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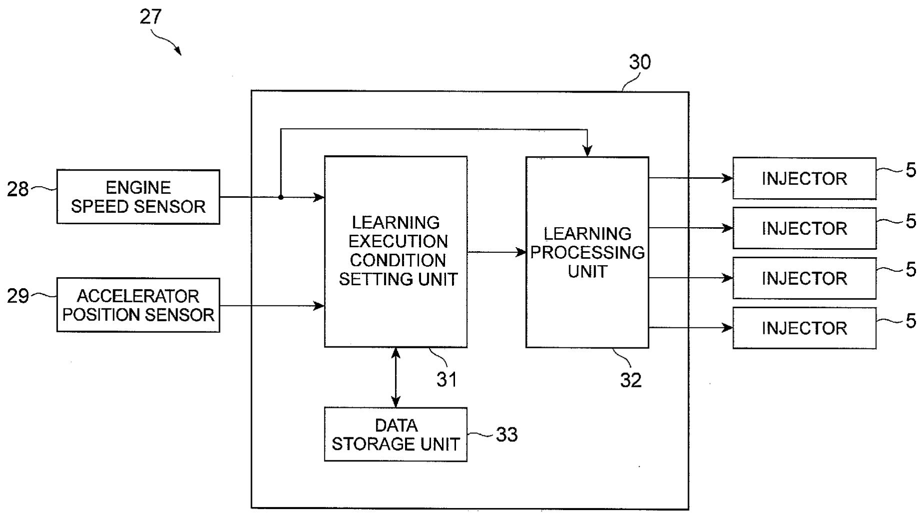
(54) Fuel injection control device

(57) A fuel injection control device (27) injects fuel for learning into a combustion chamber (4) of an engine (1) from a nozzle (7) of a fuel injection valve (5), to perform learning of injection quantity of the fuel injection valve (5). The fuel injection control device (27) is provided with an exposed heat temperature detection means (28, 31) for detecting an exposed heat temperature of the nozzle (7), an exposed heat amount acquisition means (31) for acquiring an exposed heat amount of the nozzle (7), based on the exposed heat temperature of the nozzle (7) detected by the exposed heat temperature detection means (28, 31) and an operating time of the engine (1), and a learning interval change means (31) for changing an interval of execution of the injection quantity learning, according to the exposed heat amount of the nozzle (7) acquired by the exposed heat amount acquisition means (31).

Fig.3



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Description

Technical Field

[0001] The present invention relates to a fuel injection control device to implement learning of quantity of fuel (injection quantity) to be injected from a fuel injection valve.

Background Art

[0002] It is known that pilot injection is carried out in a diesel engine, in order to reduce combustion noise and control NOx. In the pilot injection, an extremely small quantity of fuel is injected prior to main injection. Improvement in fuel injection accuracy in small quantity is required for the pilot injection with the small injection quantity, in order to fully exhibit the effects of reduction of combustion noise and control of NOx. Then the control as described below is proposed. Fuel injection for learning is carried out under an operating condition that an engine state is no load to cut fuel in general. A quantity of fuel actually injected from fuel injection valves (real injection quantity) is estimated based on an engine speed change of the engine caused by the learning fuel injection and correction is made for a difference between the real injection quantity and a command injection quantity to the fuel injection valves. The difference between the real injection quantity and the command injection quantity is made by instrumental difference and temporal change of injection-related components including the fuel injection valves.

[0003] For example, the technology described in Patent Literature 1 is known as a conventional technology to perform the learning of injection quantity of the fuel injection valves as described above. The technology described in Patent Literature 1 is as described below. Once the learning condition is met, single-shot injection for learning is executed by the fuel injection valves. The real injection quantity is calculated based on a change of the engine speed upon execution of the single-shot injection for learning, and an average and a standard deviation of real injection quantities are calculated. If the standard deviation of real injection quantities is within a target accuracy range and if the number of single-shots for learning is not less than a minimum injection number, a correction amount for the command injection quantity is calculated based on a deviation between the average of real injection quantities and a target injection quantity.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Patent Application Laid-open No. 2010-261334

Summary of Invention

Technical Problem

[0005] Injection quantity change characteristics of the fuel injection valves differ depending upon operating conditions of a vehicle. For this reason, a difference can be made between the real injection quantity and the learning value (command injection quantity after learning) if the learning timing does not suit an injection quantity change situation of the fuel injection valves. Specifically, the difference between the real injection quantity and the learning value tends to increase if the interval of learning is too long with a significant change in the injection quantity of the fuel injection valves. The difference between the real injection quantity and the learning value leads to increase of exhaust particulate matter and degradation of combustion sound. However, the foregoing conventional technology does not take the learning timing into consideration at all.

[0006] An object of the present invention is to provide a fuel injection control device capable of promptly decreasing the difference between the real injection quantity and the learning value of the fuel injection valve.

Solution to Problem

[0007] The present invention provides a fuel injection control device which injects fuel for learning into a combustion chamber of an engine from a nozzle of a fuel injection valve, to perform injection quantity learning of the fuel injection valve, the fuel injection control device comprising: exposed heat temperature detection means for detecting an exposed heat temperature of the nozzle; exposed heat amount acquisition means for acquiring an exposed heat amount of the nozzle, based on the exposed heat temperature of the nozzle detected by the exposed heat temperature detection means and an operating time of the engine; and learning interval change means for changing an interval of execution of the injection quantity learning, according to the exposed heat amount of the nozzle acquired by the exposed heat amount acquisition means.

[0008] In the present invention, the exposed heat temperature of the nozzle of the fuel injection valve is detected, the exposed heat amount of the nozzle is acquired based on the exposed heat temperature of the nozzle and the operating time of the engine, and the interval of execution of the injection quantity learning (which will also be referred to hereinafter as "learning interval") is changed according to the exposed heat amount of the nozzle. Since the learning is executed at appropriate timing according to an injection quantity change characteristic of the fuel injection valve, the difference between the real injection quantity and the learning value (command injection quantity after learning) of the fuel injection valve can be reduced in an early stage.

[0009] The below will describe an example of a break-in period of the fuel injection valve. In the break-in period of the fuel injection valve, the real injection quantity of the fuel injection valve changes in a non-linear pattern. Namely, a change rate of real injection quantity is large in an initial region of the break-in period and a change rate of real injection quantity is small in a terminal region of the break-in period. In the initial region of the break-in period, the exposed heat amount of the nozzle is small. Therefore, if the learning interval is set short with the exposed heat amount of the nozzle being small, the frequency of execution of learning will increase in the initial region of the break-in period where the change rate of real injection quantity is large. The exposed heat amount of the nozzle is large in the terminal region of the break-in period. Therefore, if the learning interval is set long with the exposed heat amount of the nozzle being large, the frequency of execution of learning will decrease in the terminal region of the break-in period where the change rate of real injection quantity is small.

[0010] The exposed heat temperature detection means may have: means for detecting an engine speed of the engine; and means for acquiring the exposed heat temperature of the nozzle, based on the engine speed of the engine and an injection quantity of the fuel injection valve. In this case, since the exposed heat temperature of the nozzle is acquired based on the detected engine speed of the engine and the injection quantity of the fuel injection valve, the exposed heat temperature of the nozzle of the fuel injection valve can be readily detected.

[0011] The fuel injection control device may further comprise determination means for determining whether the fuel injection valve is in a break-in period, and, when the determination means determines that the fuel injection valve is in the break-in period, the learning interval change means may change the interval of execution of the injection quantity learning, according to the exposed heat amount of the nozzle. Since the change of the real injection quantity of the fuel injection valve proceeds in a short period under an operating condition that the exposed heat temperature of the nozzle becomes high, in the break-in period of the fuel injection valve, a difference is readily made between the real injection quantity and the learning value of the fuel injection valve. Therefore, since the learning interval is changed according to the exposed heat amount of the nozzle in the break-in period of the fuel injection valve, the difference between the real injection quantity and the learning value of the fuel injection valve can be securely and promptly reduced.

[0012] The fuel injection control device may further comprise learning-time injection number change means for changing an injection number of the fuel for learning, according to the exposed heat amount of the nozzle acquired by the exposed heat amount acquisition means. In this case, since the learning is executed in a short period according to the injection quantity change characteristic of the fuel injection valve, the difference between the real injection quantity and the learning value of the fuel injection valve can be more promptly reduced.

[0013] The below will again describe an example of the aforementioned break-in period of the fuel injection valve. The exposed heat amount of the nozzle is small, as described above, in the initial region of the break-in period. Therefore, if the injection number of the fuel for learning (which will also be referred to as "learning-time injection number") is set small with the exposed heat amount of the nozzle being small, the learning will be completed sooner in the initial region of the break-in period where the change rate of real injection quantity is large. The exposed heat amount of the nozzle is large, as described above, in the terminal region of the break-in period. Therefore, if the learning-time injection number is set large with the exposed heat amount of the nozzle being large, the accuracy of learning improves in the terminal region of the break-in period where the change rate of real injection quantity is small.

[0014] The fuel injection control device may further comprise determination means for determining whether the fuel injection valve is in the break-in period; when the determination means determines that the fuel injection valve is in the break-in period, the learning interval change means may change the interval of execution of the injection quantity learning, according to the exposed heat amount of the nozzle; when the determination means determines that the fuel injection valve is in the break-in period, the learning-time injection number change means may change the injection number of the fuel for learning, according to the exposed heat amount of the nozzle. Since the change of the real injection quantity of the fuel injection valve proceeds in a short period under the operating condition that the exposed heat temperature of the nozzle becomes high, in the aforementioned break-in period of the fuel injection valve, the difference between the real injection quantity and the learning value of the fuel injection valve is readily made. Therefore, since the learning interval and learning-time injection number are changed according to the exposed heat amount of the nozzle in the break-in period of the fuel injection valve, the difference between the real injection quantity and the learning value of the fuel injection valve can be more securely and promptly reduced.

Advantageous Effect of Invention

[0015] The present invention can provide the fuel injection control device capable of promptly reducing the difference between the real injection quantity and the learning value of the fuel injection valve.

Brief Description of Drawings

[0016] Fig. 1 is a schematic configuration diagram showing a diesel engine with a fuel injection control device according to an embodiment of the present invention.

Fig. 2 is a cross-sectional view of a nozzle of an injector shown in Fig. 1.

Fig. 3 is a block diagram showing a configuration of the fuel injection control device according to an embodiment of the present invention.

Fig. 4 is a flowchart showing a processing procedure in which a learning execution condition setting unit shown in Fig. 3 sets a learning execution condition.

Fig. 5 is a graph showing a comparison between valve opening timings of nozzles before and after lapping of nozzles.

Fig. 6 is a graph showing a comparison between change characteristics of real injection quantity of injectors in different operating conditions.

Fig. 7 is a graph showing a relationship among exposed heat temperature of nozzles, real injection quantity of injectors, and operating time.

Fig. 8 is a flowchart showing a processing procedure for setting a learning interval for initial break-in.

Fig. 9 is a drawing showing an example of change of the learning interval.

Fig. 10 is a flowchart showing a modification example of the processing procedure in which the learning execution condition setting unit sets the learning execution condition.

Fig. 11 is a flowchart showing a processing procedure for setting a learning interval and a learning-time injection number for initial break-in.

Fig. 12 is a drawing showing an example of change of the learning interval and learning-time injection number.

Description of Embodiments

[0017] The preferred embodiments of the present invention will be described below in detail with reference to the accompanying drawings. In the drawings, identical or equivalent elements will be denoted by the same reference signs, without redundant description.

[0018] Fig. 1 is a schematic configuration diagram showing a diesel engine provided with a fuel injection control device according to the present embodiment. In Fig. 1, the diesel engine 1 is a four-cylinder in-line diesel engine of a common rail system, which is mounted as a driving source on a vehicle.

[0019] The diesel engine (which will be referred to hereinafter as "engine") 1 is provided with an engine body 2 and four cylinders 3 are arranged in the engine body 2. Each cylinder 3 is equipped with an injector (fuel injection valve) 5 to inject fuel into a combustion chamber 4. Each injector 5 is connected to a common rail 6 and high-pressure fuel accumulated in the common rail 6 is supplied to each injector 5.

[0020] A nozzle 7 is arranged at the distal end of each injector 5. The nozzle 7, as shown in Fig. 2, has a nozzle body 8 and a needle 9. The needle 9 is housed in the nozzle body 8 so as to be movable in the axial direction of the nozzle body 8. A plurality of holes 8a are formed at the distal end of nozzle body 8. The needle 9 is moved in the axial direction of the nozzle body 8 by action of an electromagnet (not shown) provided at the base end of the injector 5. This movement induces injection of fuel from each hole 8a.

[0021] An intake passage 10 to take air into the combustion chambers 4 is connected through intake manifold 11 to the engine body 2. On the intake passage 10 there are an air cleaner 12, a compressor 14 of turbocharger 13, an intercooler 15, and a throttle valve 16 arranged from upstream to downstream. An exhaust passage 17 to discharge emissions after combustion is connected through exhaust manifold 18 to the engine body 2. On the exhaust passage 17 there are a turbine 19 of turbocharger 13 and a DPF-incorporated catalyst 20 arranged from upstream to downstream.

[0022] The engine 1 is equipped with an EGR unit 21 to return a part of emissions after combustion, as exhaust gas recirculation (EGR) gas into the combustion chambers 4. The EGR unit 21 has an EGR passage 22 to return the EGR gas, an EGR valve 23, an EGR cooler 24, a bypass line 25, and a changeover valve 26. The EGR passage 22 is arranged so as to connect the intake passage 10 and the exhaust manifold 18. The EGR valve 23 controls a recirculation amount of EGR gas from the exhaust manifold 18 to the intake passage 10. The EGR cooler 24 cools the EGR gas passing through the EGR passage 22. The bypass line 25 is connected to the EGR passage 22 so as to bypass the EGR cooler 24. The changeover valve 26 changes over the flow path of the EGR gas to the EGR cooler 24 side or to the bypass line 25 side.

[0023] The engine 1 is provided with the fuel injection control device 27. The fuel injection control device 27, as shown in Fig. 3, has an engine speed sensor 28, an accelerator position sensor 29, and an electronic control unit (ECU) 30. The engine speed sensor 28 detects the number of rotations of the engine 1 (engine speed). The accelerator position sensor 29 detects a step-on angle of the accelerator pedal (accelerator position). The ECU 30 controls each injector 5, based on output signals from various sensors including the engine speed sensor 28 and the accelerator position sensor 29.

[0024] The ECU 30 is constructed with a learning execution condition setting unit 31, a learning processing unit 32, and a data storage unit 33. The learning execution condition setting unit 31 sets a learning execution condition for execution of injection quantity learning of the injectors 5. The learning execution condition includes an interval of execution of the injection quantity learning (which will be referred to hereinafter as "learning interval") and a single-shot injection number in execution of the injection quantity learning (which will be referred to hereinafter as "learning-time injection number"). In this single-shot injection, a minute quantity of fuel is injected as fuel for learning. The processing of the learning execution condition setting unit 31 will be detailed later.

[0025] The learning processing unit 32 calculates a command injection quantity for learning to the injectors

5, based on output signals from the engine speed sensor 28 and the accelerator position sensor 29. The learning processing unit 32 controls the injectors 5 so as to perform fuel injection according to the command injection quantity, in accordance with the learning execution condition set by the learning execution condition setting unit 31. The command injection quantity for learning is a command injection quantity for the injectors 5 to inject the fuel for learning, i.e., a minute amount of fuel.

[0026] The learning processing unit 32 executes the injection quantity learning of injectors 5. Specifically, the learning processing unit 32 estimates a quantity of fuel actually injected from the injectors 5 (which will be referred to hereinafter as "real injection quantity"), based on a state change of the engine 1 caused by the fuel injection according to the command injection quantity for learning, and makes a correction for a difference between the command injection quantity and the real injection quantity. In the present embodiment, the learning processing unit 32 estimates the real injection quantity, based on a change of the engine speed detected by the engine speed sensor 28, as the state change of the engine 1.

[0027] The data storage unit 33 preliminarily stores data necessary for the injection quantity learning and control of the injectors 5. Also successively stored into the data storage unit 33 are the result of the above learning and information on whether an initial break-in (described below) of the injectors 5 is completed.

[0028] Fig. 4 is a flowchart showing a processing procedure for the learning execution condition setting unit to set the learning execution condition. The learning execution condition setting unit 31 executes the setting of the learning execution condition in every predetermined period. First, the learning execution condition setting unit 31 determines whether the initial break-in (running-in operation) of injectors 5 is uncompleted, based on the information stored in the data storage unit 33 (S101).

[0029] The initial break-in of injectors 5 is implemented in such a manner that the injectors 5 operate in an initial stage after a start of operation of the engine 1 to cause lapping between needles 9 and nozzle bodies 8 in the nozzles 7 of the injectors 5. By the lapping between needles 9 and nozzle bodies 8 (which will be referred to hereinafter as "lapping of nozzles 7"), the needles 9 come to slide smoothly relative to the nozzle bodies 8. As a result of this, the response of needles 9 improves, as shown in Fig. 5, and therefore the real injection quantity of fuel to be injected increases even in the same opening period of nozzles 7. In Fig. 5, dashed line N indicates the valve opening timing before the lapping of nozzles 7 and solid line M the valve opening timing after the lapping of nozzles 7.

[0030] As shown in Fig. 6, the initial break-in of injectors 5 proceeds, particularly, during a high-load operation. During a low-load operation, the temperature in the combustion chambers 4 (cylinder temperature) is not high enough and, in conjunction therewith, the exposed heat temperature of nozzles 7 does not rise high. For this reason, the lapping of nozzles 7 is unlikely to proceed. Therefore, the initial break-in of injectors 5 does not proceed during the low-load operation and there is little change in the real injection quantity of fuel from the nozzles 7. Conventionally, the initial break-in period was generally determined to be a duration from a start point of operation of the engine 1 to a point of completion of the lapping of nozzles 7. However, the present embodiment newly determines a point of a substantial start of the initial break-in after the start of operation of the engine 1, based on the foregoing knowledge. After completion of the initial break-in of injectors 5, the real injection quantity of fuel injected from the nozzles 7 gradually decreases with increase in traveling distance because of adhesion of soot or the like to the surroundings of the holes 8a of the nozzles 7.

[0031] As shown in Fig. 7, the lapping of nozzles 7 is completed in a shorter time as the exposed heat temperature of nozzles 7 becomes higher. In Fig. 7 thick solid line P, thick dashed line Q, thin solid line R, and thin dashed line S indicate characteristics of real injection quantity against operating time, for example, at the exposed heat temperatures of nozzles 7 of 100°C, 200°C, 300°C, and 400°C, respectively.

[0032] When the exposed heat temperature of nozzles 7 is 100°C, there is almost no variation in the characteristic of real injection quantity, regardless of the operating time. When the exposed heat temperature of nozzles 7 is 200°C, the characteristic of real injection quantity varies, but the variation in the characteristic of real injection quantity reaches a steady state, before completion of the lapping of nozzles 7. When the exposed heat temperature of nozzles 7 is 300°C or 400°C, completion of the lapping of nozzles 7 is confirmed. In this respect, the lapping of nozzles 7 is completed in a shorter time with the exposed heat temperature of 400°C than with the exposed heat temperature of 300°C. It is found from the foregoing characteristics of real injection quantity in this example that the lower limit of exposed heat temperature to achieve completion of the lapping of nozzles 7 is between 200°C and 300°C. When the start point of the initial break-in period of injectors 5 is determined from the exposed heat temperature of nozzles 7, for example, the foregoing lower limit of exposed heat temperature or a value larger than it is defined as a break-in start threshold. This break-in start threshold is preliminarily determined by test or the like and is stored as data in the data storage unit 33.

[0033] When the learning execution condition setting unit 31 determines in the process of S101 that the initial break-in of injectors 5 is uncompleted, the learning execution condition setting unit 31 performs an advance preparation for determining whether the injectors 5 are in the initial break-in period. In this process, the learning execution condition setting unit 31 obtains the exposed heat temperature of nozzles 7, in order to determine the start point of the initial break-in of injectors 5 (S102). The exposed heat temperature of nozzles 7 is determined based on the engine speed detected by the engine speed sensor 28 and the aforementioned command injection quantity determined by the learning processing unit 32. The exposed heat temperature of nozzles 7 is determined by preparing an exposed heat temperature map indicative of relationship among engine speed, command injection quantity, and exposed heat temperature, and finding the exposed heat temperature from the exposed heat temperature map.

[0034] Next, the learning execution condition setting unit 31 determines whether the injectors 5 are in the initial break-in period, i.e., whether the present status of injectors 5 is after the start point and before an end point of the initial break-in of injectors 5 (S103). The start point of the initial break-in of injectors 5 is determined by a comparison between the exposed heat temperature of nozzles 7 and the break-in start threshold preliminarily stored in the data storage unit 33. The end point of the initial break-in period of injectors 5 can be determined, for example, from an exposed heat amount of nozzles 7 (which will be described later). Specifically, the end point of the initial break-in period is determined to be a point of time when the exposed heat amount of nozzles 7 reaches a break-in end threshold preliminarily stored in the data storage unit 33. The start point of the initial break-in period can also be determined from an exposed heat amount per unit time of nozzles 7, or, from the accelerator position as engine load. When the end point of the initial break-in period is determined to be reached based on the exposed heat amount of the nozzles 7, information of completion of the initial break-in is stored into the data storage unit 33.

[0035] When the learning execution condition setting unit 31 determines in the process of S101 that the initial break-in of injectors 5 is completed or determines in the process of S103 that the injectors 5 are not in the initial break-in period, the learning execution condition setting unit 31 sets a regular learning interval (S104). The regular learning interval is estimated by general running patterns. Specifically, the regular learning interval is set to a value calculated by multiplication of a predetermined basic interval and a correction coefficient according to traveling distance.

[0036] When the learning execution condition setting unit 31 determines in the process of S103 that the injectors 5 are in the initial break-in period, the learning execution condition setting unit 31 sets a break-in learning interval (S105). The details of the process of S105 are shown in Fig. 8.

[0037] As shown in Fig. 8, the learning execution condition setting unit 31 obtains the exposed heat amount of nozzles 7 (S112). The exposed heat amount of nozzles 7 is determined based on the exposed heat temperature of nozzles 7 obtained by the process of S102 and the operating time of the engine 1 (vehicle). The exposed heat amount of nozzles 7 is determined by preparing an exposed heat amount map indicative of relationship among exposed heat temperature, operating time, and exposed heat amount, and finding the exposed heat amount from the exposed heat amount map. The operating time is obtained from a timer built in the ECU 30. The exposed heat amounts in the exposed heat amount map are cumulative values to increase with progress of the lapping of nozzles 7. Therefore, the status of the lapping of nozzles 7 can be estimated from the exposed heat amount of nozzles 7.

[0038] Next, the learning execution condition setting unit 31 determines the break-in learning interval (S113). The break-in learning interval is determined based on the exposed heat amount of nozzles 7 obtained by the process of S112. The learning interval is determined by preparing a learning interval map indicative of relationship between exposed heat amount and learning interval, and finding the learning interval from the learning interval map. The break-in learning interval, as shown in Fig. 9, is set to be smaller than the regular learning interval set in the process of S104. As shown in Fig. 9, the break-in learning interval is set so as to become longer with increase in the exposed heat amount of nozzles 7, i.e., so as to become longer with progress of the lapping of nozzles 7.

[0039] Next, the learning execution condition setting unit 31 sends to the learning processing unit 32, information including the break-in learning interval obtained by the process of S113 (which will be referred to hereinafter as "learning interval information") (S114). The learning processing unit 32 controls the injectors 5 to perform the fuel injection for learning when the engine 1 moves into a no-load condition, after arrival at the learning timing corresponding to the learning interval information (cf. Fig. 9). This control results in executing the injection quantity learning of injectors 5. The learning-time injection number is fixed (at a certain number of shots) regardless of whether the injectors 5 are in the initial break-in period.

[0040] In the configuration described above, the engine speed sensor 28 and the learning execution condition setting unit 31 constitute an exposed heat temperature detection means to detect the exposed heat temperature of nozzles 7. The learning execution condition setting unit 31 constitutes an exposed heat amount acquisition means to acquire the exposed heat amount of nozzles 7, based on the exposed heat temperature of nozzles 7 detected by the exposed heat temperature detection means and the operating time of the engine 1, a learning interval change means to change the interval of execution of learning of injection quantity, according to the exposed heat amount of nozzles 7 acquired by the exposed heat amount acquisition means, and a determination means to determine whether the fuel injection valves 5 are in the break-in period. The process of S102 shown in Fig. 4 functions as a part of the exposed heat temperature detection means. The process of S103 shown in Fig. 4 functions as the determination means. The process of S112 shown in Fig. 8 functions as the exposed heat amount acquisition means. The process of S113 shown in Fig. 8 functions as the learning interval change means.

[0041] As described above, as the exposed heat temperature of nozzles 7 becomes higher, the lapping of nozzles 7 is completed earlier (cf. Fig. 7) and the initial break-in period of injectors 5 becomes shorter. In the initial break-in period of injectors 5, the real injection quantity of fuel injected from the nozzles 7 non-linearly increases with increase in traveling distance (cf. Fig. 6). Specifically, an increase rate of real injection quantity of injectors 5 is higher and therefore the lapping of nozzles 7 proceeds in an earlier stage in a region near the start point of the initial break-in period than in a region near the end point of the initial break-in period. For this reason, the difference between the real injection quantity of injectors 5 and the learning value (command injection quantity after the correction) is more likely to occur in the region near the start point of the initial break-in period than in the region near the end point of the initial break-in period.

[0042] In the present embodiment, during the initial break-in period, the exposed heat temperature of nozzles 7 is determined based on the engine speed and the command injection quantity to the injectors 5, and the exposed heat amount of the nozzles 7 is determined based on the exposed heat temperature of nozzles 7 and the operating time of the vehicle. The status of the lapping of nozzles 7 is estimated based on the determined exposed heat amount of nozzles 7 and the learning interval is changed according to the status of the lapping of nozzles 7. Specifically, the learning interval is set longer with progress of the lapping of nozzles 7. By this setting, as shown in Fig. 9, the learning interval is set shorter to increase the frequency of execution of learning in the region near the start point of the initial break-in period than in the region near the end point of the initial break-in period.

[0043] Since the learning interval is changed according to the status of the lapping of nozzles 7, the learning can be performed at optimum timings for injection quantity change characteristics of injectors 5 differing depending upon operating conditions of the vehicle. This can quickly reduce the difference between the real injection quantity of the injectors 5 and the learning value due to a mismatch between the learning timing and the injection quantity change characteristic. As a result, it becomes feasible to prevent increase of exhaust particulate matter (PM) and degradation of combustion sound.

[0044] The learning execution condition setting unit 31 determines whether the injectors 5 are in the initial break-in period, based on the parameters corresponding to heat to which the nozzles 7 are exposed due to combustion of fuel. The present embodiment uses the exposed heat temperature of nozzles 7 and the exposed heat amount of nozzles 7 as the foregoing parameters. The learning execution condition setting unit 31 determines the start point of the initial break-in of injectors 5, based on the exposed heat temperature of nozzles 7, and determines the end point of the initial break-in period of injectors 5, based on the exposed heat amount of nozzles 7. This allows an appropriate determination to be made on whether the injectors 5 are in the initial break-in period. The parameter to be adopted for determining the start point of the initial break-in of injectors 5 can also be the exposed heat amount per unit time of nozzles 7 or the accelerator position (engine load), as described above, instead of the exposed heat temperature of nozzles 7.

[0045] Next, the fuel injection control device according to a modification example of the present embodiment will be described with reference to Fig. 10. Fig. 10 is a flowchart showing a modification example of the processing procedure for the learning execution condition setting unit to set the learning execution condition. The present processing is executed in every predetermined period.

[0046] In Fig. 10, the processes of S101 to S103 are the same as those shown in Fig. 4. When the learning execution condition setting unit 31 determines in the process of S101 that the initial break-in of injectors 5 is completed or determines in the process of S103 that the injectors 5 are not in the initial break-in period, the learning execution condition setting unit 31 sets the regular learning interval and learning-time injection number (S104A). The state change of the engine 1 caused by the single-shot injection includes dispersion of real injection quantity or combustion or the like. For this reason, the learning-time injection number is set to be the number of two or more shots per learning. The regular learning-time injection number is set to be a fixed value independent of traveling distance (cf. Fig. 12).

[0047] When the learning execution condition setting unit 31 determines in the process of S103 that the injectors 5 are in the initial break-in period, the learning execution condition setting unit 31 sets the break-in learning interval and learning-time injection number (S105A). The details of the process of S105A are shown in Fig. 11.

[0048] In Fig. 11, the processes of S112 and S113 are the same as those shown in Fig. 8. After execution of the processes of S112 and S113, the learning execution condition setting unit 31 determines the break-in learning-time injection number, based on the exposed heat amount of nozzles 7 obtained by the process of S112 (S121). The learning-time injection number is determined by preparing a learning-time injection number map indicative of relationship between exposed heat amount and learning-time injection number, and finding the learning-time injection number from the learning-time injection number map. The break-in learning-time injection number, as shown in Fig. 12, is set to be smaller than the regular learning-time injection number set in the process of S104A. The break-in learning-time injection number is set, as shown in Fig. 12, so that the learning-time injection number increases with increase in the exposed heat amount of nozzles 7, i.e., with progress of the lapping of nozzles 7.

[0049] Next, the learning execution condition setting unit 31 sends to the learning processing unit 32, the learning interval information obtained by the process of S113 and information including the learning-time injection number obtained by the process of S121 (which will be referred to hereinafter as "learning-time injection number information") (S122). The learning processing unit 32 controls the injectors 5 to perform the learning fuel injection by the learning-time injection number corresponding to the learning-time injection number information when the engine 1 moves into a no-load condition, after arrival at the learning timing corresponding to the learning interval information (cf. Fig. 12). This control results in executing the injection quantity learning of injectors 5.

[0050] The learning execution condition setting unit 31 constitutes a learning-time injection number change means to change the injection number of the minute amount of fuel, according to the exposed heat amount of nozzles 7 acquired by the exposed heat amount acquisition means. The process of S121 shown in Fig. 11 functions as the learning-time injection number change means.

[0051] In the present modification example, as described above, the exposed heat temperature of nozzles 7 is determined based on the engine speed and the command injection quantity to the injectors 5 and the exposed heat amount of nozzles 7 is determined based on the exposed heat temperature of nozzles 7 and the operating time of the vehicle, during the initial break-in period. The status of the lapping of nozzles 7 is estimated based on the determined exposed heat amount of nozzles 7, and the learning interval and learning-time injection number are changed according to the status of the lapping of nozzles 7. Specifically, the learning interval is set longer and the learning-time injection number is set larger with progress of the lapping of the nozzles 7. By this setting, as shown in Fig. 12, the learning-time injection number is set smaller to complete the injection quantity learning earlier in the region near the start point of the initial break-in period than in the region near the end point of the initial break-in period. As a result of this, the difference between the real injection quantity and the learning value of injectors 5 can be reduced in a much earlier stage.

[0052] It is noted that the present invention is not limited to the above embodiment. For example, the above embodiment showed the example wherein the exposed heat temperature of nozzles 7 was determined based on the engine speed and the command injection quantity to the injectors 5, but the present invention is not limited to this example. The exposed heat temperature of nozzles 7 may also be determined using an intake air amount instead of the engine speed. In this case, an air flow meter to detect the intake air amount is arranged on the intake passage 10.

[0053] The above embodiment showed the example wherein at least the learning interval out of the learning interval and the learning-time injection number was changed according to the status of the lapping of nozzles 7, during the initial break-in period of injectors 5, but the present invention is not limited to this example. The present invention is also applicable to any other period than the initial break-in period of injectors 5 as long as it is a period in which there is significant variation in the fuel injection quantity (real injection quantity) from the injectors 5 relative to the traveling distance of the vehicle.

Industrial Applicability

[0054] The present invention is applicable to the fuel injection control devices of diesel engine.

Reference Signs List

[0055] 1...diesel engine; 5...injector (fuel injection valve); 7 ... nozzle; 27... fuel injection control device; 28... engine speed sensor (exposed heat temperature detection means); 30...ECU; 31...learning execution condition setting unit (exposed heat temperature detection means, exposed heat amount acquisition means, learning interval change means, learning-time injection number change means, and determination means); 32...learning processing unit.

[0056] A fuel injection control device (27) injects fuel for learning into a combustion chamber (4) of an engine (1) from a nozzle (7) of a fuel injection valve (5), to perform learning of injection quantity of the fuel injection valve (5). The fuel injection control device (27) is provided with an exposed heat temperature detection means (28, 31) for detecting an exposed heat temperature of the nozzle (7), an exposed heat amount acquisition means (31) for acquiring an exposed heat amount of the nozzle (7), based on the exposed heat temperature of the nozzle (7) detected by the exposed heat temperature detection means (28, 31) and an operating time of the engine (1), and a learning interval change means (31) for changing an interval of execution of the injection quantity learning, according to the exposed heat amount of the nozzle (7) acquired by the exposed heat amount acquisition means (31).

Claims

1. A fuel injection control device (27) which injects fuel for learning into a combustion chamber (4) of an engine (1) from a nozzle (7) of a fuel injection valve (5), to perform injection quantity learning of the fuel injection valve (5), the fuel injection control device (27) comprising:

exposed heat temperature detection means (28, 31) for detecting an exposed heat temperature of the nozzle (7);
exposed heat amount acquisition means (31) for acquiring an exposed heat amount of the nozzle (7), based on the exposed heat temperature of the nozzle (7) detected by the exposed heat temperature detection means (28, 31) and an operating time of the engine (1); and
learning interval change means (31) for chang-

ing an interval of execution of the injection quantity learning, according to the exposed heat amount of the nozzle (7) acquired by the exposed heat amount acquisition means (31).

2. The fuel injection control device (27) according to claim 1, wherein the exposed heat temperature detection means (28, 31) has:

means (28) for detecting an engine speed of the engine (1); and
means (31) for acquiring the exposed heat temperature of the nozzle (7), based on the engine speed of the engine (1) and an injection quantity of the fuel injection valve (5).

3. The fuel injection control device (27) according to claim 1 or 2, further comprising:

determination means (31) for determining whether the fuel injection valve (5) is in a break-in period,
wherein when the determination means (31) determines that the fuel injection valve (5) is in the break-in period, the learning interval change means (31) changes the interval of execution of the injection quantity learning, according to the exposed heat amount of the nozzle (7).

4. The fuel injection control device (27) according to claim 1 or 2, further comprising:

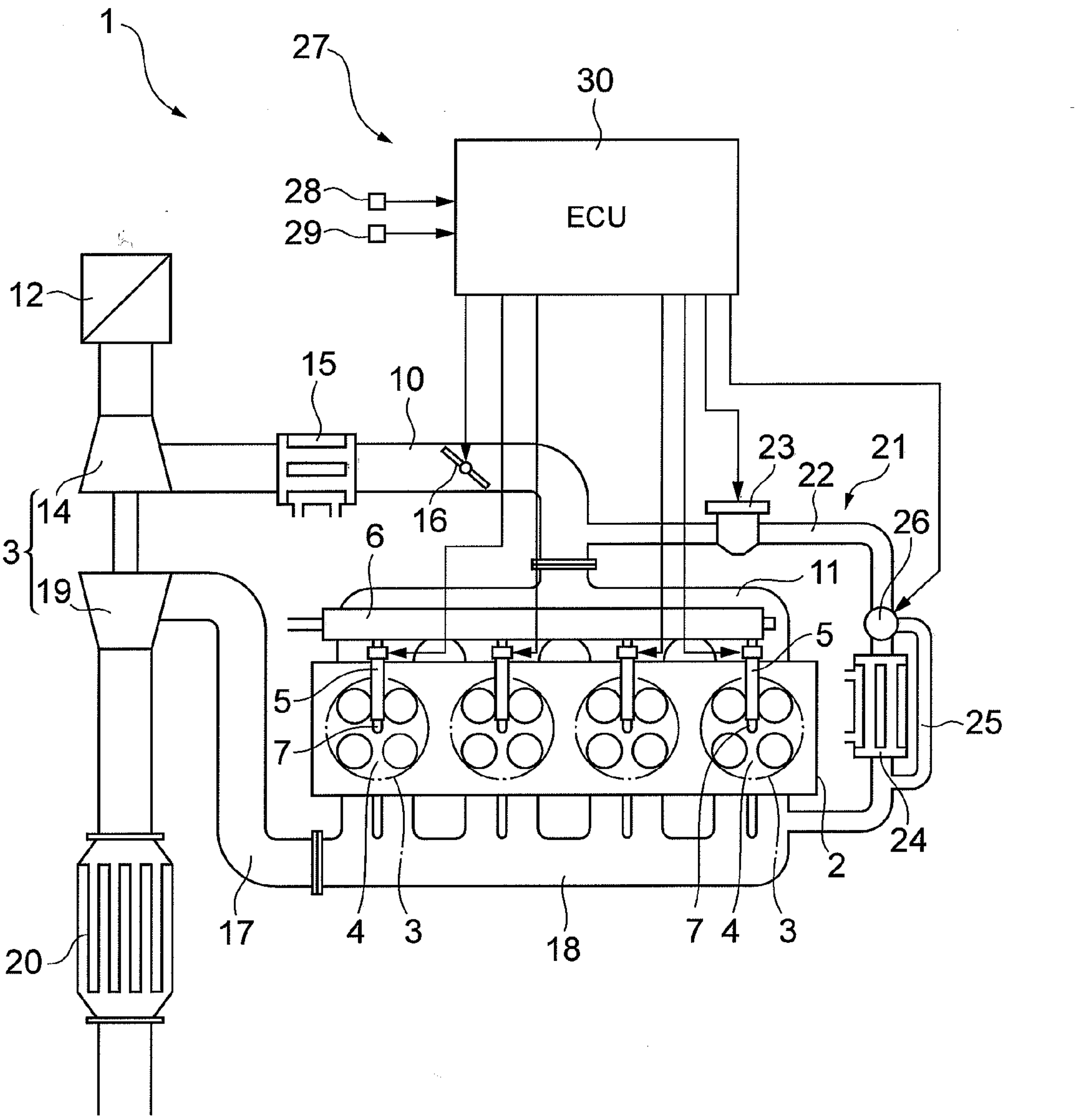
learning-time injection number change means (31) for changing an injection number of the fuel for learning, according to the exposed heat amount of the nozzle (7) acquired by the exposed heat amount acquisition means (31).

5. The fuel injection control device (27) according to claim 4, further comprising:

determination means (31) for determining whether the fuel injection valve (5) is in a break-in period,
wherein when the determination means (31) determines that the fuel injection valve (5) is in the break-in period, the learning interval change means (31) changes the interval of execution of the injection quantity learning, according to the exposed heat amount of the nozzle (7), and
wherein when the determination means (31) determines that the fuel injection valve (5) is in the break-in period, the learning-time injection number change means (31) changes the injection number of the fuel for learning, according to the exposed heat amount of the nozzle (7).

6. The fuel injection control device (27) according to claim 3 or 5,
wherein the determination means (31) determines whether the fuel injection valve (5) is in the break-in period, based on a parameter corresponding to heat to which the nozzle (7) is exposed due to combustion of the fuel.

Fig.1


1
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30
ECU
28
29
12
15
10
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14
13
19
23
22
21
26
6
11
5
5
7
25
24
2
17
4
3
18
7
4
3
20

Fig.2

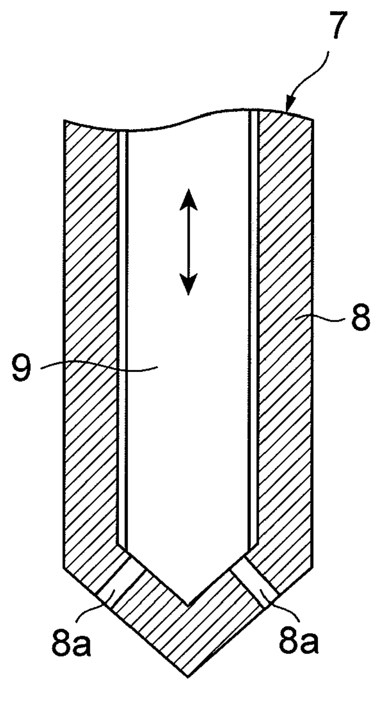


Fig.3

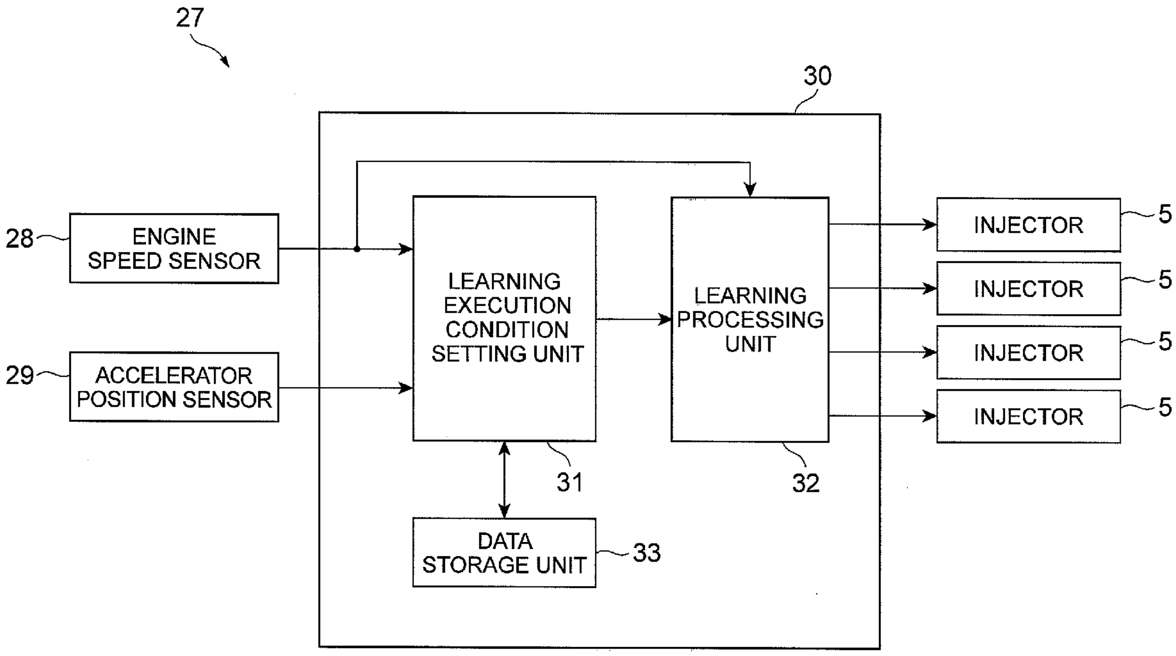

27
30
28
ENGINE SPEED SENSOR
29
ACCELERATOR POSITION SENSOR
LEARNING EXECUTION CONDITION SETTING UNIT
LEARNING PROCESSING UNIT
31
32
DATA STORAGE UNIT
33
INJECTOR
5
INJECTOR
5
INJECTOR
5
INJECTOR
5

Fig.4

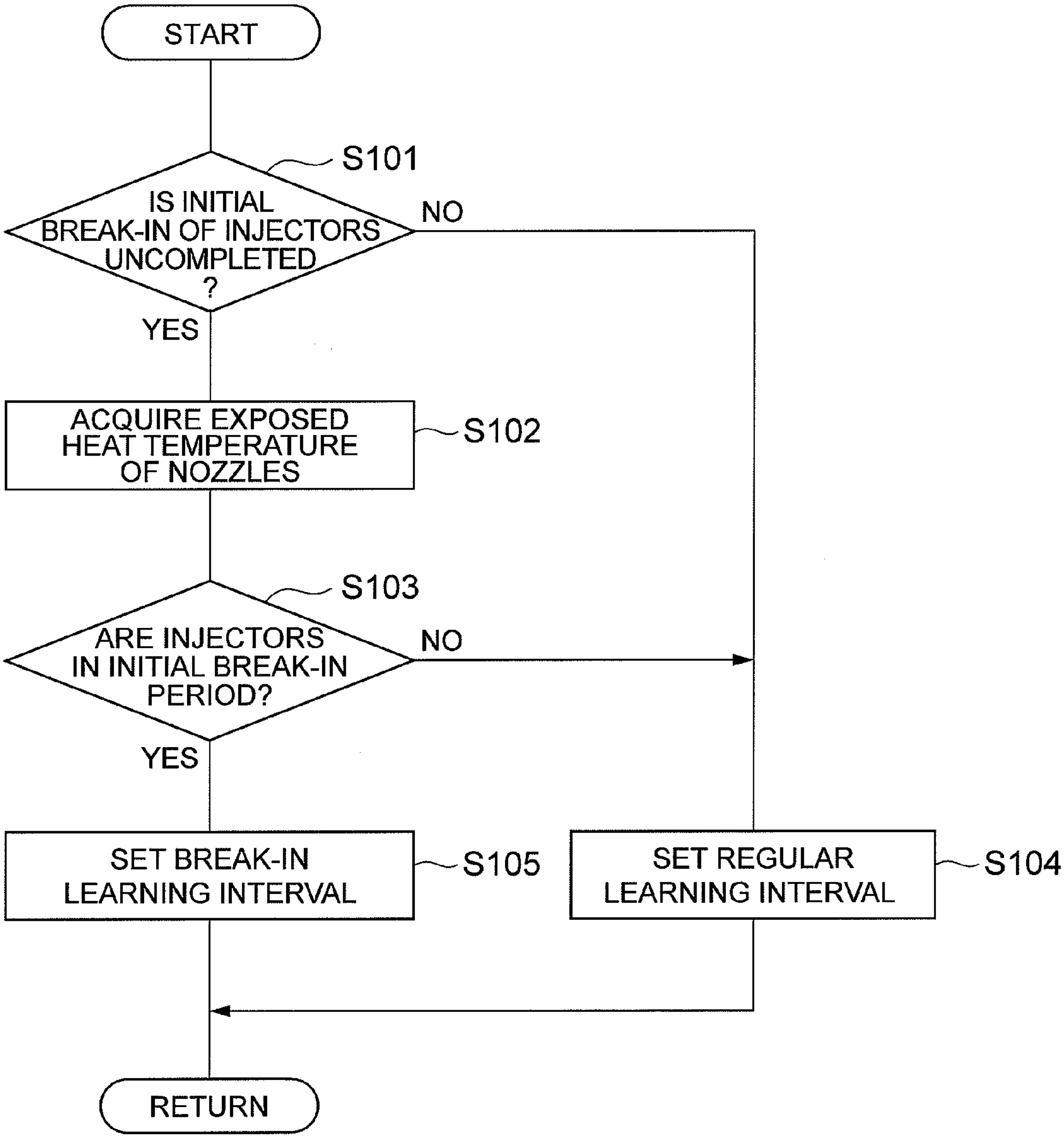

START
S101
IS INITIAL BREAK-IN OF INJECTORS UNCOMPLETED ?
NO
YES
ACQUIRE EXPOSED HEAT TEMPERATURE OF NOZZLES
S102
S103
ARE INJECTORS IN INITIAL BREAK-IN PERIOD?
NO
YES
SET BREAK-IN LEARNING INTERVAL
S105
SET REGULAR LEARNING INTERVAL
S104
RETURN

Fig.5

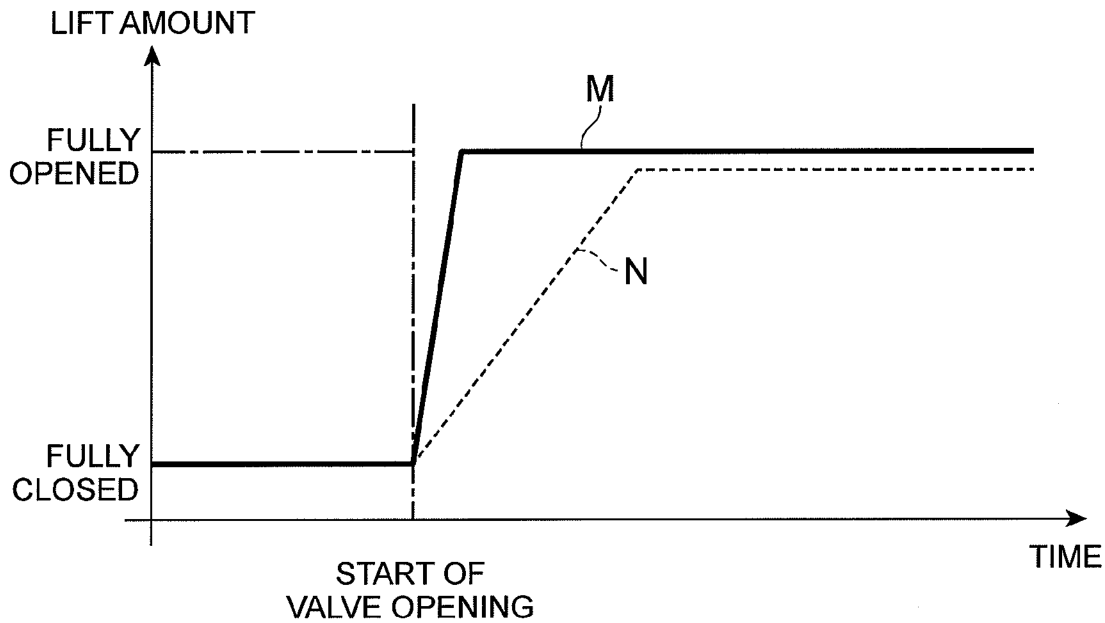
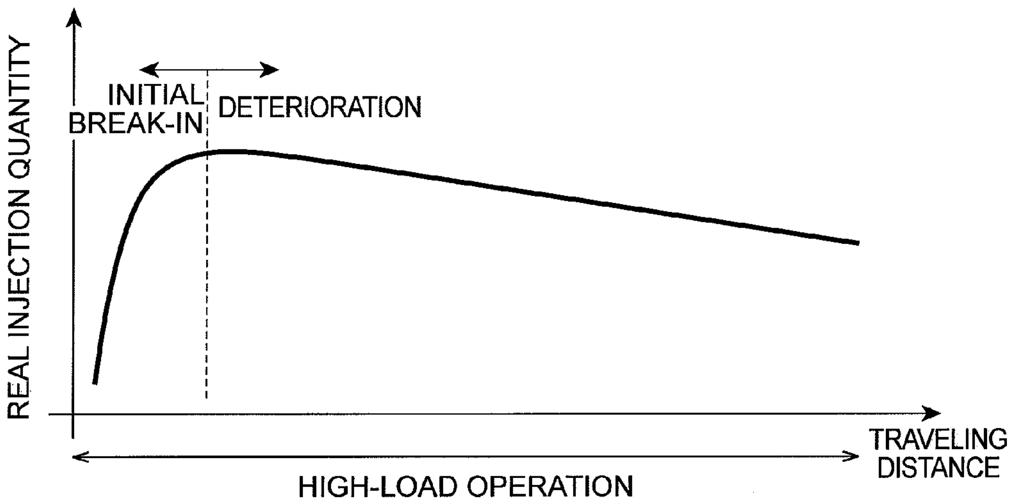

LIFT AMOUNT
M
FULLY
OPENED
N
FULLY
CLOSED
TIME
START OF
VALVE OPENING

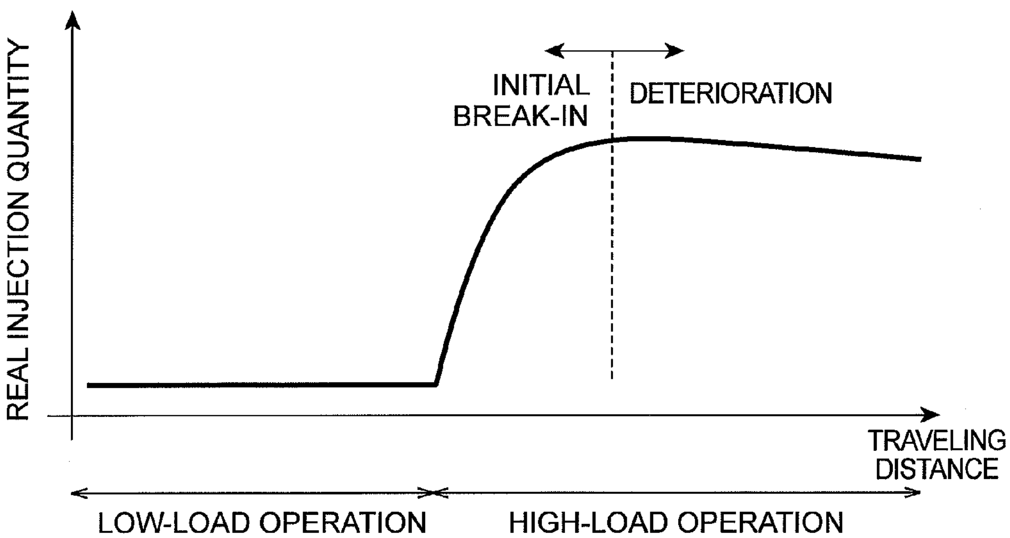
Fig.6

(a)



REAL INJECTION QUANTITY
INITIAL BREAK-IN
DETERIORATION
TRAVELING DISTANCE
HIGH-LOAD OPERATION

(b)



REAL INJECTION QUANTITY
INITIAL BREAK-IN
DETERIORATION
TRAVELING DISTANCE
LOW-LOAD OPERATION
HIGH-LOAD OPERATION

Fig.7

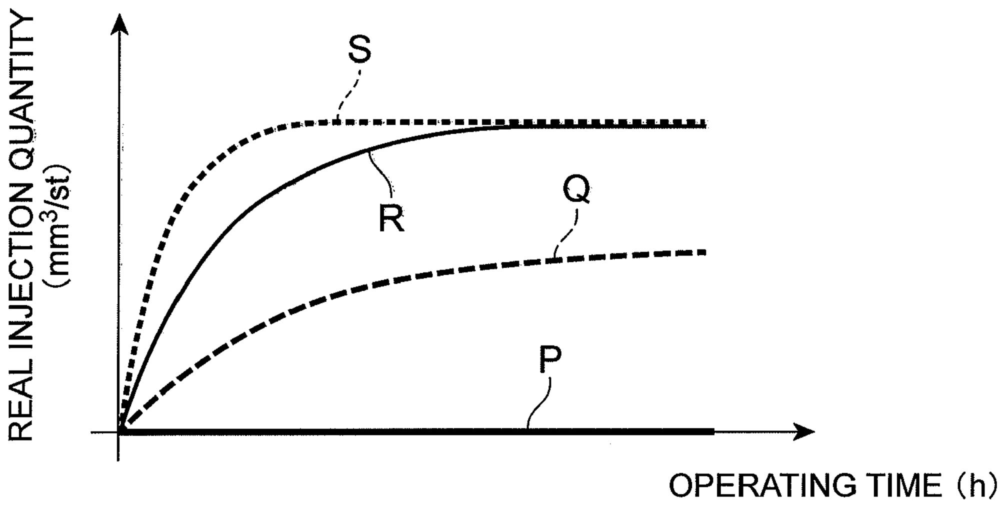


Fig.8

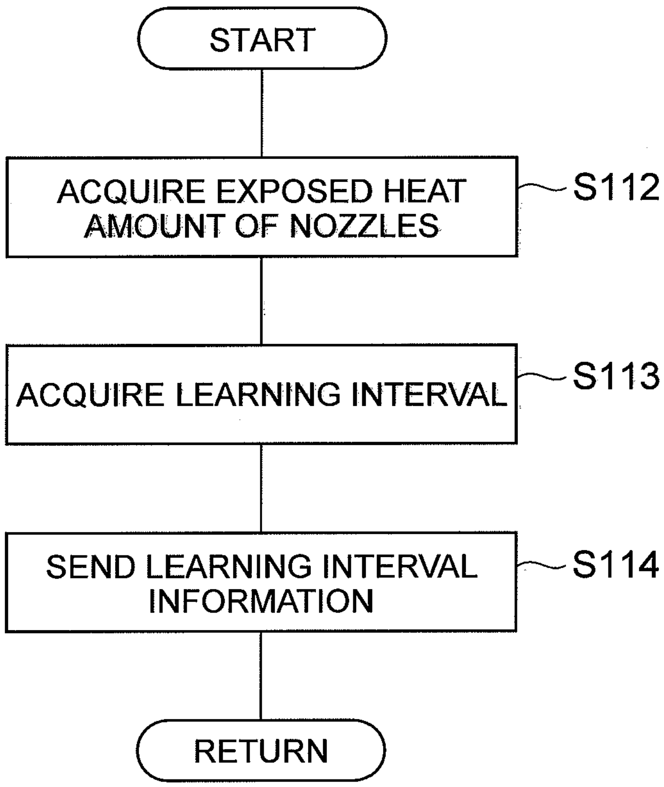

START
ACQUIRE EXPOSED HEAT AMOUNT OF NOZZLES
S112
ACQUIRE LEARNING INTERVAL
S113
SEND LEARNING INTERVAL INFORMATION
S114
RETURN

Fig.9

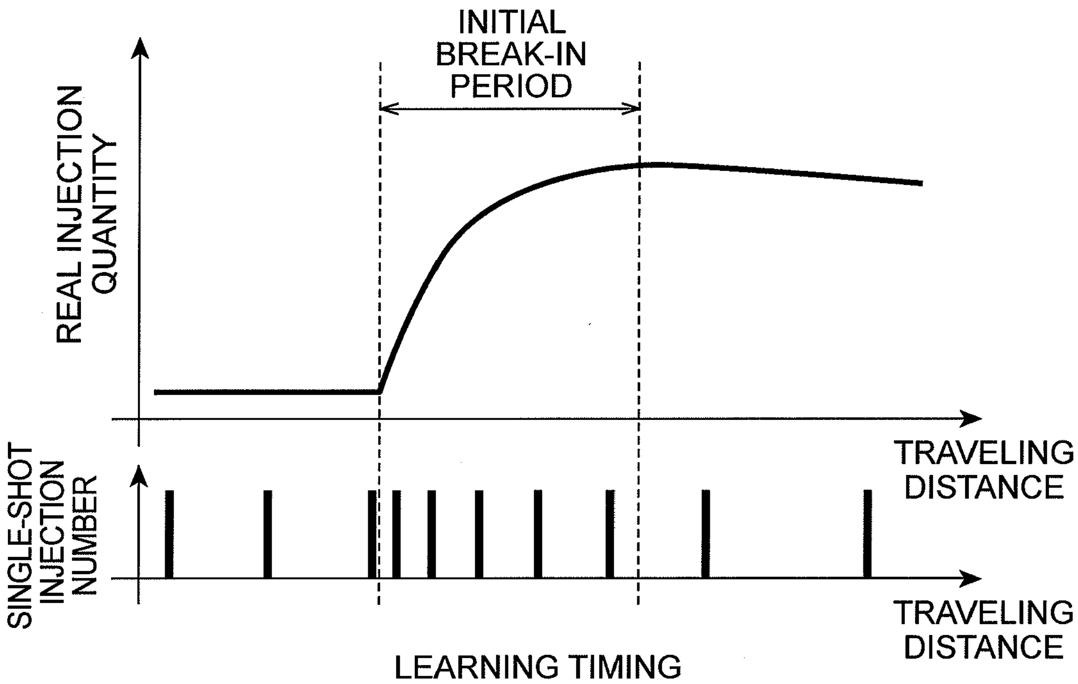

INITIAL
BREAK-IN
PERIOD
REAL INJECTION
QUANTITY
TRAVELING
DISTANCE
SINGLE-SHOT
INJECTION
NUMBER
TRAVELING
DISTANCE
LEARNING TIMING

Fig.10

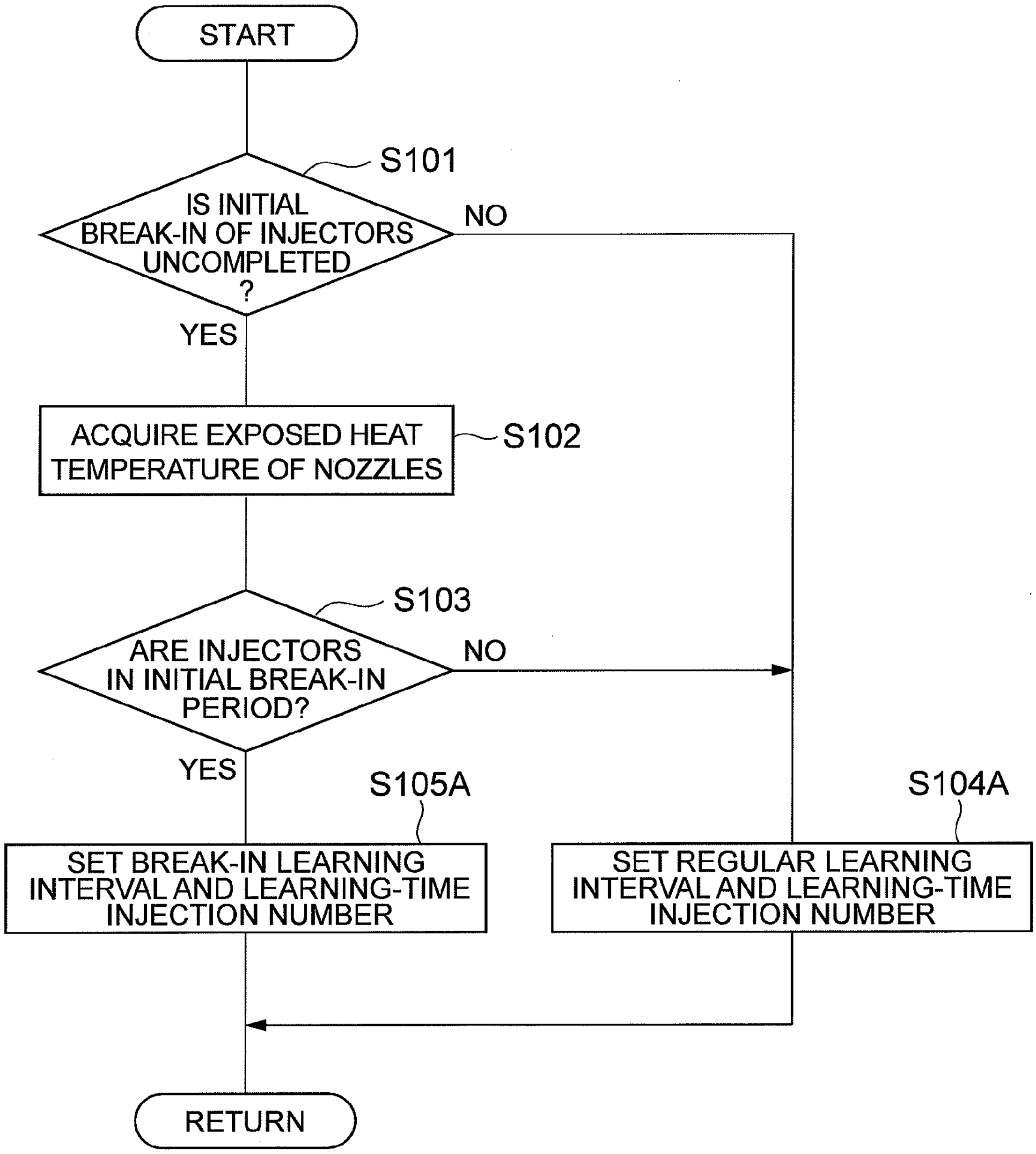

START
S101
IS INITIAL BREAK-IN OF INJECTORS UNCOMPLETED ?
NO
YES
ACQUIRE EXPOSED HEAT TEMPERATURE OF NOZZLES
S102
S103
ARE INJECTORS IN INITIAL BREAK-IN PERIOD?
NO
YES
S105A
S104A
SET BREAK-IN LEARNING INTERVAL AND LEARNING-TIME INJECTION NUMBER
SET REGULAR LEARNING INTERVAL AND LEARNING-TIME INJECTION NUMBER
RETURN

Fig.11

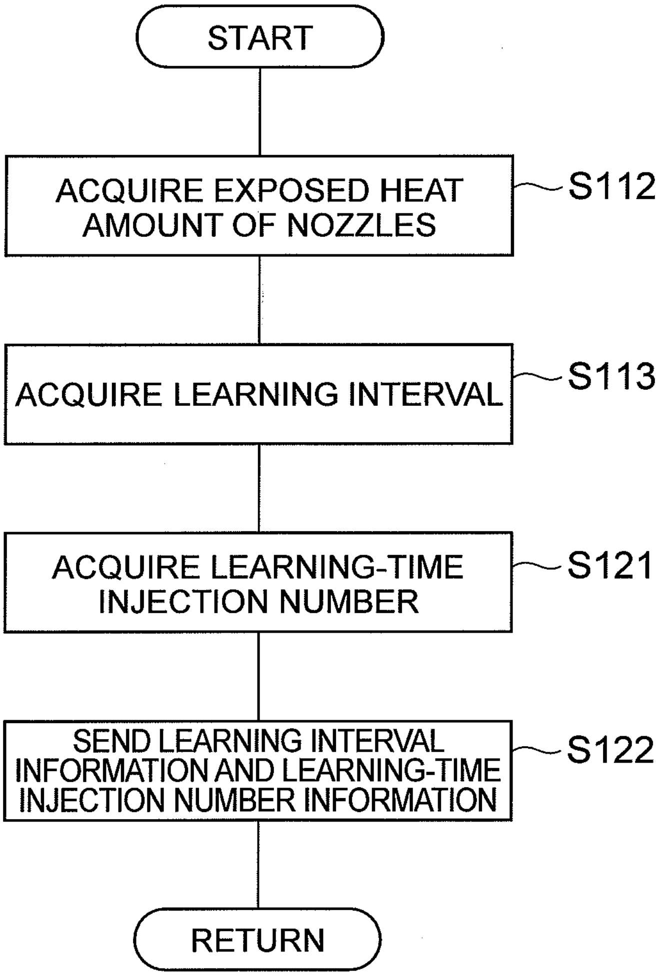
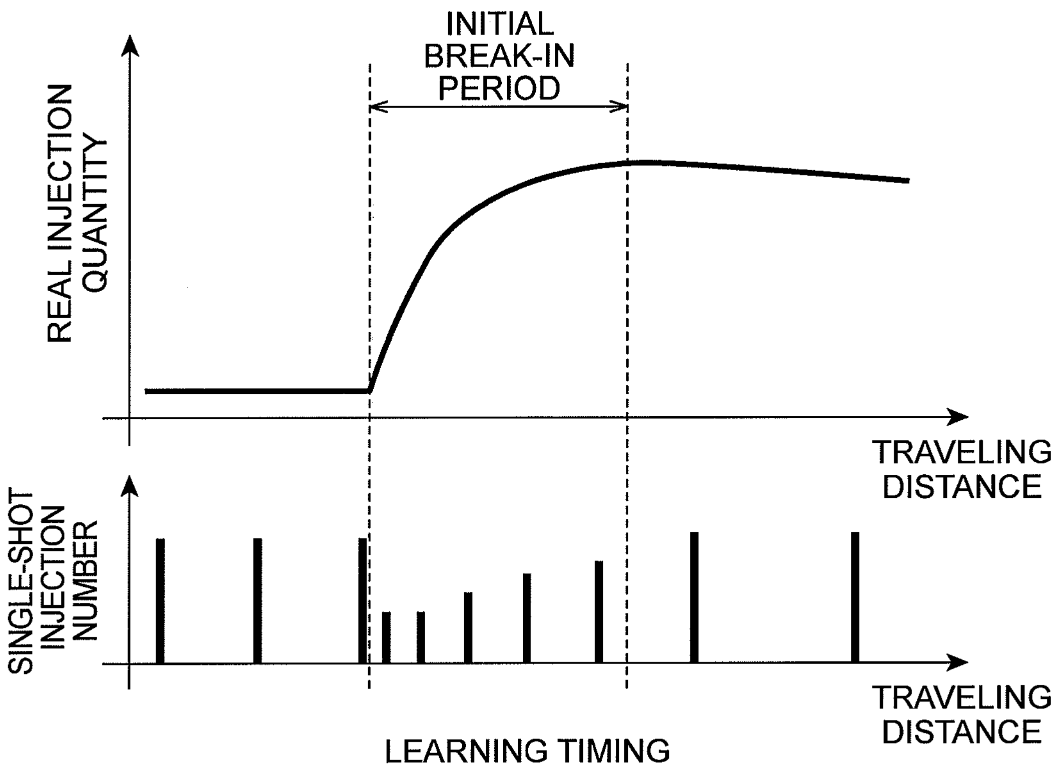

START
ACQUIRE EXPOSED HEAT AMOUNT OF NOZZLES
S112
ACQUIRE LEARNING INTERVAL
S113
ACQUIRE LEARNING-TIME INJECTION NUMBER
S121
SEND LEARNING INTERVAL INFORMATION AND LEARNING-TIME INJECTION NUMBER INFORMATION
S122
RETURN

Fig.12


INITIAL
BREAK-IN
PERIOD
REAL INJECTION
QUANTITY
TRAVELING
DISTANCE
SINGLE-SHOT
INJECTION
NUMBER
TRAVELING
DISTANCE
LEARNING TIMING

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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 2222

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2008/155648 A1 (TOYOTA MOTOR CO LTD [JP]; FUTONAGANE YOSHINORI [JP]; OMAE KAZUHIRO [JP) 24 December 2008 (2008-12-24) * paragraphs [0006], [0007] * -----	1-6	INV. F02D41/24
A	WO 2007/105080 A2 (TOYOTA MOTOR CO LTD [JP]; ASHIZAWA TAKESHI [JP]; TOMINO OSAMU [JP]) 20 September 2007 (2007-09-20) * paragraphs [0006], [0008] * -----	1-6	

TECHNICAL FIELDS SEARCHED (IPC)
F02D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	28 November 2013	Jackson, Stephen

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons
& : member of the same patent family, corresponding document

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The members are as contained in the European Patent Office EDP file on
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28-11-2013

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WO 2008155648 A1	24-12-2008	CN 101568718 A	28-10-2009
		EP 2069636 A1	17-06-2009
		JP 2009002229 A	08-01-2009
		US 2010094527 A1	15-04-2010
		WO 2008155648 A1	24-12-2008
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		JP 2007239686 A	20-09-2007
		KR 20080098655 A	11-11-2008
		US 2009000595 A1	01-01-2009
		WO 2007105080 A2	20-09-2007

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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