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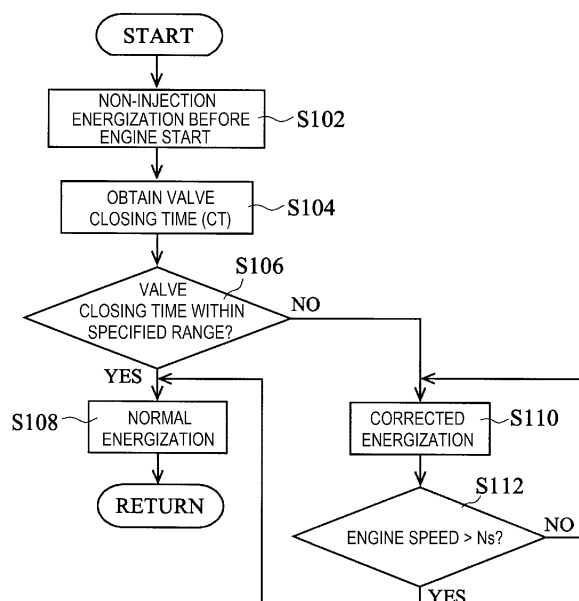
(54) **FUEL INJECTOR ENERGIZATION CONTROL METHOD AND COMMON RAIL FUEL INJECTION CONTROL APPARATUS**

(57) Deterioration of a start characteristic of a fuel injector, which is caused by sludge, at a start of an engine is reliably suppressed or prevented.

Non-injection energization is performed on fuel injectors 2-1 to 2-n at a start of a vehicle (S102), and a valve closing time at the time is measured (S104). If the valve closing time exceeds a specified range (S106), a

cause that deteriorates a starting state of an engine 3 is present, and energization control of the fuel injectors 2-1 to 2-n is executed on the basis of a corrected energization condition until an engine speed exceeds a specified speed (S110, S112). In this way, the deterioration of the start characteristic at the start of the engine is suppressed or prevented.

Fig. 4



Description

Technical Field

[0001] The invention relates to an energization control method for a fuel injector and a common rail fuel injection control apparatus and, in particular, to improvement in stability and reliability of a starting characteristic of the fuel injector.

Background Art

[0002] A fuel injector that injects fuel into an engine is an essential component of a vehicle system that has a significant impact on quality of an engine operation, and fuel injectors with various configurations have been proposed and commercially available on the basis of a variety of perspectives.

[0003] For example, as a fuel injector with merits of reduced power consumption, reduced size, and the like, what is called a pressure-balanced fuel injector has been available.

[0004] This pressure-balanced fuel injector is basically the same as a so-called ball valve fuel injector, which has conventionally been available, in points that a control chamber capable of controlling inflow/outflow of high pressure fuel is provided near an end of a nozzle needle on an opposite side from an injection hole, so as to assist in seating/separation of the nozzle needle on/from a valve seat and that the inflow/outflow of the fuel to/from the control chamber can be controlled by an electromagnetic valve. However, as will be described below, usage of the electromagnetic valve, which controls the inflow/outflow of the fuel to/from the control chamber, in the pressure-balanced fuel injector differs from that in the ball valve fuel injector.

[0005] More specifically, in the pressure-balanced fuel injector, an armature that constitutes the electromagnetic valve for controlling the inflow/outflow of the fuel to/from the control chamber differs from conventional one and is provided to be in a substantially line contact state with the valve seat in a longitudinal axial direction of the nozzle needle.

[0006] The ball valve fuel injector is configured that the armature or a valve needle attached to the armature is provided to be in a surface contact state with the valve seat. Accordingly, when the armature or the valve needle is seated on the valve seat, high fuel pressure acts on the valve needle or the armature, and the valve needle or the armature has to be pressed with a large spring set force so as to resist the fuel pressure. Meanwhile, when the valve is opened, an electromagnetic force that overcomes the large spring set force is necessary. For this reason, an energized current is increased, and the power consumption is consequently increased.

[0007] On the contrary, unlike the above-described ball valve fuel injector, the high fuel pressure does not act on the armature or the valve needle in the pressure-bal-

anced fuel injector. In addition, the electromagnetic force only has to be large enough to separate the armature from the valve seat. Accordingly, various advantages such as the reduced power consumption and reduced size of the electromagnetic valve from the ball valve fuel injector can be achieved. Therefore, the pressure-balanced fuel injector has been adapted for a variety of uses (for example, see PTL 1).

10 Citation List

Patent Literature

[0008] [PTL 1] JP-A-2012-526227

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Disclosure of Invention

Technical Problem

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[0009] The above-described pressure-balanced fuel injector is configured that the above-described valve needle is slidably inserted in the armature, and sludge is possibly accumulated in an extremely small clearance therebetween. In particular, when the fuel injector starts being energized at a start of a vehicle, sliding of the armature is resisted by the sludge, which leads to such problems that a fuel injection amount becomes insufficient due to a delay in a start of the injection, that a desired engine speed cannot be achieved, and that a starting characteristic of the engine is deteriorated.

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[0010] The invention has been made in view of the above circumstances and therefore provides a fuel injector energization control method and a common rail fuel injection control apparatus that suppress or prevent deterioration of a starting characteristic of a fuel injector, which is caused by sludge, at a start of an engine, that can reliably secure desired fuel injection, and that can improve reliability and stability of fuel injection control.

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Solution to Problem

[0011] In order to achieve the above purpose of the invention, a fuel injector energization control method according to the invention is a fuel injector energization control method that controls energization of a fuel injector at a start of a vehicle, and is configured to: determine whether a cause that deteriorates a starting state of an engine is present at the start of the vehicle; and, when it is determined that the cause that deteriorates the starting state of the engine is present, correct an energization condition of the fuel injector and energize the fuel injector on the basis of the corrected energization condition.

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[0012] In addition, in order to achieve the above purpose of the invention, a common rail fuel injection control apparatus according to the invention is a common rail fuel injection control apparatus in which fuel in a fuel tank is pressurized and pressure-fed to a common rail by a high-pressure pump and which is provided with an elec-

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tronic control unit capable of executing injection control of high pressure fuel to an engine via a fuel injector connected to said common rail. The electronic control unit is configured to: determine whether a cause that deteriorates a starting state of an engine at a start of a vehicle is present; and, when it is determined that the cause that deteriorates the starting state of the engine is present, correct an energization condition in energization control of the fuel injector; and be able to execute the energization control of the fuel injector on the basis of the corrected energization condition.

Advantageous Effects of Invention

[0013] According to the invention, when it is determined that the cause that deteriorates the starting state of the engine is present at the start of the vehicle, the energization condition of the fuel injector is corrected, and the energization is performed. In this way, an insufficient fuel injection amount can be compensated, and deterioration of a start characteristic of the engine can reliably be avoided. Accordingly, in particular, in the case where an operation of the fuel injector is temporarily disturbed by sludge or the like at the start of the vehicle, a reduction in an engine speed is reliably suppressed or alleviated, and the deterioration of the start characteristic can thereby be avoided. Therefore, an effect of improving reliability and stability of fuel injection control is exerted.

Brief Description of Drawings

[0014]

Fig. 1 is a configuration diagram that illustrates a configuration example of a common rail fuel injection control apparatus to which a fuel injector energization control method in an embodiment of the invention is applied.

Fig. 2 is a schematic view that schematically illustrates a cross-sectional structure of a fuel injector, to which the fuel injector energization control method in the embodiment of the invention is applied, in a longitudinal direction at a time when fuel is not injected.

Fig. 3 is a schematic view that schematically illustrates a cross-sectional structure of the fuel injector, to which the fuel injector energization control method in the embodiment of the invention is applied, in the longitudinal direction at a time when the fuel is injected.

Fig. 4 is a subroutine flowchart that illustrates a procedure of a first example of fuel injector energization control processing in the embodiment of the invention.

Fig. 5 is a subroutine flowchart that illustrates a procedure of a second example of the fuel injector energization control processing in the embodiment of the invention.

Fig. 6 includes schematic charts, each of which schematically illustrates an energization waveform of the fuel injector in the embodiment of the invention, in which (A) of Fig. 6 is a schematic chart that illustrates an example of the energization waveform in a normal time and (B) of Fig. 6 is a schematic chart that illustrates an example of the energization waveform in a case where an energization condition is corrected.

10 Description of Embodiment

[0015] A description will hereinafter be made on an embodiment of the invention with reference to Fig. 1 to Fig. 6.

[0016] Note that members, arrangement, and the like, which will be described below, do not limit the invention and various modifications can be made thereto within the scope of the gist of the invention.

[0017] First, referring to Fig. 1, a description will be made on a common rail fuel injection control apparatus to which a fuel injector energization control method in the embodiment of the invention is applied.

[0018] This common rail fuel injection control apparatus is configured by including, as main components: a high-pressure pump device 50 that pressure-feeds high pressure fuel; a common rail 1 that stores the high pressure fuel pressure-fed from this high-pressure pump device 50; plural fuel injectors 2-1 to 2-n, each of which injects the high pressure fuel, which is supplied from this common rail 1, into a cylinder of an engine 3; and an electronic control unit (indicated as an "ECU" in Fig. 1) 4 that performs fuel injection control processing, rail pressure control processing, which will be described below, and the like.

[0019] Such a configuration itself is the same as a basic configuration of a fuel injection control apparatus of this type that has conventionally been well known.

[0020] The high-pressure pump device 50 has a known/well-known configuration including, as main components, a supply pump 5, a metering valve 6, and a high-pressure pump 7.

[0021] In such a configuration, fuel in a fuel tank 9 is pumped by the supply pump 5 and supplied to the high-pressure pump 7 via the metering valve 6. An electromagnetic proportional control valve is used as the metering valve 6, and an energization amount thereof is controlled by the electronic control unit 4. In this way, a flow rate of the supply fuel to the high-pressure pump 7, in other words, a discharge amount of the high-pressure pump 7 is adjusted.

[0022] Note that a return valve 8 is provided between an output side of the supply pump 5 and the fuel tank 9 and thus can return a surplus of the fuel on the output side of the supply pump 5 to the fuel tank 9.

[0023] In addition, the supply pump 5 may be provided as a separate component from the high-pressure pump device 50 on an upstream side of the high-pressure pump device 50 or may be provided in the fuel tank 9.

[0024] The fuel injectors 2-1 to 2-n are respectively pro-

vided for the cylinders of the engine 3. Each of the fuel injectors 2-1 to 2-n is supplied with the high pressure fuel from the common rail 1 and injects the fuel through injection control by the electronic control unit 4.

[0025] In the common rail 1 of the invention, a pressure control valve 12 as an electromagnetic proportional control valve is provided in a return passage (not illustrated) through which a surplus of the high pressure fuel is returned to the tank 9. The pressure control valve 12 is used together with the metering valve 6 to control rail pressure.

[0026] In the embodiment of the invention, an operation state of each of the metering valve 6 and the pressure control valve 12 is appropriately changed in accordance with an operation state of the engine 3. In this way, appropriate rail pressure control is realized.

[0027] The electronic control unit 4, for example, has a microcomputer (not illustrated) with a known/well-known configuration as a principal component and also has storage elements (not illustrated) such as RAM and ROM. In addition, the electronic control unit 4 is configured by including, as main components: a drive circuit (not illustrated) that drives the fuel injectors 2-1 to 2-n; and an energization circuit (not illustrated) that energizes the metering valve 6 and the pressure control valve 12.

[0028] Such an electronic control unit 4 receives a detection signal of a pressure sensor 11 that detects pressure of the common rail 1, and also receives various detection signals such as an engine speed, an accelerator operation amount, and a fuel temperature that are used for operation control and fuel injection control of the engine 3 as well as for the fuel injector energization control processing in the embodiment of the invention, which will be described below, and the like.

[0029] Such a configuration itself is the same as a basic configuration of a common rail fuel injection control apparatus of this type that has conventionally been known.

[0030] As each of the fuel injectors 2-1 to 2-n in the above configuration, for example, a fuel injector with a configuration of a so-called pressure-balanced type is used. Needless to say, the fuel injectors 2-1 to 2-n are not limited thereto. A fuel injector with a configuration of a so-called ball valve type that has conventionally been well known may be used therefor.

[0031] Next, Fig. 2 and Fig. 3 each schematically illustrate a configuration example of a pressure-balanced fuel injector. Referring to the same drawings, a description will hereinafter be made particularly on a schematic configuration of a portion near an end of the pressure-balanced fuel injector on an opposite side from an injection hole. Note that portions with hatched lines represent the fuel in Fig. 2 and Fig. 3. In the pressure-balanced fuel injector, a nozzle needle 23 that opens/closes the injection hole (not illustrated) is slidably provided in a valve body 22 accommodated in a housing 21, and a control chamber 24, into/from which the fuel flows, is formed on a rear end side of the nozzle needle 23, that is, between the portion near the opposite end from the unillustrated

injection hole and the valve body 22. Furthermore, it is configured that an electromagnetic valve 25 that controls inflow/outflow of the fuel to/from this control chamber 24 is provided on an end side of the valve body 22. Such a configuration is basically the same as that of a so-called ball valve fuel injector.

[0032] On a top side of the valve body 22, a ring-shaped valve seat 26 is formed to be projected to an opposite side from the control chamber 24, and a communication passage 27 that communicates with the control chamber 24 is formed in an inner portion of this valve seat 26.

[0033] Width of the valve seat 26, that is, width thereof in an orthogonal direction to a longitudinal axial direction of the fuel injector (in other words, a longitudinal axial direction of the nozzle needle 23) as a vertical direction of the sheet in Fig. 3 is extremely small. A seating section 32c of an armature 32 constituting the electromagnetic valve 25, which will be described next, comes in substantially line contact in a ring shape with the valve seat 26 (see Fig. 3).

[0034] The electromagnetic valve 25 is configured by including, as main components, an electromagnetic coil 31, the armature 32, and a coil spring 33, and the configuration thereof itself is basically the same as that of a conventional electromagnetic valve.

[0035] The armature 32, for which a magnetic body is used, is configured to be largely divided into: a columnar section 32a that is formed in a hollow cylinder shape; and a disc-shaped plate section 32b that extends orthogonally from an end of the columnar section 32a.

[0036] A columnar support member 28 is slidably inserted in the columnar section 32a. One end side of this support member 28 is projected outward from the plate section 32b in appropriate length, and the coil spring 33 and a spring receiver plate 34 are attached thereonto. The spring receiver plate 34 is placed on the plate section 32b of the armature 32.

[0037] The electromagnetic coil 31 is disposed in a manner to surround the coil spring 33.

[0038] Near an end of the support member 28, which is projected from the plate section 32b, a top surface side of the electromagnetic coil 31 is closed by a closing member 29, and the coil spring 33 is disposed in a space that is substantially defined by the electromagnetic coil 31 and the closing member 29.

[0039] In such a configuration, when the fuel injection is stopped, the electromagnetic coil 31 is brought into an unenergized state, and the armature 32 is brought into a state where the seating section 32c thereof is seated on the valve seat 26 by a pressing force of the coil spring 33 (see Fig. 2).

[0040] In this way, the control chamber 24 is brought into a state having high fuel pressure. Accordingly, the nozzle needle 23 is pressed in a direction toward the injection hole (not illustrated) by the fuel pressure, and the injection hole is thereby brought into a closed state.

[0041] On the contrary, when the fuel is injected, the

electromagnetic coil 31 is energized. Then, the armature 32 is displaced to the electromagnetic coil 31 side against the pressing force of the coil spring 33, and the seating section 32c is separated from the valve seat 26. In this way, the control chamber 24 communicates with a low-pressure chamber 30 via the communication passage 27 (see Fig. 3).

[0042] As a result, the fuel in the control chamber 24 flows into the low-pressure chamber 30, and the fuel pressure in the control chamber 24 is reduced. In this way, while a downward pressing force, which is generated by the fuel pressure, from an upper surface side of the nozzle needle 23 facing the control chamber 24 side is reduced, an upward force, which is generated by the fuel pressure, on a lower side of the nozzle needle 23 overcomes the above-described force that presses the nozzle needle 23 downward from the control chamber 24 side. As a result, the nozzle needle 23 is instantaneously separated from the injection hole (not illustrated), and the injection is thereby started.

[0043] In such a pressure-balanced fuel injector, sludge is accumulated in a slight clearance between the armature 32 and the support member 28, which particularly deteriorates smoothness of the displacement of the armature 32 as described above and causes a delay in the displacement from a normal time when the fuel injector is energized at a start of a vehicle. Accordingly, such problems that a desired fuel injection amount is not achieved, that an engine starting state is deteriorated, and the like occur.

[0044] The fuel injector energization control method in the embodiment of the invention prevents or suppresses such deterioration of the engine starting state, which is caused by the sludge, at the start of the vehicle, more specifically, a reduced engine speed at the start. Referring to Fig. 4 and Fig. 5, a description will hereinafter be made on a procedure of the fuel injector energization control processing in the embodiment of the invention that is performed by the electronic control unit 4.

[0045] First, referring to Fig. 4, a first example will be described.

[0046] Once the electronic control unit 4 initiates the processing, the fuel injector is first energized before the engine starts, and a valve closing time is measured (see steps S102, S104 in Fig. 4).

[0047] First, in step S102, so-called non-injection energization of the fuel injectors 2-1 to 2-n is performed before the engine starts. That is, the fuel injectors 2-1 to 2-n are each energized for a predetermined energization time without supplying the fuel to the engine 3.

[0048] Next, a valve closing time CT of each of the fuel injectors 2-1 to 2-n, which is associated with termination of the energization, is measured and obtained (see step S104 in Fig. 4).

[0049] The valve closing time CT is duration of time from a time point at which the fuel injectors 2-1 to 2-n stop being energized to a time point at which the armature 32 is seated on the valve seat 26. The valve closing time

CT can be measured by using a conventionally well-known method, and the method used for the measurement does not have to be particularly limited. For example, more specifically, a method of obtaining the valve closing time CT by using a counter electromotive force has been available. The counter electromotive force is generated in the electromagnetic coil 31 after the fuel injectors 2-1 to 2-n stop being energized.

[0050] As it has been well known, the counter electromotive force is generated in the electromagnetic coil 31 after the fuel injectors 2-1 to 2-n stop being energized. A time point at which the counter electromotive force reaches a peak value matches valve closing timing by the nozzle needle 23. Thus, the above-described method of measuring the valve closing time CT by using the counter electromotive force, which is generated in the electromagnetic coil 31, uses this fact.

[0051] Next, it is determined whether a cause that deteriorates the starting state of the engine 3 is present on the basis of a determination on whether the valve closing time CT, which is obtained as described above, falls within a specified range (see step S106 in Fig. 4). If it is determined that the valve closing time CT falls within the specified range (if YES), the cause that deteriorates the starting state of the engine 3 is absent, and the processing proceeds to step S108.

[0052] On the contrary, if it is determined that the valve closing time CT does not fall within the specified range (if NO), the cause that deteriorates the starting state of the engine 3 is present, and the processing proceeds to step S110.

[0053] In step S108, from such a determination result in step S106 that the valve closing time CT falls within the specified range, it is considered that an operation of each of the fuel injectors 2-1 to 2-n is in a normal state. Accordingly, a normal energization time is set, and the fuel injectors 2-1 to 2-n are driven for energization.

[0054] On the contrary, in step S110, from such a determination result in step S106 that the valve closing time CT does not fall within the specified range, it is considered that the operation of each of the fuel injectors 2-1 to 2-n is abnormal, and corrected energization is performed. More specifically, energization conditions in the normal time are corrected. Then, energization control of the fuel injectors 2-1 to 2-n is executed on the basis of the corrected energization conditions.

[0055] Here, referring to Fig. 6, a description will be made on the corrected energization of the fuel injectors 2-1 to 2-n.

[0056] When the fuel injectors 2-1 to 2-n are usually energized, as it has generally been well known, inductance of the electromagnetic coil 31 is large, and the armature 32 has to be displaced significantly at a start of the energization. For this reason, the energization is performed using a relatively large current, and this current at the start of the energization is referred to as a "pull-up" current, for example.

[0057] In other words, the pull-up current can be said

as an energization current that is required to generate a desired initial electromagnetic force at the start of the energization of the fuel injectors 2-1 to 2-n.

[0058] Then, after the armature 32 is displaced to a desired position by the pull-up current, the electromagnetic force only has to be large enough to maintain the state of the armature 32. Thus, a magnitude of the current becomes smaller than that of the pull-up current, and the energization is performed using a so-called "hold current", a magnitude of which is smaller than that of the current at the start of the energization, for example.

(A) of Fig. 6 illustrates a waveform example of an energization current as described above that is used for the fuel injectors 2-1 to 2-n in the normal time.

[0059] In the normal time, that is, if it is determined in the processing in above step S106 that the valve closing time CT falls within the specified range (YES), the energization conditions of the fuel injectors 2-1 to 2-n are defined by calculation and the like on the basis of the operation state of the engine 3 at the time point, and the like. Here, the energization conditions includes, for example, a total energization time, a pull-up current value, an energization time using the pull-up current, and the like.

[0060] The corrected energization in step S110 is performed as it is considered that the time required for the displacement of the armature 32 is longer than the normal time or that a displacement amount of the armature 32 is insufficient when compared to that in normal energization. Accordingly, the energization conditions are basically corrected by extending the total energization time, increasing the magnitude of the pull-up current, and extending the energization time using the pull-up current.

[0061] Here, referring to (A) of Fig. 6, a description will be made on each of the above-described energization conditions.

[0062] First, the total energization time is duration of time from the start of the energization to a time point at which the energization current becomes zero, and is indicated as "ETn" in (A) of Fig. 6.

[0063] Next, as it has already been described, the pull-up current is the required current at the start of the energization of the fuel injectors 2-1 to 2-n, and is indicated as "Ip1" in (A) of Fig. 6. The pull-up current value is an average value of the pull-up current, from which overshoot thereof at the start of the energization is excluded.

[0064] Furthermore, the energization time using the pull-up current (hereinafter referred to as a "pull-up energization time" for convenience of the description) is duration of time from the start of the energization to a time point at which the pull-up current is switched to the hold current, and is indicated as "ETpn" in (A) of Fig. 6.

[0065] In addition, when the total energization time, the pull-up current value, and the pull-up energization time in the corrected energization are respectively indicated as ETs, Ip2, and ETps (see (B) of Fig. 6), these are set

to satisfy $ETs > ETn$, $Ip2 > Ip1$, and $ETps > ETpn$.

[0066] Note that a method of computing the total energization time, the pull-up current value, and the pull-up energization time in the corrected energization by correcting the total energization time, the pull-up current value, and the pull-up energization time in the normal time is not particularly limited. However, it is considered to adopt a method of extending the total energization time, increasing the pull-up current value, extending the pull-up energization time, and the like in accordance with a deviation of the valve closing time CT from a reference time.

[0067] Note that, as described above, the total energization time, the pull-up current value, and the pull-up energization time in the corrected energization are each extended or increased through the correction in the embodiment of the invention. However, all of these may not have to be corrected. As the simplest method, any one of these or any combination of two of these is preferably extended or increased through the correction.

[0068] Next, it is determined whether the engine speed exceeds a specified speed Ns (see step S112 in Fig. 4). If it is determined that the engine speed exceeds the specified speed Ns (if YES), the processing returns to the state where the normal energization is performed on the fuel injectors 2-1 to 2-n (see step S108 in Fig. 4), and a series of the processing is terminated.

[0069] On the contrary, if it is determined that the engine speed does not exceed the specified speed Ns (if NO), the corrected energization is continued until the above-described determination of YES is made.

[0070] Note that, as described above, the determination on whether to continue the corrected energization (see step S110 in Fig. 4) is made on the basis of the engine speed. However, a ground for the determination is not limited thereto. For example, the corrected energization is preferably performed for predetermined duration of time.

[0071] Referring to Fig. 5, a description will be made on a procedure of a second example of the fuel injector energization control processing.

[0072] When cranking is started through an operation of an ignition key (not illustrated) of the vehicle, the energization of the fuel injectors 2-1 to 2-n is prepared, and the fuel injectors 2-1 to 2-n are each brought into a state capable of injecting the fuel (an injection start prepared state) (see step S202 in Fig. 5).

[0073] Next, it is determined whether the cause that deteriorates the starting state of the engine 3 is present on the basis of a determination on whether the engine speed achieved by the cranking exceeds a specified speed Nn (see step S204 in Fig. 5).

[0074] In regard to the determination on the engine speed herein, because the engine speed is in the middle of a gradual increase by the cranking, a value obtained by adding a specified speed, which is set by a test, a simulation, or the like, to the speed achieved by the cranking, or the like is preferably used as the specified speed

Nn.

[0075] If it is determined in step S204 that the engine speed exceeds the specified speed Nn (if YES), the cause that deteriorates the starting state of the engine 3 is absent, and the operation of each of the fuel injectors 2-1 to 2-n is in the normal state. Accordingly, the fuel injectors 2-1 to 2-n are energized under setting of the normal energization time (see step S206 in Fig. 5).

[0076] On the contrary, if it is determined in step S204 that the engine speed does not exceed the specified speed Nn (if NO), the cause that deteriorates the starting state of the engine 3 is present, and the operation of each of the fuel injectors 2-1 to 2-n is abnormal. Accordingly, the corrected energization is performed. Note that the corrected energization has already been described in step S110 (see Fig. 4) and thus the detailed description thereon will not be repeated.

[0077] Next, it is determined again whether the engine speed exceeds the specified speed Nn (see step S210 in Fig. 5). If it is determined that the engine speed exceeds the specified speed Nn (if YES), the processing returns to the state where the normal energization is performed on the fuel injectors 2-1 to 2-n (see step S206 in Fig. 5), and a series of the processing is terminated.

[0078] On the contrary, if it is determined that the engine speed does not exceed the specified speed Nn (if NO), the corrected energization is continued until the above-described determination of YES is made.

[0079] It has been described that the fuel injectors 2-1 to 2-n are the pressure-balanced fuel injectors in the above-described embodiment of the invention. However, the fuel injector energization control method in the embodiment of the invention is not only applied to the pressure-balanced fuel injectors but may also be applied to the so-called ball valve fuel injectors.

Industrial Applicability

[0080] The invention can be applied to the common rail fuel injection control apparatus that is desired to reliably suppress or prevent deterioration of a fuel injection characteristic due to generation of the sludge at the start of the vehicle.

Reference Signs List

[0081]

- 1: Common rail
- 2-1 to 2-n: Fuel injector
- 4: Electronic control unit

Claims

1. A fuel injector energization control method that controls energization of a fuel injector at a start of a vehicle, the fuel injector energization control method

characterized by comprising:

determining whether a cause that deteriorates a starting state of an engine is present at the start of the vehicle; and
when it is determined that the cause that deteriorates the starting state of the engine is present, correcting an energization condition of the fuel injector and energizing the fuel injector on the basis of the corrected energization condition.

2. The fuel injector energization control method according to claim 1 **characterized in that** the determination on presence or absence of the cause that deteriorates the starting state of the engine is made by performing non-injection energization of the fuel injector at the start of the vehicle, measuring a valve closing time at the time, and determining whether the valve closing time exceeds a specified range,
when it is determined that the valve closing time exceeds the specified range, the cause that deteriorates the starting state of the engine is present, the energization condition is at least one or a combination of two or more of a total energization time, a pull-up current value, and a pull-up energization time, and
the total energization time is duration of time from a start of the energization of the fuel injector to a time point at which a current value becomes zero due to a stop of the energization, the pull-up current value is an energization current value that is required to generate an initial electromagnetic force at the start of the energization of the fuel injector, and the pull-up energization time is an energization time using the pull-up current.
3. The fuel injector energization control method according to claim 2 **characterized in that** the energization of the fuel injector based on the corrected energization condition is continued until an engine speed exceeds a specified speed.
4. The fuel injector energization control method according to claim 2 **characterized in that** the energization of the fuel injector based on the corrected energization condition is performed for a specified time.
5. The fuel injector energization control method according to claim 1 **characterized in that** the determination on presence or absence of the cause that deteriorates the starting state of the engine is made by determining whether an engine speed exceeds a specified speed after a start of cranking,
when it is determined that the engine speed falls be-

low the specified speed, the cause that deteriorates the starting state of the engine is present, the energization condition is at least one or a combination of two or more of a total energization time, a pull-up current value, and a pull-up energization time, and

the total energization time is duration of time from a start of the energization of the fuel injector to a time point at which a current value becomes zero due to a stop of the energization, the pull-up current value is an energization current value that is required to generate an initial electromagnetic force at the start of the energization of the fuel injector, and the pull-up energization time is an energization time using the pull-up current.

6. The fuel injector energization control method according to claim 5 **characterized in that** the energization of the fuel injector based on the corrected energization condition is continued until the engine speed exceeds the specified speed.

7. A common rail fuel injection control apparatus in which fuel in a fuel tank is pressurized and pressured to a common rail by a high-pressure pump and which is provided with an electronic control unit capable of executing injection control of high pressure fuel to an engine via a fuel injector connected to said common rail, the common rail fuel injection control apparatus **characterized in that** the electronic control unit is configured to:

determine whether a cause that deteriorates a starting state of the engine is present at a start of a vehicle;
when it is determined that the cause that deteriorates the starting state of the engine is present, correct an energization condition in energization control of the fuel injector; and
be able to execute the energization control of the fuel injector on the basis of the corrected energization condition.

8. The common rail fuel injection control apparatus according to claim 7 **characterized in that** the electronic control unit is configured to perform non-injection energization of the fuel injector at the start of the vehicle, measure a valve closing time at the time, and determine that the cause that deteriorates the starting state of the engine is present when the valve closing time exceeds a specified range, the energization condition is at least one or a combination of two or more of a total energization time, a pull-up current value, and a pull-up energization time, and
the total energization time is duration of time from a start of the energization of the fuel injector to a time point at which a current value becomes zero due to

a stop of the energization, the pull-up current value is an energization current value that is required to generate an initial electromagnetic force at the start of the energization of the fuel injector, and the pull-up energization time is an energization time using the pull-up current.

9. The common rail fuel injection control apparatus according to claim 8 **characterized in that** the electronic control unit is configured to continue the energization of the fuel injector on the basis of the corrected energization condition until an engine speed exceeds a specified speed.

10. The common rail fuel injection control apparatus according to claim 8 **characterized in that** the electronic control unit is configured to perform the energization of the fuel injector on the basis of the corrected energization condition for a specified time.

11. The common rail fuel injection control apparatus according to claim 7 **characterized in that** the electronic control unit is configured to determine that the cause that deteriorates the starting state of the engine is present when an engine speed falls below a specified speed after a start of cranking, the energization condition is at least one or a combination of two or more of a total energization time, a pull-up current value, and a pull-up energization time, and
the total energization time is duration of time from a start of the energization of the fuel injector to a time point at which a current value becomes zero due to a stop of the energization, the pull-up current value is an energization current value that is required to generate an initial electromagnetic force at the start of the energization of the fuel injector, and the pull-up energization time is an energization time using the pull-up current.

12. The common rail fuel injection control apparatus according to claim 11 **characterized in that** the electronic control unit is configured to continue the energization of the fuel injector on the basis of the corrected energization condition until the engine speed exceeds the specified speed.

Fig. 1

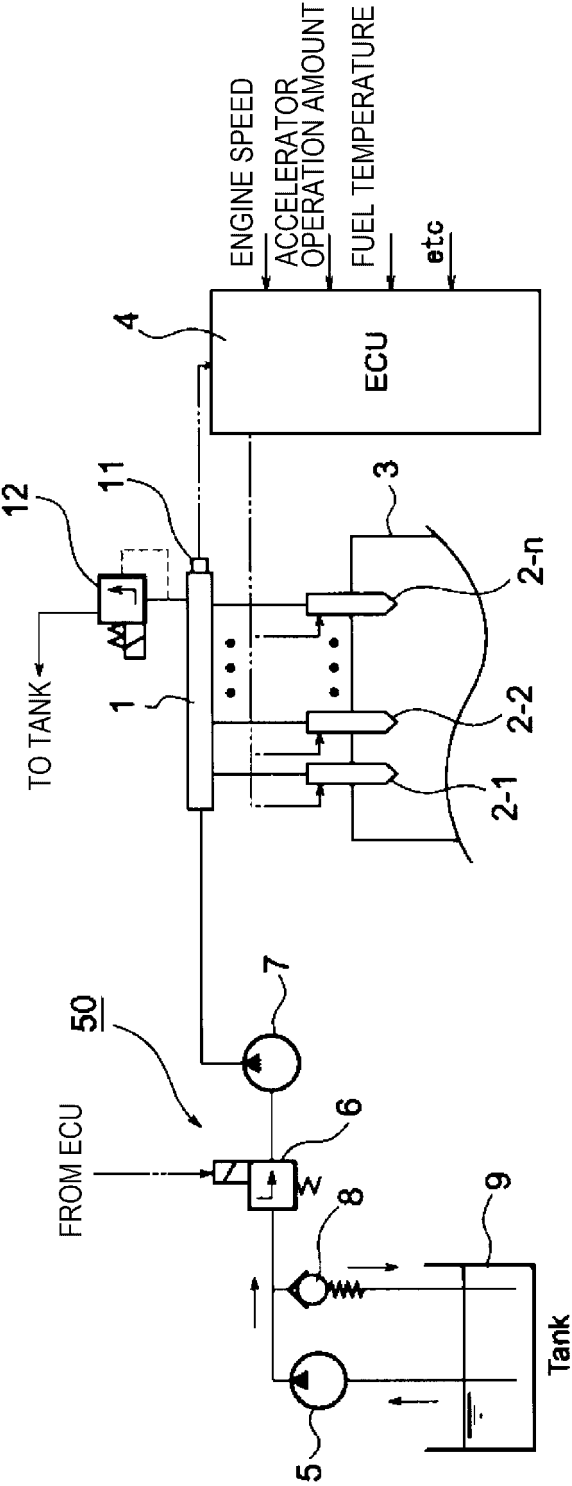


Fig. 2

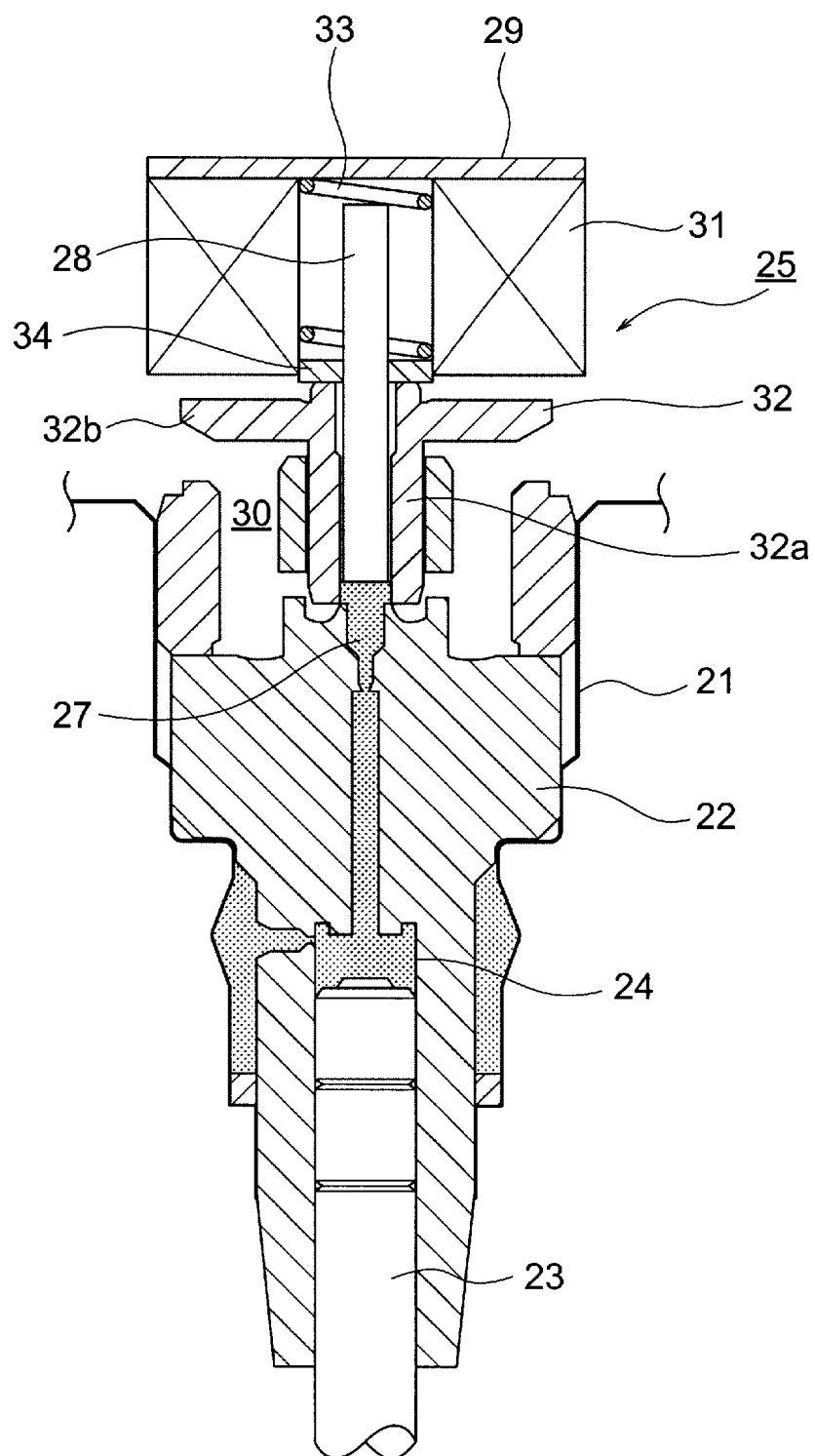


Fig. 3

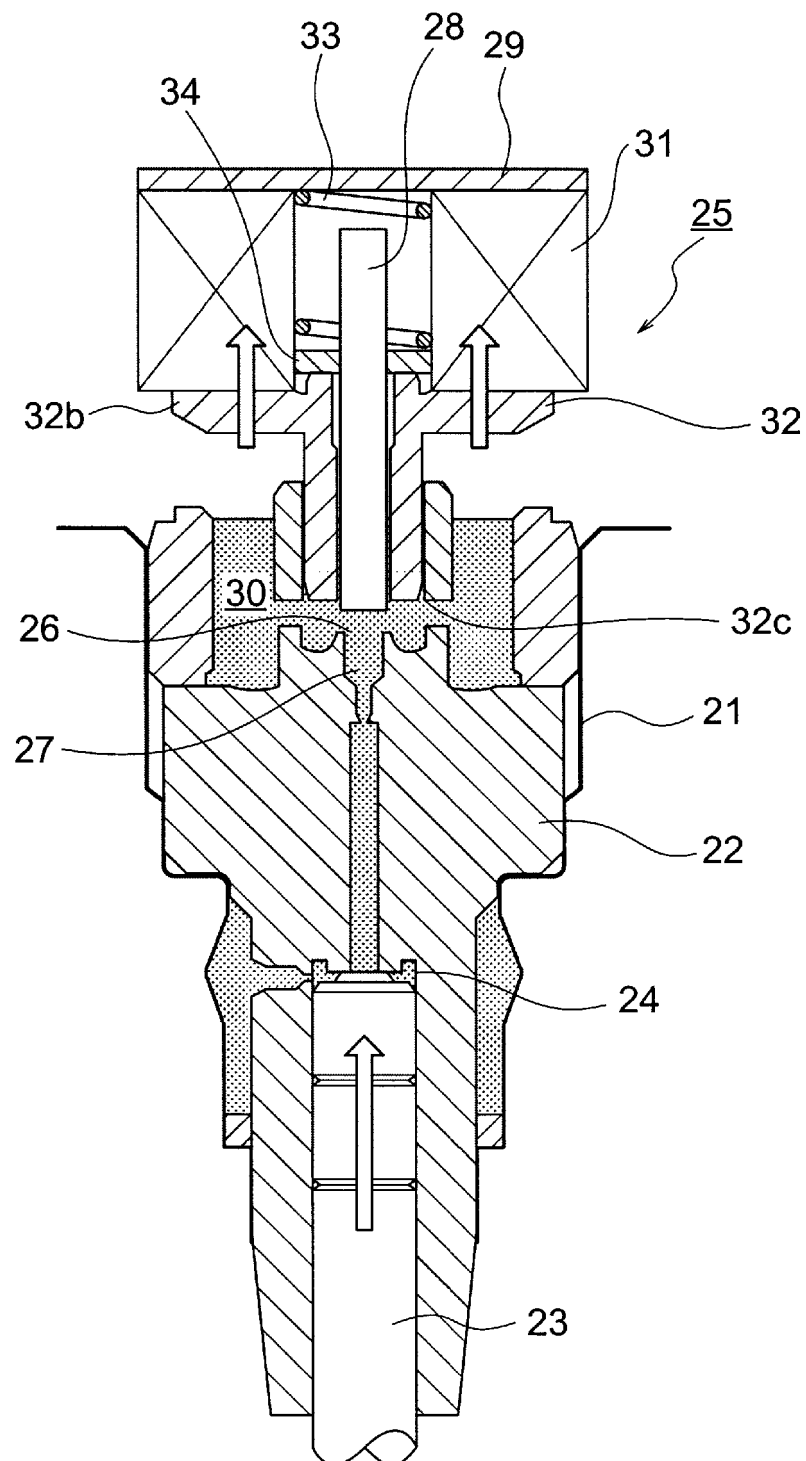


Fig. 4

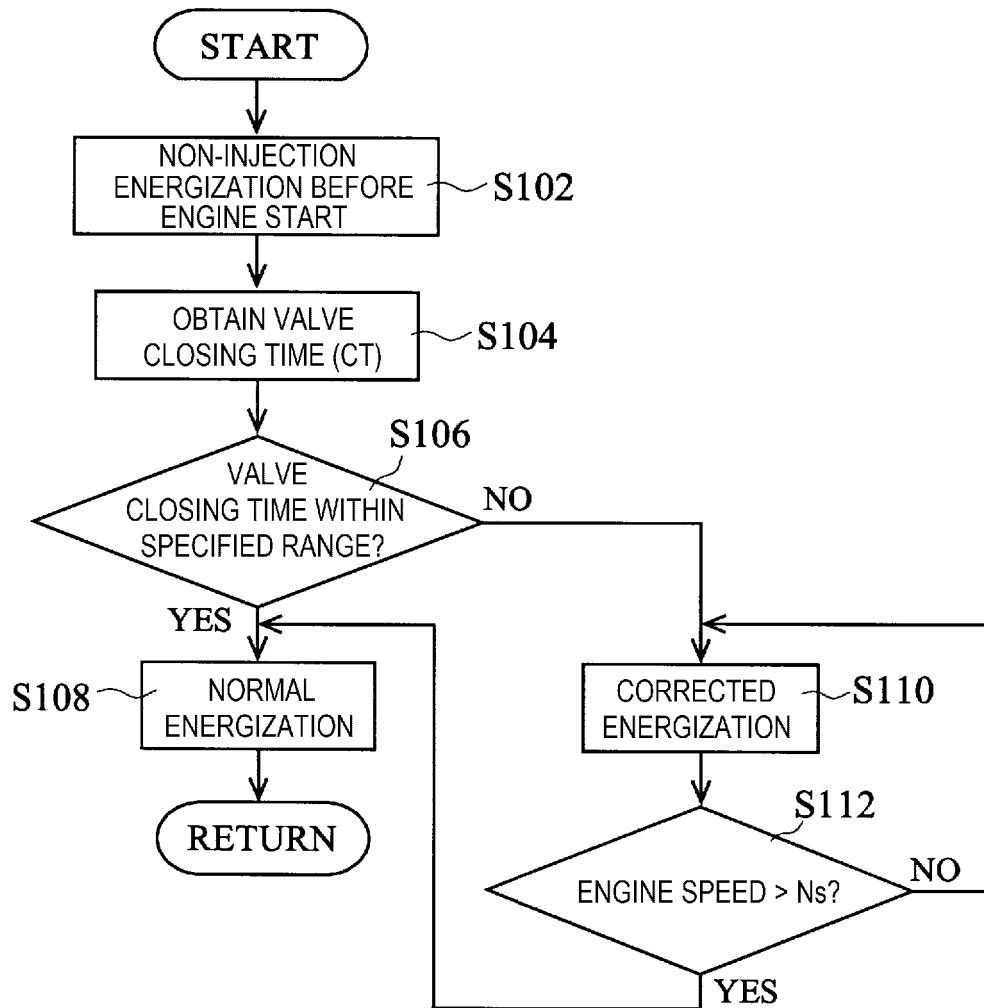


Fig. 5

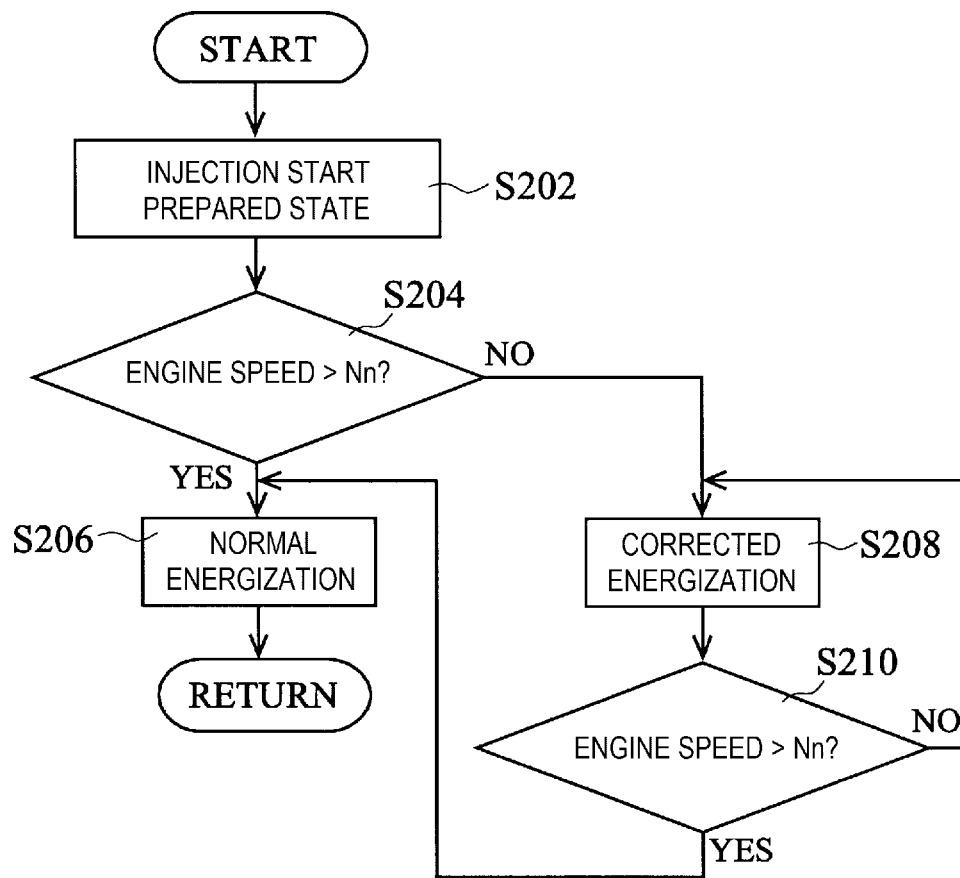
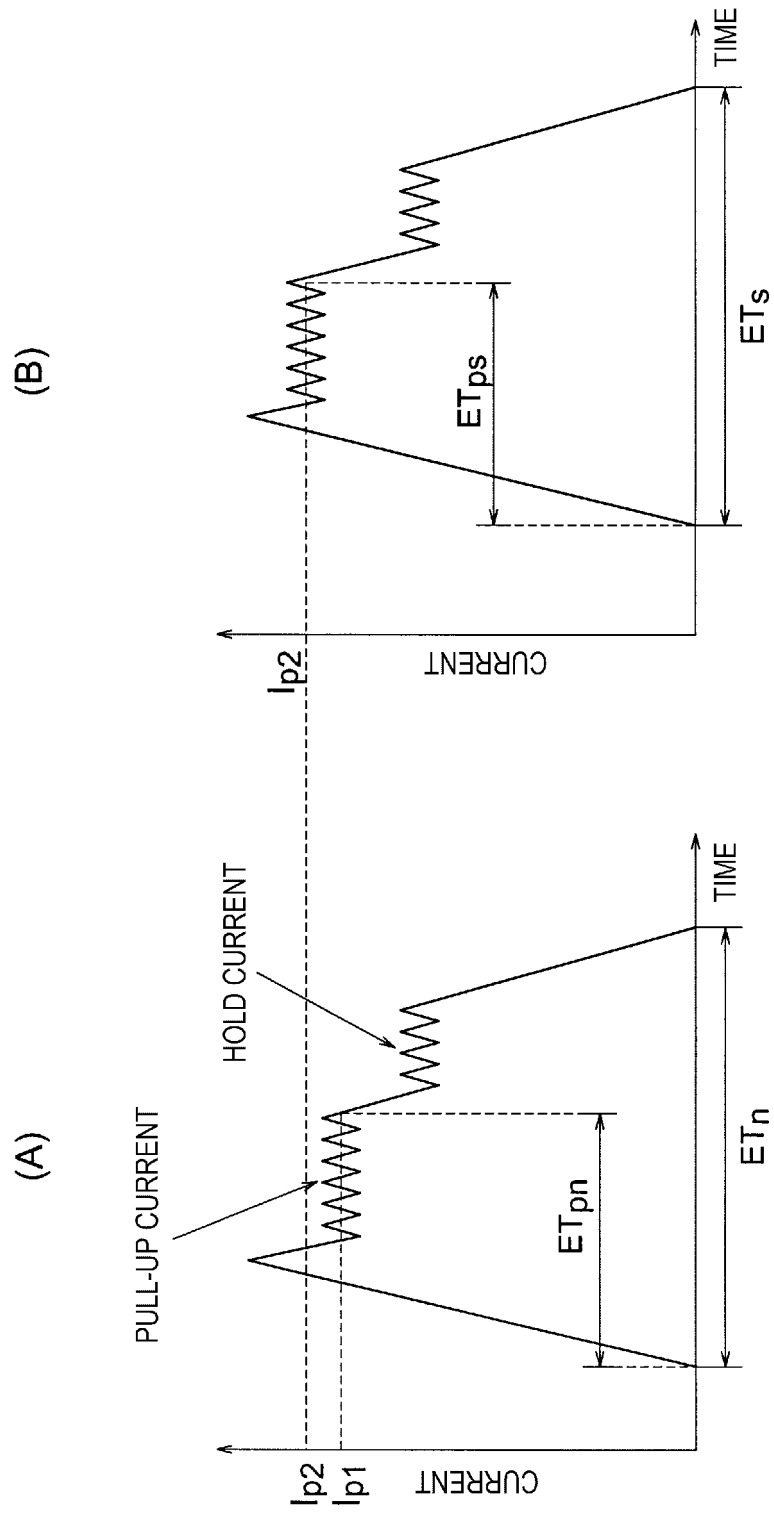


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/052408

A. CLASSIFICATION OF SUBJECT MATTER

INV. F02D41/06 F02D41/20 F02D41/24
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2014 201206 A1 (BOSCH GMBH ROBERT [DE]) 23 July 2015 (2015-07-23)	1-4,7-10
Y	abstract; figures 1,3,5 paragraph [0003] - paragraph [0004] paragraph [0008] - paragraph [0009] paragraph [0026] - paragraph [0027] paragraph [0034] - paragraph [0035]	5,6,11, 12
Y	DE 197 02 556 A1 (UNISIA JECS CORP [JP]) 31 July 1997 (1997-07-31) abstract; figures 2,3,4,7 column 5, line 45 - column 7, line 3	5,6,11, 12
X	EP 1 323 914 A2 (DEERE & CO [US]) 2 July 2003 (2003-07-02) abstract; figure 2 paragraph [0007] - paragraph [0022]	1-4,7-10
	----- -/-	

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

15 August 2017

Date of mailing of the international search report

22/08/2017

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/052408

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2014 217685 B3 (CONTINENTAL AUTOMOTIVE GMBH [DE]) 17 December 2015 (2015-12-17) abstract; claim 1; figure 1 paragraph [0021] - paragraph [0023] -----	1,3,4,7, 9,10

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2017/052408

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102014201206 A1	23-07-2015	NONE	
DE 19702556 A1	31-07-1997	DE 19702556 A1 JP 3355269 B2 JP H09203342 A US 5817923 A	31-07-1997 09-12-2002 05-08-1997 06-10-1998
EP 1323914 A2	02-07-2003	BR 0207598 A DE 60222368 T2 EP 1323914 A2 JP 2003206819 A US 2003120418 A1	08-09-2004 12-06-2008 02-07-2003 25-07-2003 26-06-2003
DE 102014217685 B3	17-12-2015	NONE	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2012526227 A [0008]