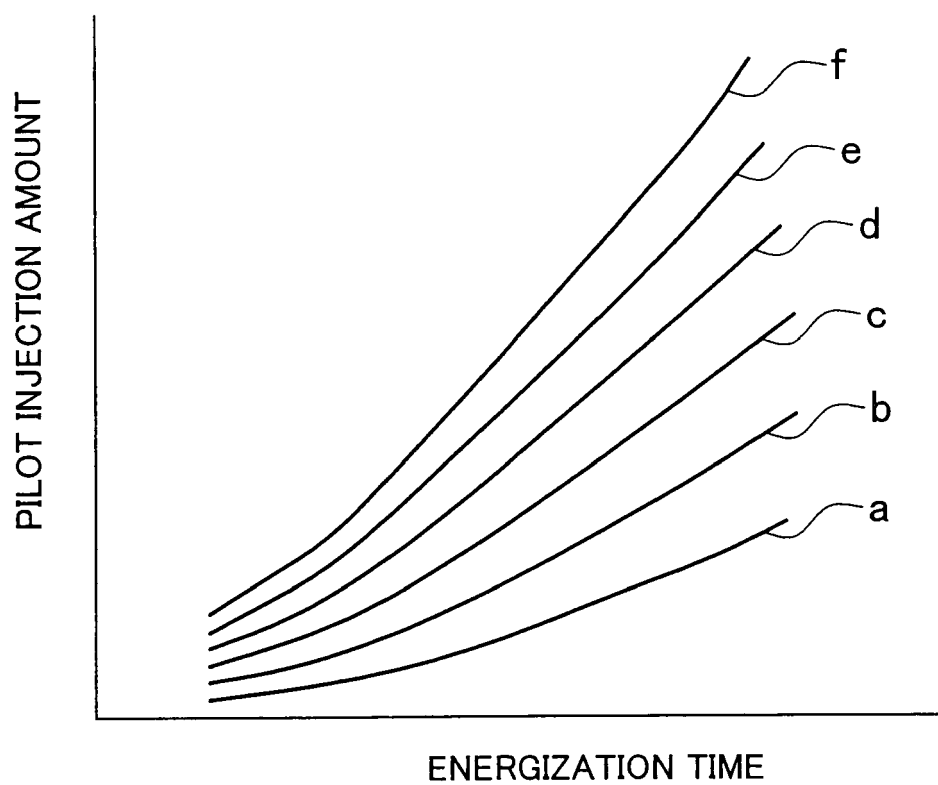


FIG. 3

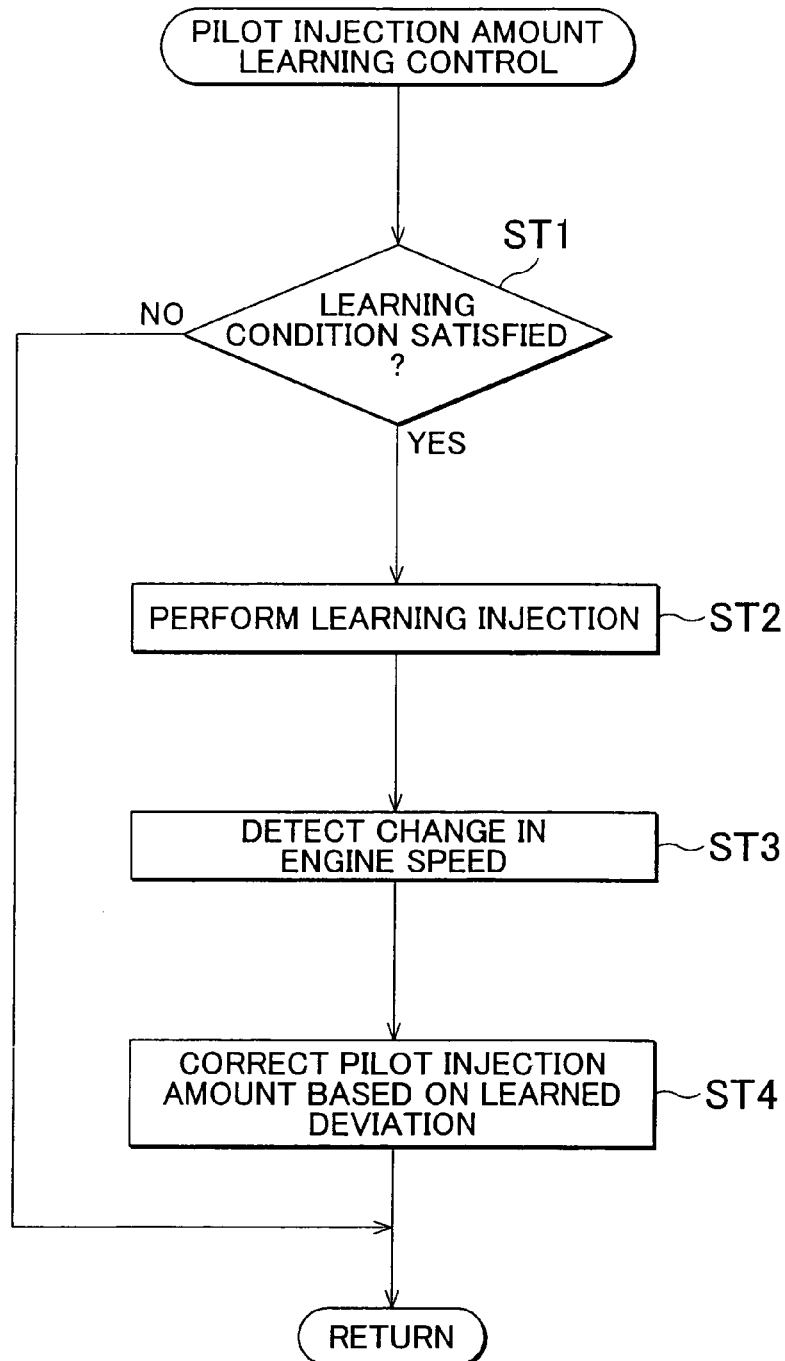


FIG. 4

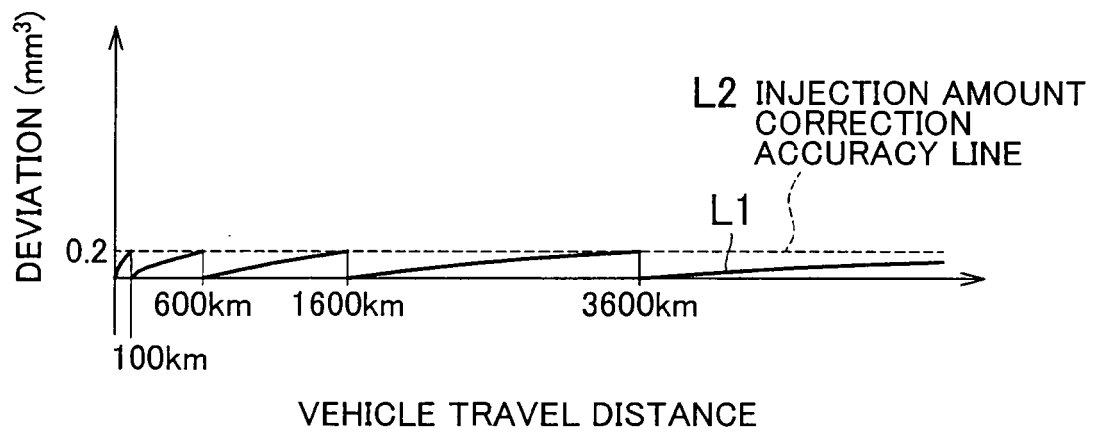


FIG. 5

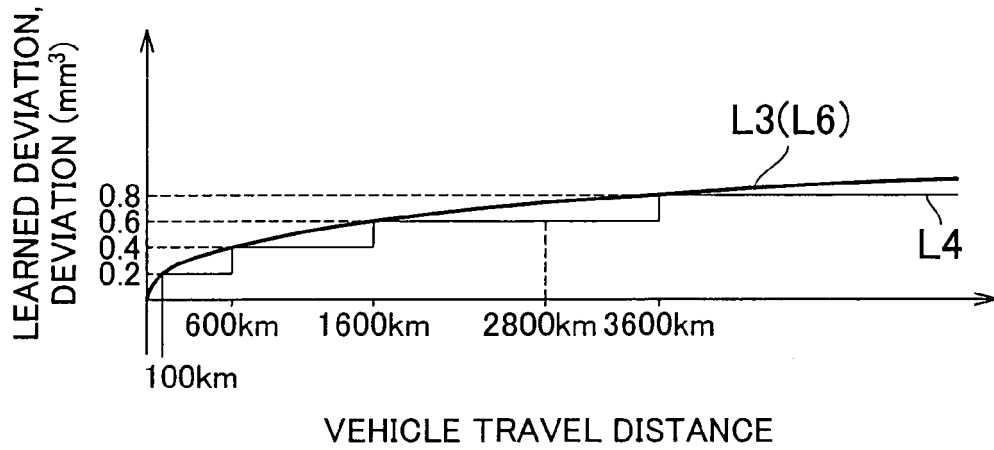


FIG. 6

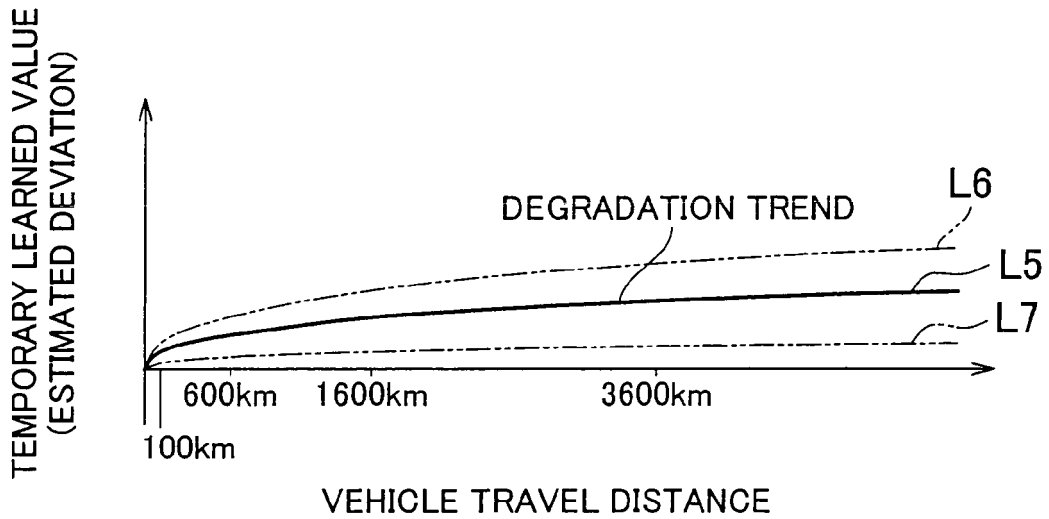


FIG. 7

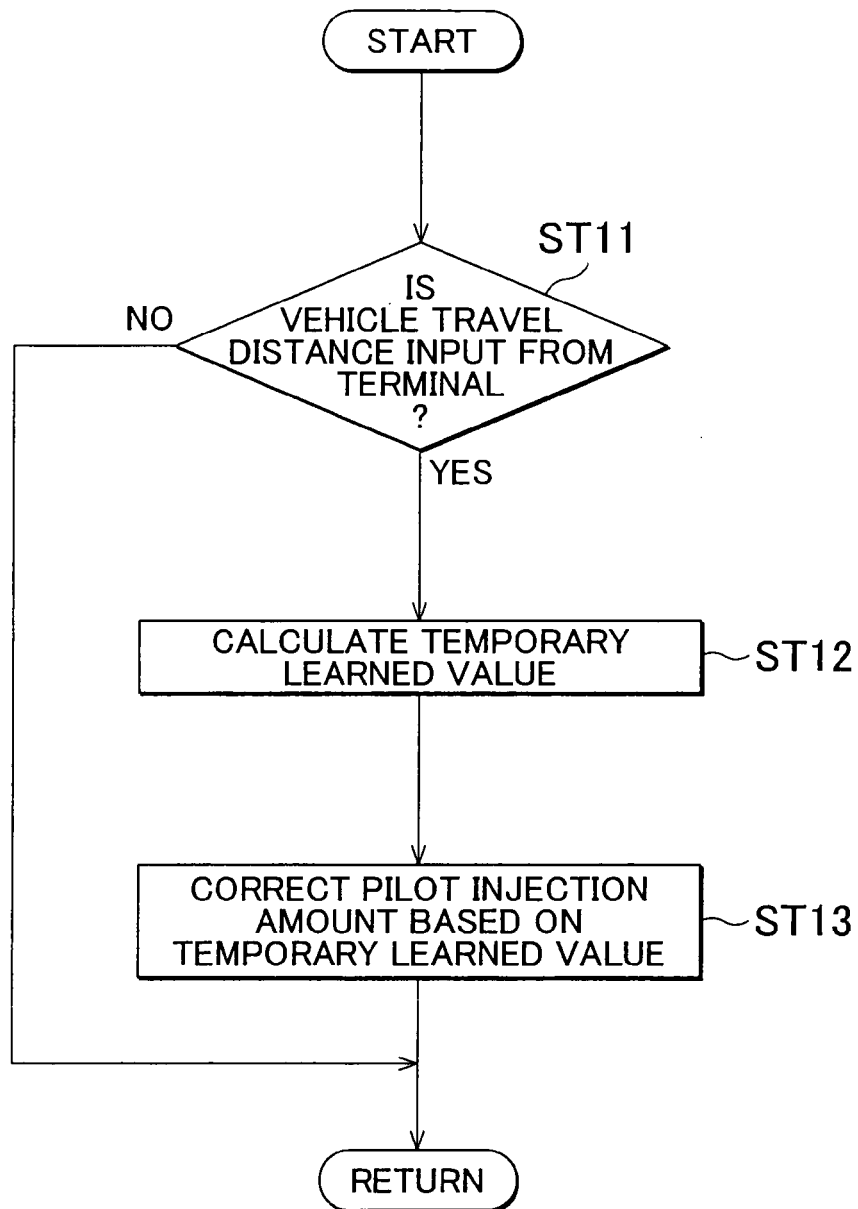


FIG. 8

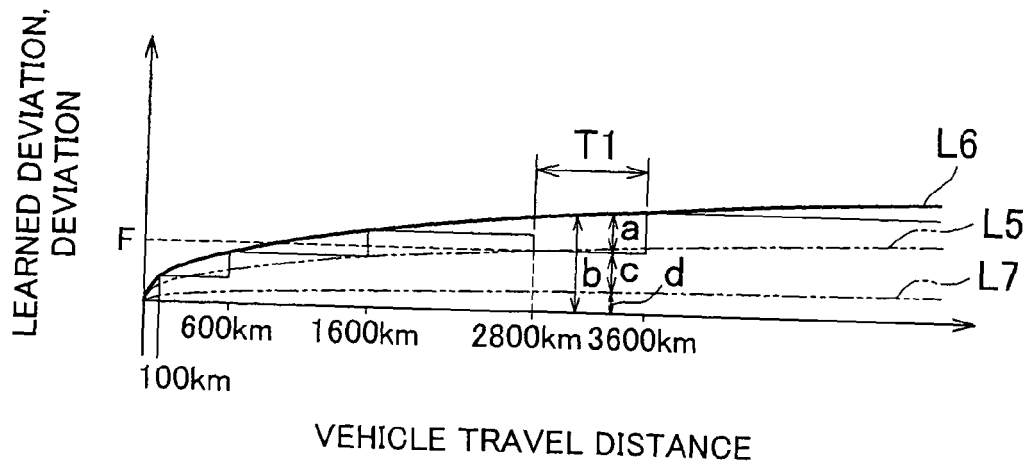


FIG. 9

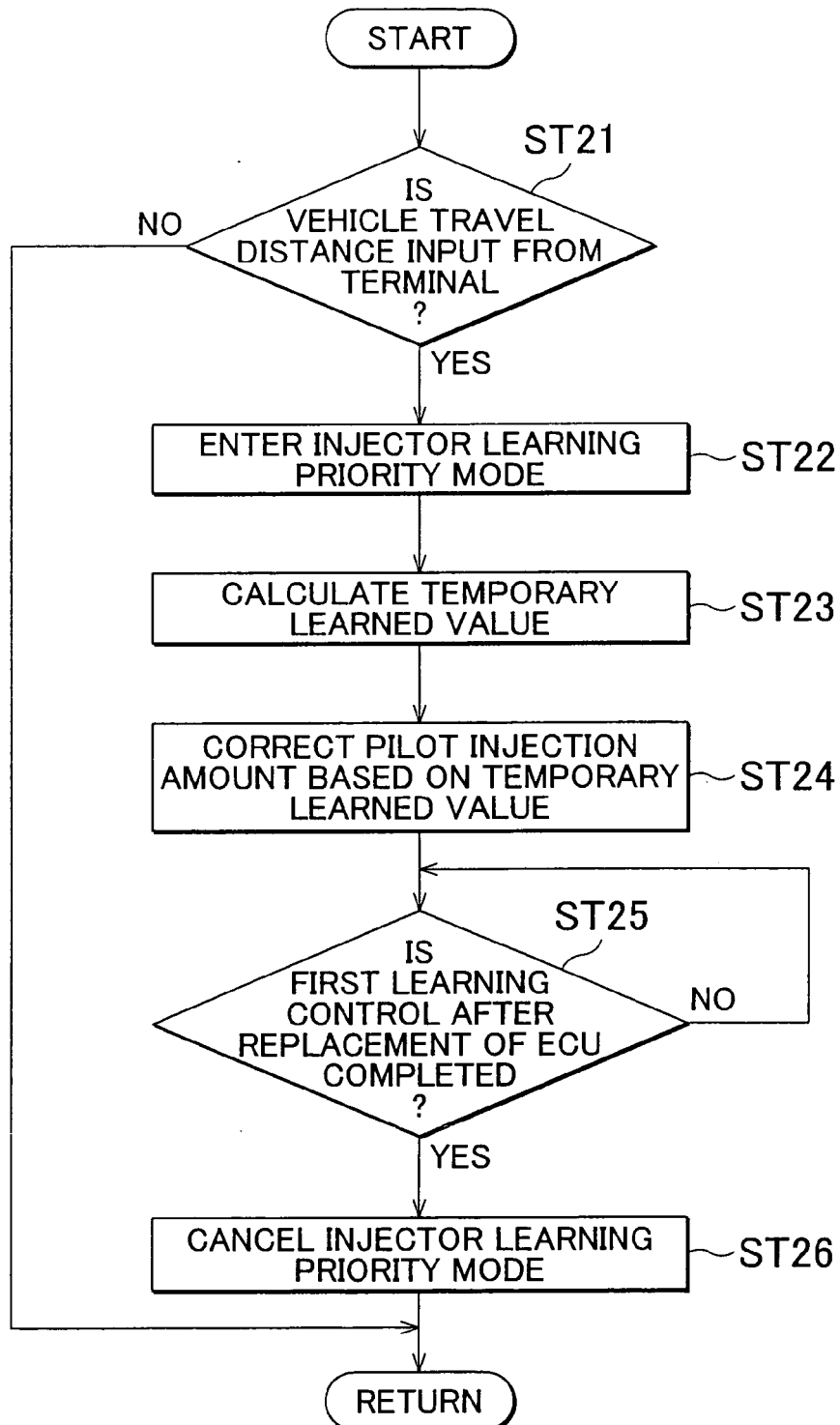


FIG. 10

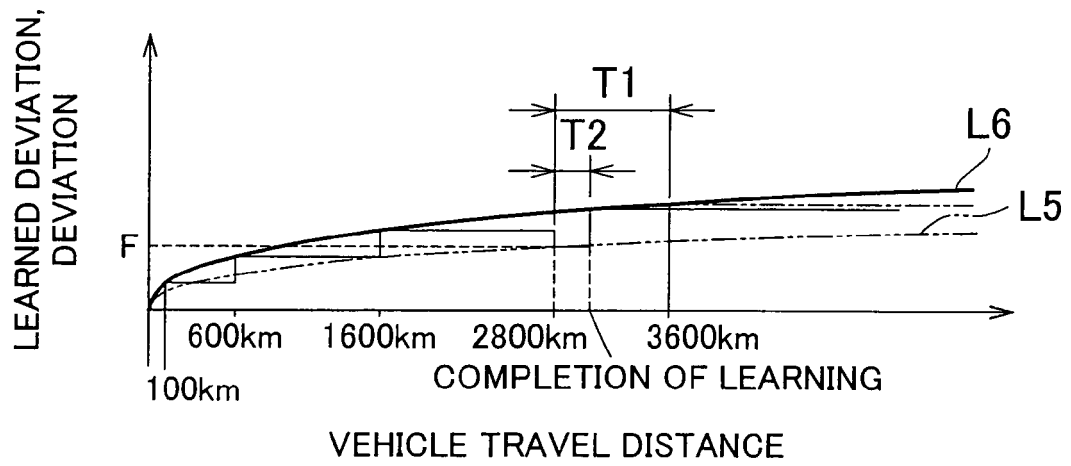


FIG. 11

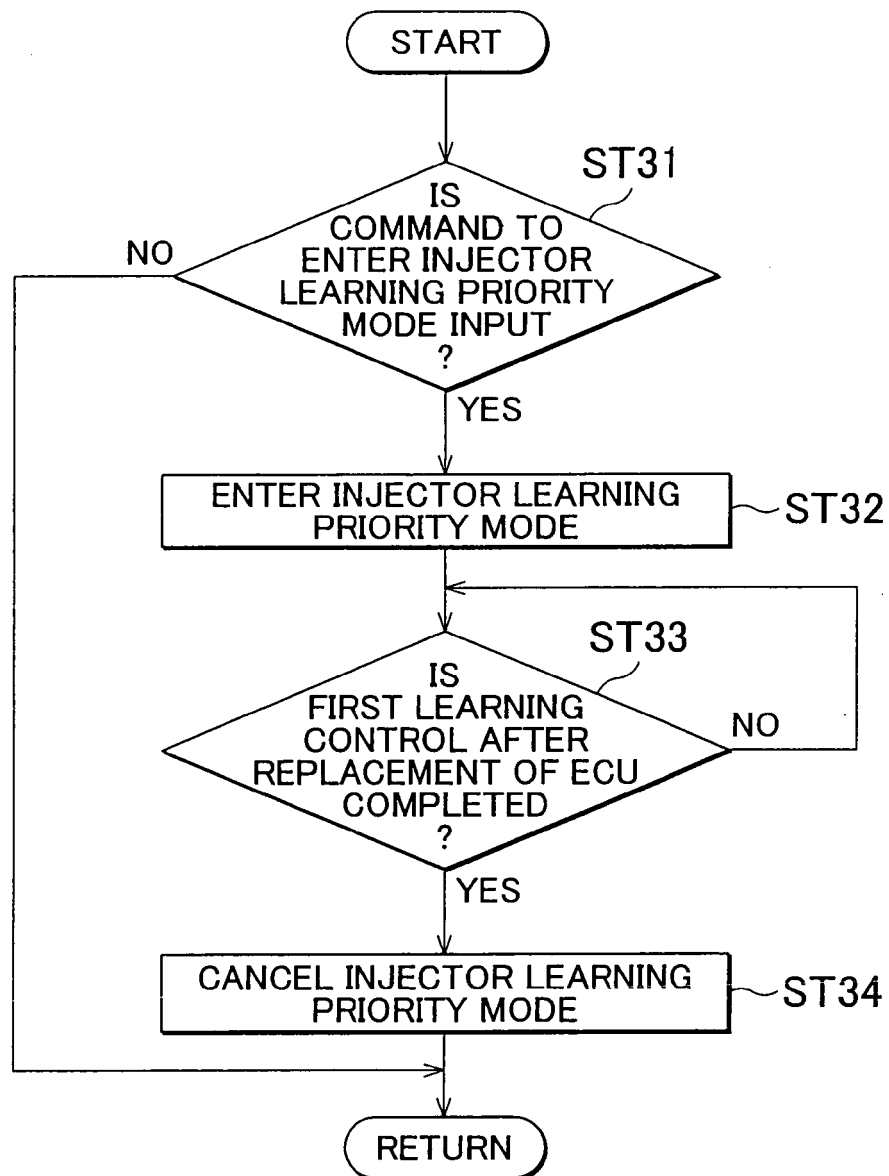
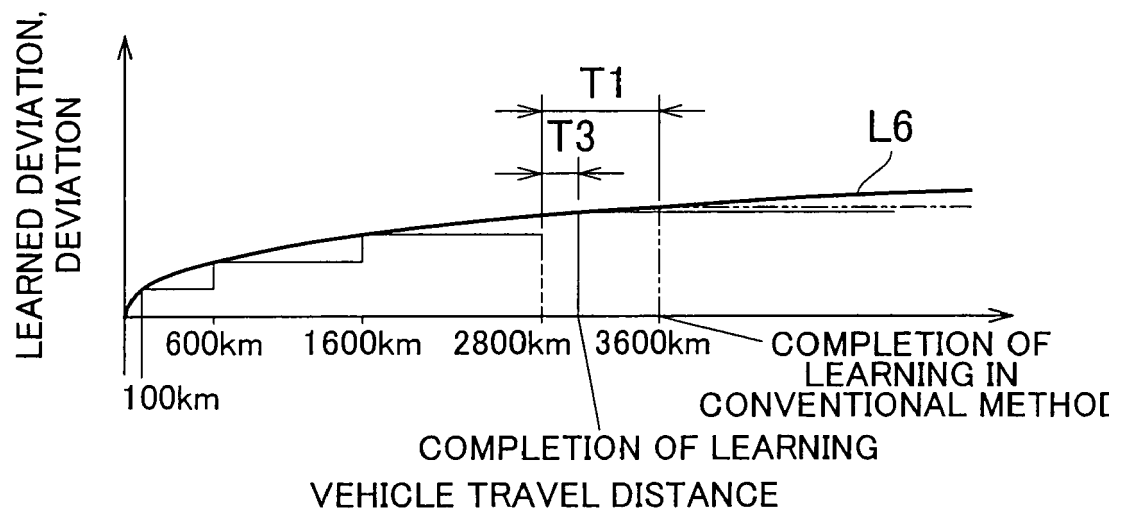


FIG. 12



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2001065399 A [0003] [0007]
- JP 2003056398 A [0004] [0008]
- JP 2001349259 A [0005]
- JP 2005036788 A [0006]