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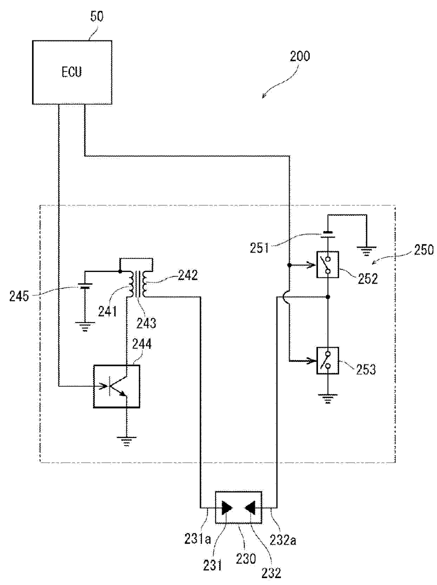
(54) **ENGINE**

(57) An engine (1) is provided with an ignition device (200). The ignition device (200) is provided with: a central electrode (231); a grounding electrode (232) which is provided corresponding to the central electrode (231) and which is connected to ground (GND); and a potential rise promoting unit (250) disposed between ground (GND) and the grounding electrode (232). According to such a configuration, by raising the potential on the grounding electrode 232 side, an electric field in an electric discharge region formed by the central electrode (231) and the grounding electrode (232) can be strengthened before spark discharge occurs. As a result, the voltage when spark discharge begins can be suppressed, and a deterioration in an electrode unit configured from the central electrode (231) and the grounding electrode (232) can be suppressed.

Fig.2



EP 3 705 714 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an engine provided with an ignition device.

BACKGROUND ART

[0002] In a known engine, a spark plug is arranged in a combustion chamber of an engine, a voltage generated by an ignition coil is applied to an electrode part including a center electrode and a ground electrode to cause an arc discharge in a discharge region of the electrode part, and thus, an air-fuel mixture supplied to the combustion chamber of the engine is ignited.

[0003] For example, Patent Literature 1 (PTL 1) discloses an ignition device provided with a main electrode including a main high-voltage electrode and a main ground electrode, and an auxiliary electrode including an auxiliary high-voltage electrode and an auxiliary ground electrode. In the ignition device of PTL 1, the high voltage of a secondary coil connected to a battery is applied to the auxiliary electrode, and a switch is changed after a lapse of a predetermined time period to apply the high voltage to the main electrode to generate a spark discharge.

[0004] Further, Patent Literature 2 (PTL 2) discloses an ignition device in which a terminal for observing a discharge voltage waveform is provided on one of discharge electrodes and a resistance (R3) for observing a discharge current waveform is provided on the other of the discharge electrodes, to easily calculate a discharge energy by a waveform observing means using an oscilloscope, in a spark discharge generator.

CITATION LIST

Patent Literature

[0005]

PTL 1: Japanese Patent Application Laid-Open No. 2007-032349
PTL 2: Japanese Patent Application Laid-Open No. 2005-185027

DISCLOSURE OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006] In the known ignition devices disclosed in PTLs 1 and 2 described above, the ground electrode is always connected to the ground (GND), and the voltage on the ground electrode side is maintained at approximately 0 V. In such a configuration, there is a problem in that the voltage of the main electrode or the auxiliary electrode, which voltage is required for generating a spark discharge, is relatively large, and a high current flows when a spark discharge occurs, so that each of the electrodes is easily deteriorated.

MEANS FOR SOLVING THE PROBLEMS

[0007] To solve the main technical problem described above, according to the present invention, there is provided an engine including an ignition device, which includes a center electrode, a ground electrode provided to correspond to the center electrode and connected to ground, and a potential increase promotor arranged between the ground and the ground electrode.

[0008] The potential increase promotor includes a power source, to which the ground electrode provided to correspond to the center electrode is connected via a first switch, and a control unit that generates a spark discharge on the ignition device. The ground electrode is connected to the ground via a second switch. The control unit performs potential increase control, in which the control unit turns the first switch ON while keeping the second switch OFF to connect the ground electrode to the power source and increase a potential of the ground electrode. After performing the potential increase control, the control unit applies a voltage between the center electrode and the ground electrode while keeping the potential of the ground electrode increased to generate the spark discharge.

[0009] The control unit may be configured to turn the first switch from ON to OFF before generating the spark discharge after turning the first switch ON to perform the potential increase control.

[0010] Further, the control unit may be configured to generate the spark discharge while turning the first switch ON to perform the potential increase control.

[0011] Further, the control unit may turn the second switch ON for a predetermined time period while keeping the first switch OFF after generating the spark discharge.

[0012] The potential increase promotor may be a response delay generation unit provided between the ground and the ground electrode. In that case, the ground electrode provided to correspond to the center electrode and connected to the ground is included in the potential increase promotor.

[0013] The response delay generation unit includes a winding part.

[0014] The engine may further include a cylinder head including an attachment hole for attaching a spark plug including the center electrode and the ground electrode. In that case, the spark plug includes a conductive housing formed with the ground electrode, the spark plug is attached to the attachment hole via an insulator, and the housing and the cylinder head are connected via the response delay generation unit. The response delay generation unit may be formed as a gasket used when the spark plug is attached to the attachment hole.

[0015] It is also possible that the engine further includes a cylinder head including an attachment hole for attaching a spark plug including the center electrode and the ground electrode, the response delay generation unit includes a resistor and a winding part arranged between the resistor and the cylinder head, and that the spark plug includes a conductive housing formed with the ground electrode and is attached to the attachment hole via the resistor.

[0016] It is also possible that the engine further includes a cylinder head including an attachment hole for attaching a spark plug including the center electrode and the ground electrode, the spark plug including the center electrode and the ground electrode includes a conductive housing formed with the ground electrode, and the response delay generation unit is arranged between the housing and the attachment hole.

[0017] It is also possible that the engine further includes a cylinder head including an attachment hole for attaching a spark plug including the center electrode and the ground electrode, the spark plug includes a conductive housing formed with the ground electrode and attached to the attachment hole, and the ground electrode is connected to the housing via the response delay generation unit.

[0018] It is also possible that the engine further includes a cylinder head including an attachment hole for attaching a spark plug including the center electrode and the ground electrode, the spark plug includes a housing insulated from the center electrode and the ground electrode and is attached to the attachment hole via the housing, and a terminal of the ground electrode and the cylinder head are connected via the response delay generation unit.

EFFECT OF THE INVENTION

[0019] An engine according to the present invention includes an ignition device. The ignition device includes a center electrode, a ground electrode provided to correspond to the center electrode and connected to ground, and a potential increase promotor arranged between the ground and the ground electrode. With such configuration, an electric field in a discharge region formed by the center electrode and the ground electrode is enhanced before the spark discharge occurs by increasing the potential on the ground electrode side. As a result, the voltage at the start of spark discharge is suppressed, which makes it possible to suppress deterioration of an electrode part constituted of the center electrode and the ground electrode.

[0020] The potential increase promotor of the engine according to the present invention includes a power source and a control unit. To the power source, the ground electrode provided to correspond to the center electrode is connected via a first switch. The ground electrode is connected to the ground via a second switch. The control unit performs potential increase control, in which the control unit turns the first switch ON while keeping the second switch OFF to connect the ground electrode to the power source and increase the potential of the ground electrode. After performing the potential increase control, the control unit applies a voltage between the center electrode and the ground electrode while keeping the potential of the ground electrode increased to generate the spark discharge. With such configuration, an electric field in a discharge region formed by the center electrode and the ground electrode is enhanced before the spark discharge occurs. As a result, it is possible to suppress deterioration of the electrode part constituted of the center electrode and the ground electrode.

[0021] The potential increase promotor of the engine according to the present invention may include a center electrode, a ground electrode, and a response delay generation unit. The ground electrode is provided to correspond to the center electrode and is connected to the ground. The response delay generation unit is provided between the ground and the ground electrode. Thus, the electric field in a discharge region formed by the center electrode and the ground electrode is enhanced before spark ignition, and the voltage for generating a spark is reduced. As a result, it is possible to suppress deterioration of an electrode part constituted of the center electrode and the ground electrode. In addition, the electric field of the electrode part before the spark discharge is to be enhanced, so that the formation of an initial flame kernel when an air-fuel mixture is ignited is promoted to shorten the combustion period.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

FIG. 1 is a schematic diagram of an engine according to a first embodiment of the present invention.

FIG. 2 is a block diagram illustrating a simplified configuration of an ignition device arranged in the engine illustrated in FIG 1.

FIGS. 3(a) to 3(c) are time charts illustrating changes respectively in a secondary voltage, a first switch, and a second switch in ignition control according to the first embodiment.

FIGS. 4(a) to 4(c) are time charts illustrating changes respectively in a secondary voltage, a first switch, and a second switch in ignition control according to a second embodiment.

FIG. 5 is a graph illustrating pressure change histories when an air-fuel mixture is ignited for each of the first embodiment, the second embodiment, and the prior art.

FIG. 6 is a schematic diagram of an engine including an ignition device according to a third embodiment.

FIG. 7 is a block diagram illustrating a simplified configuration of the ignition device arranged in the engine illustrated in FIG 6.

FIGS. 8(a) to 8(c) are diagrams illustrating circuit examples of a response delay generation unit of the ignition device illustrated in FIG. 7.

FIGS. 9(a) and 9(b) are time charts illustrating a center electrode-side voltage, a ground electrode-side voltage, and a current when ignition control is performed respectively by a known ignition device and an ignition device according to each embodiment.

FIGS. 10(a) to 10(e) are diagrams illustrating other embodiments for a spark plug and an attachment structure of the spark plug.

FIG. 11 is a graph illustrating pressure change histories when an air-fuel mixture is ignited according to the third embodiment and the prior art.

DESCRIPTION OF EMBODIMENTS

[0023] A first embodiment of an engine configured according to the present invention will be described below in detail with reference to the accompanying drawings.

(First Embodiment)

[0024] FIG. 1 schematically illustrates a configuration of an engine 100 in which an ignition device 200 is arranged. The gas engine 100 is, for example, an engine using city gas supplied from a pipeline, as fuel. The engine 100 is a type of engine in which an air-fuel mixture of fuel gas G and air is supplied to a combustion chamber M described later and is ignited with a spark plug 230.

[0025] The engine 100 includes an engine main body 10, an intake system 20, an exhaust system 30, and the ignition device 200 including an engine control unit (ECU) 50 serving as a control unit and the spark plug 230. The spark plug 230 includes a center electrode 231 and a ground electrode 232.

[0026] The engine main body 10 is constituted of a cylinder head 70, and a cylinder block 80. The engine main body 10 includes a plurality of cylinders 11. FIG. 1 illustrates only one of the plurality of cylinders 11. Each of the cylinders 11 is communicated by the intake system 20 and also communicated by the exhaust system 30. The intake system 20 is constituted of an intake port 21 formed in the cylinder head 70 and an intake manifold 22. The exhaust system 30 is constituted of an exhaust port exhaust port 31 and an exhaust manifold 32.

[0027] The intake manifold 22 is provided with a gas injector 42. An intercooler, a main throttle, a turbocharger compressor, and the like (not illustrated) are arranged upstream of the intake system 20. A turbocharger turbine and the like (not illustrated) are arranged downstream of the exhaust manifold 32 in the exhaust system 30.

[0028] The ECU 50 has a function of performing ignition control (described later) for the ignition device 200, and controlling the main throttle and the like so that an intake manifold pressure being the air flow rate reaches a target intake manifold pressure, and controls the entire engine 100.

[0029] A configuration of the cylinder head 70 will be further described with reference to FIG. 1.

[0030] The cylinder head 70 is arranged above the cylinder block 80. The cylinder head 70 is provided with an intake valve 71, an exhaust valve 72, and the spark plug 230 facing the combustion chamber M described later.

[0031] A piston P is slidably housed in a cylindrical part 12 of the cylinder 11. The combustion chamber M is formed by an inner wall of the cylindrical part 12 of the cylinder 11, a lower surface of the cylinder head 70, and a top of the piston P.

[0032] The intake manifold 22 is connected to a fuel supply pipe 41 via the gas injector 42, and is provided with an intake manifold pressure sensor 54. The fuel supply pipe 41 is provided with a fuel gas pressure sensor 55 configured to detect a fuel gas pressure and a fuel gas pressure regulator 56.

[0033] The engine 100 is further provided with an engine speed sensor 51 configured to detect an engine speed Ne and an engine output sensor 52 configured to detect an engine output W. The engine speed sensor 51 and the engine output sensor 52, in addition to the gas injector 42, the fuel gas pressure sensor 55, and the fuel gas pressure regulator 56, are connected to the ECU 50. Not only the sensors and devices described above, but also various other sensors and devices may be connected to the ECU 50.

[0034] A fuel injection rate map is set in the ECU 50. The fuel injection rate map represents a correlation among the engine speed Ne, the engine output W, and an instruction fuel injection rate Q being a fuel flow rate, and determines the instruction fuel injection rate Q with respect to the engine speed Ne and the engine output W. The ECU 50 controls the gas injector 42, based on the instruction fuel injection rate Q.

[0035] A target intake manifold pressure map is further set in the ECU 50. The target intake manifold pressure map represents a correlation among the engine speed Ne, the engine output W, and a target intake manifold pressure Pi, and determines the target intake manifold pressure Pi with respect to the engine speed Ne and the engine output W. The ECU 50 controls the main throttle so that the intake manifold pressure reaches the target intake manifold pressure Pi.

[0036] With the above configuration, the ECU 50 controls the fuel gas pressure regulator 56, the gas injector 42, the main throttle, and the like to supply a mixed gas obtained by mixing the fuel gas G and air to the intake manifold 22. The mixed gas is supplied to the combustion chamber M via the intake manifold 22 and is ignited by the spark plug 230.

[0037] The ignition device 200 will be further described with reference to FIG. 2 in addition to FIG. 1.

[0038] The ignition device 200 is constituted of the above-described ECU 50 and spark plug 230. The spark plug 230 is arranged in the cylinder 11.

[0039] As illustrated in FIG. 2, the ignition device 200 includes an ignition coil including a primary coil 241, a secondary coil 242, and a core 243, and an igniter 244. The primary coil 241 is wound around the core 243. One end of the primary coil 241 is connected to a power source

245, and the other end of the primary coil 241 is connected to the igniter 244. The secondary coil 242 is wound around the core 243. One end of the secondary coil 242 is connected to the primary coil 241, and the other end of the secondary coil 242 is connected to a terminal 231a of the center electrode 231.

[0040] The igniter 244 is constituted of, for example, a transistor, and switches between supplying and stopping the supply of power from the power source 245 to the primary coil 241 by an energization signal from the ECU 50 described above. The above-described high voltage application unit 240 is a circuit generally known as a circuit for applying a voltage to a spark plug, and various modifications can be assumed. For example, in the present embodiment, the igniter 244 is constituted of a transistor. However, the present invention is not limited thereto, and the igniter 244 may be replaced with a point (contact) type distributor.

[0041] The ignition device 200 further includes a power source 251, a first switch 252, and a second switch 253. The ground electrode 232 of the spark plug 200 is connected to the power source 251 via the first switch 252. The first switch 252 connects and disconnects the power source 251 and the ground electrode 232. The ground electrode 232 is connected to the GND via the second switch 253. The second switch 253 connects and disconnects the ground electrode 232 and the GND. The first switch 252 and the second switch 253 preferably comply with a high voltage and are capable of a high-speed response. The first switch 252 and the second switch 253 are operated by an instruction signal from the ECU 50, and are controlled at a predetermined appropriate timing. The power source 251, to which the ground electrode 232 provided to correspond to the center electrode 231 as mentioned before is connected via the first switch 252, and the ECU 50 arranged as a control unit generating a spark discharge on the ignition device 200 constitute a potential increase promotor. With the potential on the ground electrode side being increased by the potential increase promotor, the electric field in a discharge region formed by the center electrode and the ground electrode is enhanced before a spark discharge occurs.

[0042] As illustrated in FIG. 1, the spark plug 230 has a threaded part 233. The threaded part 233 is used for attaching the spark plug 230 to an attachment hole 73 formed in the cylinder head 70.

[0043] The ignition control performed in the above-described ignition device 200 will be described below with reference to FIG. 3. FIG. 3(a) illustrates a change in the secondary voltage from the ignition coil, FIG. 3(b) illustrates the ON/OFF state of the first switch 252, and FIG. 3(c) illustrates the ON/OFF state of the second switch 253.

[0044] When a spark discharge is generated with the spark plug 230, the ECU 50 performs the potential increase control of the ground electrode 232. Specifically, firstly, as illustrated in FIG. 3(b), while the second switch 253 is turned OFF, the first switch 252 of a ground electrode voltage application unit 250 is turned ON for a predetermined period by an instruction signal from the ECU 50. Thereafter, the first switch 252 is turned OFF before a voltage is applied to the spark plug 230 to generate a spark discharge (see FIG. 3(b)). Thus, the potential increase control is performed for the ground electrode 232, and the state where the electric field formed by the center electrode 231 and the ground electrode 232 is enhanced is maintained.

[0045] In parallel with the above-described potential increase control, an energization signal is sent from the ECU 50 to the igniter 244 at a timing in consideration of an ignition time determined depending on an operating state of the engine. As a result, a current is supplied from the power source 245 to the primary coil 241 to form a magnetic field around the core 243. As described above, even after the first switch 252 is turned OFF, the state where the electric field formed by the center electrode 231 and the ground electrode 232 is enhanced continues. In this state, the ECU 50 turns OFF the energization signal to the igniter 244. Thus, the power supply from the power source 245 to the primary coil 241 is stopped. When the power supply to the primary coil 241 is stopped, an electromotive force is generated at the secondary coil 242 side by the mutual induction action, and a negative secondary voltage is generated as illustrated in FIG. 3(a). The timing at which the secondary voltage occurs is indicated by ST in FIG. 3. A voltage is applied to the discharge region formed between the center electrode 231 and the ground electrode 232 by the secondary voltage, a spark discharge occurs at a timing indicated by BD in FIG. 3, and the air-fuel mixture compressed in the combustion chamber M is ignited. After the spark discharge occurs, the second switch 253 is turned ON for a predetermined time period (see FIG. 3(c)) to connect the ground electrode 232 to the GND and set the potential of the ground electrode 232 to the initial state (0 V). The time period when the second switch 253 is to be turned ON is stored in the ECU 50 in advance, for example. Although not particularly limited, the time period when the second switch 253 is to be turned ON can be set between 1 and 10 msec. Such ignition control is repeatedly performed in synchronization with the ignition timing in each of the cylinders 11.

[0046] In the present embodiment, before a spark discharge is generated by the spark plug 230, potential increase control for increasing the potential of the ground electrode 232 is performed in advance, and the electric field in the discharge region formed between the center electrode 231 and the ground electrode 232 is enhanced. Thus, the secondary voltage for generating the spark discharge in the spark plug 230 can be reduced as compared with the prior art, and as a result, deterioration of the center electrode 231 and the ground electrode 232 can be suppressed.

[0047] The present invention is not limited to the configuration described in the first embodiment described above, and various modifications can be assumed. A second embodiment will be described below.

(Second Embodiment)

[0048] The second embodiment is common to the first embodiment in that the configurations of the engine 100 and the ignition device 200 illustrated in FIG. 1 and FIG. 2 are employed, and the description of the common features is omitted. In the second embodiment, a timing of the instruction signal from the ECU 50 to the first switch 252 and the second switch 253 is different from that in the first embodiment. Here, differences from the first embodiment will be mainly described with reference to FIG. 2 and FIG. 4.

[0049] In the second embodiment, when a high voltage is applied to the spark plug 230, firstly, the first switch 252 is turned ON by an instruction signal from the ECU 50, and the ON state is maintained, as a result, potential increase control for maintaining the potential of the ground electrode 232 in a high state is performed (see FIG. 4(b)). At this time, the second switch 253 is in an OFF state. As a result, the electric field in the discharge region formed by the center electrode 231 and the ground electrode 232 is further enhanced as compared with that in the first embodiment.

[0050] An energization signal is sent from the ECU 50 to the igniter 244 while the electric field formed by the center electrode 231 and the ground electrode 232 is enhanced. The ECU 50 transmits an energization signal to the igniter 244 at a timing in consideration of the ignition time determined depending on an operating state of the engine. When the energization signal is sent from the ECU 50 to the igniter 244, a current is supplied from the power source 245 to the primary coil 241, and a magnetic field is formed around the core 243. After the predetermined time period has elapsed, the ECU 50 turns OFF the energization signal to the igniter 244 at the timing indicated by ST in FIG. 4. Thus, the power supply from the power source 245 to the primary coil 241 is stopped. When the power supply to the primary coil 241 is stopped, an electromotive force is generated at the secondary coil 242 side by the mutual induction action, and a negative secondary voltage is generated as illustrated in FIG. 4(a). A spark discharge occurs in the discharge region formed between the center electrode 231 and the ground electrode 232 by the secondary voltage at a timing indicated by BD in FIG. 4, and the air-fuel mixture compressed in the combustion chamber M is ignited. After the spark discharge occurs, the first switch 252 is turned OFF, and at the same time, the second switch 253 is turned ON for a predetermined time period to connect the ground electrode 232 to the ground and set the potential of the ground electrode 232 to the initial state (0 V). In the present embodiment, the second switch 253 is turned ON at the same time as the first switch 252 is turned OFF, however, the second switch 253 may be turned ON after the first switch 252 is turned OFF. That is, the second switch 253 only needs to be ON for a predetermined time period while the first switch 252 is turned OFF.

[0051] In the second embodiment, similarly to the first embodiment, before a spark discharge is generated by the spark plug 230, the potential increase control for increasing the potential of the ground electrode 232 is also performed in advance, and the electric field in the discharge region formed between the center electrode 231 and the ground electrode 232 is enhanced. Further, in the second embodiment, the ON state of the first switch 252 is maintained before and after the timing at which the spark discharge is generated, and therefore, the potential of the ground electrode 232 is maintained in a high state even after the spark discharge, and the electric field in the discharge region is maintained in a more enhanced state. Therefore, the secondary voltage for generating a spark discharge in the spark plug 230 can be further reduced as compared with the prior art, and as a result, deterioration of the center electrode 231 and the ground electrode 232 can be suppressed.

[0052] An effect of the ignition of the air-fuel mixture by the ignition device 200 on the pressure change history in the combustion chamber M will be described with reference to FIG. 5. Data shown in FIG. 5 shows the pressure change history in a container when an air-fuel mixture having an equivalent ratio of 0.7 is filled in a closed container having a predetermined volume and is ignited at a container internal pressure of 1 MPa. A dotted line in the figure indicates the pressure change history in the container when a spark discharge is generated by a known ignition device (conventional example) in which potential increase control is not performed. A solid line indicates the pressure change history in the container when a spark discharge is generated by the ignition control in the first embodiment described above, and a dash-dot-dash line indicates the pressure change history in the container when a spark discharge is generated by the ignition control in the second embodiment. In FIG. 5, ignition timings (0 ms) at which spark discharges occur are aligned to compare the subsequent pressure change histories in the container.

[0053] As can be understood from FIG. 5, according to the ignition control in the first embodiment shown by the solid line, the increase in the pressure after the spark discharge is accelerated as compared with the conventional example. This indicates that the electric field between the center electrode 231 and the ground electrode 232 is enhanced before the generation of the spark discharge, and the maintenance of the state where the electric field is enhanced when combustion proceeds after the air-fuel mixture is ignited promotes the formation of the initial flame kernel, causing the combustion of the air-fuel mixture to proceed favorably, and shortening the combustion period.

[0054] In the ignition control in the second embodiment indicated by the dash-dot-dash line, the increase in the pressure is further accelerated and the combustion period is further shortened as compared with that in the first embodiment. This may result from the fact that during the ignition control in the second embodiment, the ON state of the first switch 252 is maintained from before the generation of the spark discharge until after the generation of the spark discharge, and the electric field in the discharge region at the time of the spark discharge and during the subsequent combustion period is further enhanced.

[0055] A first embodiment of an engine including an ignition device will be described below in detail with reference to the accompanying drawings.

(Third Embodiment)

[0056] FIG. 6 schematically illustrates a configuration of an engine 100 including an ignition device 200 of the embodiment. The engine 100 is, for example, an engine using city gas supplied from a pipeline, as fuel, that is, a type of engine in which an air-fuel mixture of fuel gas G and air is supplied to a combustion chamber M described later and is ignited with a spark plug 230.

[0057] The engine 100 includes an engine main body 10, an intake system 20, an exhaust system 30, an engine control unit (ECU) 50 serving as a control unit, and the ignition device 200 including the spark plug 230 and a response delay generation unit 260. The spark plug 230 includes a center electrode 231 and a ground electrode 232.

[0058] The engine main body 10 is constituted of a cylinder head 70, and a cylinder block 80. The engine main body 10 includes a plurality of cylinders 11. FIG. 6 illustrates only one of the plurality of cylinders 11. Each of the cylinders 11 is communicated by the intake system 20 and also communicated by the exhaust system 30. The intake system 20 is constituted of an intake port 21 formed in the cylinder head 70 and an intake manifold 22. The exhaust system 30 is constituted of an exhaust port 31 and an exhaust manifold 32.

[0059] The intake manifold 22 is provided with a gas injector 42. An intercooler, a main throttle, a turbocharger compressor, and the like (not illustrated) are arranged upstream of the intake system 20. A turbocharger turbine and the like (not illustrated) are arranged downstream of the exhaust manifold 32 in the exhaust system 30.

[0060] The ECU 50 performs ignition control of the ignition device 200, and also controls the main throttle and the like so that an intake manifold pressure being the air flow rate reaches a target intake manifold pressure.

[0061] A configuration of the cylinder head 70 will be further described with reference to FIG. 6.

[0062] The cylinder head 70 is arranged above the cylinder block 80. The cylinder head 70 is provided with an intake valve 71, an exhaust valve 72, and the spark plug 230 facing the combustion chamber M described later. The cylinder head 70 includes an attachment hole 73 for attaching the spark plug 230 to the cylinder head 70.

[0063] A piston P is slidably housed in a cylindrical part 12 of the cylinder 11. The combustion chamber M is formed by an inner wall of the cylindrical part 12 of the cylinder 11, a lower surface of the cylinder head 70, and a top of the piston P, in the cylinder head 70.

[0064] The intake manifold 22 is connected to a fuel supply pipe 41 via the gas injector 42, and is provided with an intake manifold pressure sensor 54. The fuel supply pipe 41 is provided with a fuel gas pressure sensor 55 configured to detect a fuel gas pressure and a fuel gas pressure regulator 56.

[0065] The engine 100 is further provided with an engine speed sensor 51 configured to detect an engine speed Ne and an engine output sensor 52 configured to detect an engine output W. The engine speed sensor 51 and the engine output sensor 52, in addition to the gas injector 42, the fuel gas pressure sensor 55, and the fuel gas pressure regulator 56, are connected to the ECU 50. Not only the sensors and devices described above, but also various other sensors and devices may be connected to the ECU 50.

[0066] A fuel injection rate map is set in the ECU 50. The fuel injection rate map represents a correlation among the engine speed Ne, the engine output W, and an instruction fuel injection rate Q being a fuel flow rate, and determines the instruction fuel injection rate Q with respect to the engine speed Ne and the engine output W. The ECU 50 controls the gas injector 42, based on the instruction fuel injection rate Q.

[0067] A target intake manifold pressure map is further set in the ECU 50. The target intake manifold pressure map represents a correlation among the engine speed Ne, the engine output W, and a target intake manifold pressure Pi, and determines the target intake manifold pressure Pi with respect to the engine speed Ne and the engine output W. The ECU 50 controls the main throttle so that the intake manifold pressure reaches the target intake manifold pressure Pi.

[0068] With the above configuration, the ECU 50 controls the fuel gas pressure regulator 56, the gas injector 42, the main throttle, and the like to supply an air-fuel mixture obtained by mixing the fuel gas G and air to the intake manifold 22. The mixed gas is supplied to the combustion chamber M via the intake manifold 22 and is ignited by the spark plug 230.

[0069] The ignition device 200 will be further described with reference to FIG. 7 and FIG. 8 in addition to FIG. 6.

[0070] The ignition device 200 includes the above-described ECU 50, spark plug 230, and the response delay generation unit 260 serving as a potential increase promotor in this embodiment. As generally illustrated in FIG. 1 and FIG. 2, in the ignition device 200, a voltage is applied for generating a spark discharge between the center electrode 231 and the ground electrode 232 via a terminal 231a coupled to the center electrode 231 of the spark plug 230. The response delay generation unit 260 is arranged between the ground electrode 232 and the GND. The response delay generation unit 260 has a function of maintaining the potential of the ground electrode 232 before the spark discharge in a high state, and generating a response delay in the potential change of the ground electrode 232 to enhance the electric field in the discharge region formed between the center electrode 231 and the ground electrode 232. With the potential on the ground electrode side being increased by the response delay generation unit 260 serving as a potential increase promotor, the electric field in a discharge region formed by the center electrode and the ground electrode is enhanced before the spark discharge occurs.

[0071] As illustrated in FIG. 7, the ignition device 200 includes an ignition coil including a primary coil 241, a secondary coil 242, and a core 243, an igniter 244, and a power source 245. The primary coil 241 is wound around the core 243. One end of the primary coil 241 is connected to the power source 245, and the other end of the primary coil 241 is connected to the igniter 244. The secondary coil 242 is wound around the core 243. One end of the secondary coil 242 is connected to the primary coil 241, and the other end of the secondary coil 242 is connected to the terminal 231a of the center electrode 231 in the spark plug 230.

[0072] The igniter 244 is constituted of, for example, a transistor. The igniter 244 switches between supplying and stopping the supply of power from the power source 245 to the primary coil 241 by an energization signal from the ECU 50 described above. The above-described circuit is a circuit generally known as a circuit for applying a voltage to a spark plug, and various modifications can be assumed. For example, in the present embodiment, the igniter 244 is constituted of a transistor. However, the present invention is not limited thereto, and the igniter 244 may be replaced with a point (contact) type distributor.

[0073] As illustrated in FIG. 7, the response delay generation unit 260 is arranged between the ground electrode 232 of the spark plug 230 and the GND. The response delay generation unit 260 has a function of preventing the potential of the ground electrode 232 from decreasing after a spark discharge occurs in the discharge region formed between the center electrode 231 and the ground electrode 232. The response delay generation unit 260 preferably includes a winding part (coil). The response delay generation unit 260 generates electromotive force by an excess response because of the provision of the winding part to realize the above function.

[0074] FIG. 8 illustrates an example of a circuit constituting the response delay generation unit 260. As illustrated in FIG. 8, the response delay generation unit 260 may include an inductor serving as a winding part. More specifically, it is possible to employ, as examples of a configuration of the response delay generation unit 260, a configuration in which the response delay generation unit 260 includes an inductor 261 (see FIG. 8(a)), and a configuration in which the response delay generation unit 260 includes a resistor 262 and an inductor 263 arranged in series (see FIG. 8(b)), or a configuration in which the response delay generation unit 260 includes a resistor 264 and an inductor 265 arranged in series and a capacitor 266 arranged in parallel with the resistor 264 and the inductor 265 (see FIG. 8(c)). The configuration illustrated in FIG. 8(c) can be realized by, for example, a carbon film resistor. The carbon film resistor includes a pure carbon film tightly fixed on the surface of a porcelain bar by thermal decomposition at a high temperature and in a high vacuum, and provides a required resistance value obtained by forming a winding structure in which the carbon film is grooved in a spiral shape. When the inductance of the winding part, the resistance value of the resistors 262 and 264, and electrostatic capacitance of the capacitor 266, and the like in FIGS. 8(a) to 8(c) are adjusted, it is possible to adjust the excess response characteristic of the response delay generation unit 260. The excess response characteristic of the response delay generation unit 260 is appropriately determined by experiments or the like. The spark plug 230 included in the ignition device 200 is arranged for each of the cylinders 11.

[0075] Returning to FIG. 6, a detailed configuration of the spark plug 230 and a configuration example of the response delay generation unit 260 will be described. The center electrode 231 and the ground electrode 232 are arranged at the leading end of the spark plug 230. The spark plug 230 further includes a conductive housing 234. The center electrode 231 is electrically coupled to the terminal 231a above the center electrode 231 via a copper core passing through the center of the spark plug 230 and being surrounded by an insulator. The ground electrode 232 is formed on the conductive housing 234. The housing 234 is made of, for example, a special nickel alloy. The housing 234 includes a threaded part 243a and a head part 243b. The threaded part 243a is screwed into the attachment hole 73 of the cylinder head 70. The ground electrode 232 is locked to one end of the threaded part 243a. The head part 243b is connected to the other end of the threaded part 243a.

[0076] In the present embodiment, an approximately cylindrical insulator 74 is arranged between the attachment hole 73 of the cylinder head 70 and the housing 234 of the spark plug 230. The insulator 74 blocks the electrical conduction between the cylinder head 70 and the spark plug 230. The insulator 74 has an approximately cylindrical shape. The response delay generation unit 260 described above is arranged between the housing 234 of the spark plug 230 and the cylinder head 70. The housing 234 and the cylinder head 70 are connected via the response delay generation unit 260. With such a configuration, it is not necessary to process the spark plug 230 to form the response delay generation unit 260. Therefore, a commonly used spark plug can be employed as the spark plug 230 of the present embodiment.

[0077] The present embodiment is generally configured as described above, and ignition control performed by the above-described ignition device 200 will be described below with reference to FIGS. 6 to 9.

[0078] The ECU 50 transmits an energization signal to the igniter 244 at a timing in consideration of the ignition time determined depending on the operating state of the engine so that the spark plug 230 generates a spark discharge. As a result, a current is supplied from the power source 245 to the primary coil 241 to form a magnetic field around the core 243. Next, the energization signal to the igniter 244 is interrupted, and thus, the power supply from the power source 245 to the primary coil 241 is stopped. When the power supply to the primary coil 241 is stopped, a negative secondary voltage is generated at the secondary coil 242 side by a mutual induction action. A voltage is applied to the discharge region formed between the center electrode 231 and the ground electrode 232 by the secondary voltage, and thus, a spark discharge occurs, and the air-fuel mixture compressed in the combustion chamber M is ignited. Such ignition control is repeatedly performed in synchronization with the ignition timing in each of the cylinders 11.

[0079] FIG. 9(a) is a time chart illustrating a center electrode-side voltage, a ground electrode-side voltage, and a current when ignition control is performed by a known ignition device. FIG. 9(b) is a time chart illustrating a center electrode-side voltage, a ground electrode-side voltage, and a current when ignition control is performed by the ignition device 200 according to the present embodiment. In FIG. 9, a timing at which a spark discharge occurs is indicated by BD.

[0080] In the known ignition device, the ground electrode is always connected to the GND. Thus, as indicated by a dotted line in FIG. 9(a), in the known ignition device, the ground electrode-side voltage is maintained at approximately 0 V. In such a configuration, as indicated by a solid line in FIG. 9(a), the center electrode-side voltage required to generate a spark discharge is larger than the installation electrode-side voltage. As a result, a high current flows when a spark discharge is generated, as indicated by a dash-dot-dash line in FIG. 9(a). Therefore, the center electrode and the ground electrode are likely to deteriorate.

[0081] On the other hand, in the ignition device 200 according to the present embodiment, the response delay generation unit 260 is arranged between the ground electrode 232 and the GND. Thus, after a spark discharge occurs and the air-fuel mixture is ignited, the ground electrode-side voltage does not decrease for a while as indicated by a dotted line in FIG. 9(b). That is, a state where the electric field in the discharge region formed between the center electrode 231 and the ground electrode 232 is enhanced is maintained. When ignition control is performed in such a configuration, as indicated by solid lines in FIG. 9, the center electrode voltage for generating a spark discharge in the spark plug 230 can be reduced as compared with that in the known ignition device. As a result, it is possible to suppress the value of the current flowing when a spark discharge is generated, and also suppress deterioration of the center electrode 231 and the ground electrode 232. The response delay generation unit 260 according to the present embodiment may be configured by any of the circuit examples of the response delay generation unit 260 illustrated in FIGS. 8(a) to 8(c).

[0082] As illustrated in FIG. 9(b), in the ignition device 200 according to the present embodiment, after the spark discharge occurs, the ground electrode-side voltage decreases slowly, not suddenly. This phenomenon is called response delay. The response delay generation unit 260 is a component for causing such a response delay.

[0083] The present invention is not limited to the configuration described in the third embodiment described above, and various modifications can be assumed as long as they belong to the technical scope of the present invention. Other embodiments will be described below. The other embodiments described below differs from the third embodiment as above in the spark plug 230, the response delay generation unit 260, and the attachment structure of the spark plug 230 for the attachment hole 73 of the cylinder head 70, and the remaining configuration is common, a detailed description of the common features will thus be omitted.

(Fourth Embodiment)

[0084] A fourth embodiment will be described with reference to FIG. 10(a). The fourth embodiment illustrated in FIG. 10(a) is configured to realize the circuit example illustrated in FIG. 8(b). The response delay generation unit 260 is constituted of the resistor 262 and the inductor 261 (winding part). The resistor 262 is arranged in the attachment hole 73 of the cylinder 70, and the resistor 262 has an approximately cylindrical shape. The spark plug 230 is attached to the attachment hole 73 via the resistor 262.

[0085] In the fourth embodiment, the response delay generation unit 260 is configured by the inductor 261 and the resistor 262. In this case, it is not necessary to process the spark plug 230 for forming the response delay generation unit 260. Therefore, a commonly used spark plug can be used as is. The resistance value of the resistor 262 can be appropriately selected.

(Fifth Embodiment)

[0086] A firth embodiment will be described with reference to FIG. 10(b). In the fifth embodiment illustrated in FIG. 10(b), similarly to the third embodiment, the spark plug 230 is attached to the attachment hole 73 of the cylinder head 70 via the insulator 74. At this time, a gasket serving as the response delay generation unit 260 is arranged between the housing 234 of the spark plug 230 and the attachment hole 73 of the cylinder head 70. Airtightness between the spark plug 230 and the cylinder head is maintained by the response delay generation unit 260. In the response delay generation unit 260 according to the present embodiment, a through hole is formed at the center (not illustrated), and the threaded part 243a of the spark plug 230 is inserted into the through hole. Thus, the housing 234 of the spark plug 230 and the cylinder head 70 are not directly connected, but are connected via the response delay generation unit 260. It may be configured such that the response delay generation unit 260 according to the present embodiment has a winding structure and an inductance, for example. With such a configuration, in the present embodiment, it is also possible to provide a similar operation and effect to those of the third embodiment described above. Further, in the present embodiment, similarly to the third and fourth embodiments, the processing of the spark plug 230 for forming the response delay generation unit 260 is unnecessary.

(Sixth Embodiment)

[0087] The sixth embodiment will be described with reference to FIG. 10(c). In the sixth embodiment illustrated in FIG. 10(c), the response delay generation unit 260 including the winding part is formed in a tubular shape. The threaded part 243a of the spark plug 230 is inserted into the response delay generation unit 260. That is, the spark plug 230 is attached to the attachment hole 73 of the cylinder head 70 via the response delay generation unit 260. With such a configuration, it is possible to provide a similar operation and effect to those of the third embodiment described above. Further, in the present embodiment, similarly to the third through fifth embodiments, the processing of the spark plug 230 for forming the response delay generation unit 260 is unnecessary.

(Seventh Embodiment)

[0088] A seventh embodiment will be described with reference to FIG. 10(d). The seventh embodiment illustrated in FIG. 10(d) differs from the third to sixth embodiments in configuration of the ground electrode 232. In the present embodiment, the ground electrode 232 is coupled to the housing 234 via the response delay generation unit 260. Such a response delay generation unit 260 may be configured by, for example, a small inductor, and it is possible to provide a similar operation and effect to those of the third embodiment described above.

(Eighth Embodiment)

[0089] An eighth embodiment will be described with reference to FIG. 10(e). In the eighth embodiment illustrated in FIG. 10(e), the center electrode 231 and the ground electrode 232 are electrically insulated from the housing 234. The terminal 231a of the center electrode 231 is connected to the above-described ignition coil, and the terminal 232a of the ground electrode 232 is connected to the cylinder head 70 via the response delay generation unit 260. The spark plug 230 according to the present embodiment is directly attached to the attachment hole 73 of the cylinder head 70, but the housing 234 and the ground electrode 232 are insulated. In the present embodiment, it is also possible to provide a similar operation and effect to those of the third embodiment described above. In the seventh and eighth embodiments described above, the spark plug 230 is improved, and thus, it is not necessary to make major changes to the cylinder head 70.

[0090] An effect of the ignition of the air-fuel mixture by the ignition device 200 on the pressure change history in the combustion chamber M will be described with reference to FIG. 11. Data shown in FIG. 11 shows the pressure change history in a container when an air-fuel mixture having an equivalent ratio of 0.7 is filled in a closed container having a predetermined volume and is ignited at a container internal pressure of 1 MPa. A dotted line in the figure indicates the pressure change history in the container when the air-fuel mixture is ignited by a known ignition device (conventional example) not including the response delay generation unit 260. A solid line in the figure indicates the pressure change history in the container when the air-fuel mixture is ignited by the ignition device 200 of the third embodiment described above. In FIG. 10, ignition timings (0 ms) at which spark discharges occur are aligned to compare the subsequent pressure change histories.

[0091] As understood from FIG. 11, in the third embodiment indicated by the solid line, the increase in the pressure after ignition is accelerated as compared with the conventional example. This may result from the fact that electric field between the center electrode 231 and the ground electrode 232 is enhanced by the response delay generation unit 260. FIG. 11 indicates that in the third embodiment, the maintenance of the state where the electric field is enhanced even when combustion proceeds after the air-fuel mixture is ignited promotes the formation of the initial flame kernel, causing the combustion of the air-fuel mixture to proceed favorably, and shortening the combustion period.

[0092] The present invention is not limited to the embodiments described above, and can include various modifications as long as they are included in the technical scope of the present invention. Although all the first through sixth embodiments describe examples in which the first through eighth embodiments are applied to a gas engine using city gas supplied from a pipeline, as fuel, the present invention is not limited thereto. For example, the present invention can be applied to any engine in which fuel ignites by a spark discharge, such as another gas engine using CNG or LNG as fuel, or a gasoline engine.

DESCRIPTION OF REFERENCE NUMERALS

[0093]

10	Engine main body
11	Cylinder
20	Intake system
21	Intake port
22	Intake manifold
30	Exhaust system

31	Exhaust port
32	Exhaust manifold
41	Fuel supply path
42	Gas injector
50	ECU (control unit)
70	Cylinder head
80	Cylinder block
100	Engine
200	Ignition device
230	Spark plug
231	Center electrode
232	Ground electrode
234	Housing
250	Ground electrode voltage application unit
251	Power source
252	First switch
253	Second switch
260	Response delay generation unit
261, 263, 265	Inductor (winding part)
262, 264	Resistor
266	Capacitor

Claims

1. An engine comprising an ignition device, the ignition device including:

a center electrode;
a ground electrode provided to correspond to the center electrode and connected to ground; and
a potential increase promotor arranged between the ground and the ground electrode.

2. The engine according to claim 1,
wherein the potential increase promotor includes a power source, to which the ground electrode provided to correspond to the center electrode is connected via a first switch, and a control unit that generates a spark discharge on the ignition device,
wherein the ground electrode is connected to the ground via a second switch, and
wherein the control unit performs potential increase control, in which the control unit turns the first switch ON while keeping the second switch OFF to connect the ground electrode to the power source and increase a potential of the ground electrode, and, after performing the potential increase control, applies a voltage between the center electrode and the ground electrode while keeping the potential of the ground electrode increased to generate the spark discharge.

3. The engine according to claim 2, wherein the control unit turns the first switch from ON to OFF before generating the spark discharge after turning the first switch ON to perform the potential increase control.

4. The engine according to claim 2, wherein the control unit generates the spark discharge while turning the first switch ON to perform the potential increase control.

5. The engine according to claim 3 or claim 4, wherein the control unit turns the second switch ON for a predetermined time period while keeping the first switch OFF after generating the spark discharge.

6. The engine according to claim 1,
wherein the potential increase promotor includes a response delay generation unit provided between the ground and the ground electrode, and
wherein the ground electrode provided to correspond to the center electrode and connected to the ground is included in the potential increase promotor.

7. The engine according to claim 6, wherein the response delay generation unit includes a winding part.

8. The engine according to claim 6 or claim 7, further comprising a cylinder head including an attachment hole for attaching a spark plug including the center electrode and the ground electrode,
wherein the spark plug includes a conductive housing formed with the ground electrode, the spark plug is attached to the attachment hole via an insulator, and the housing and the cylinder head are connected via the response delay generation unit.

9. The engine according to claim 8, wherein the response delay generation unit is formed as a gasket used when the spark plug is attached to the attachment hole.

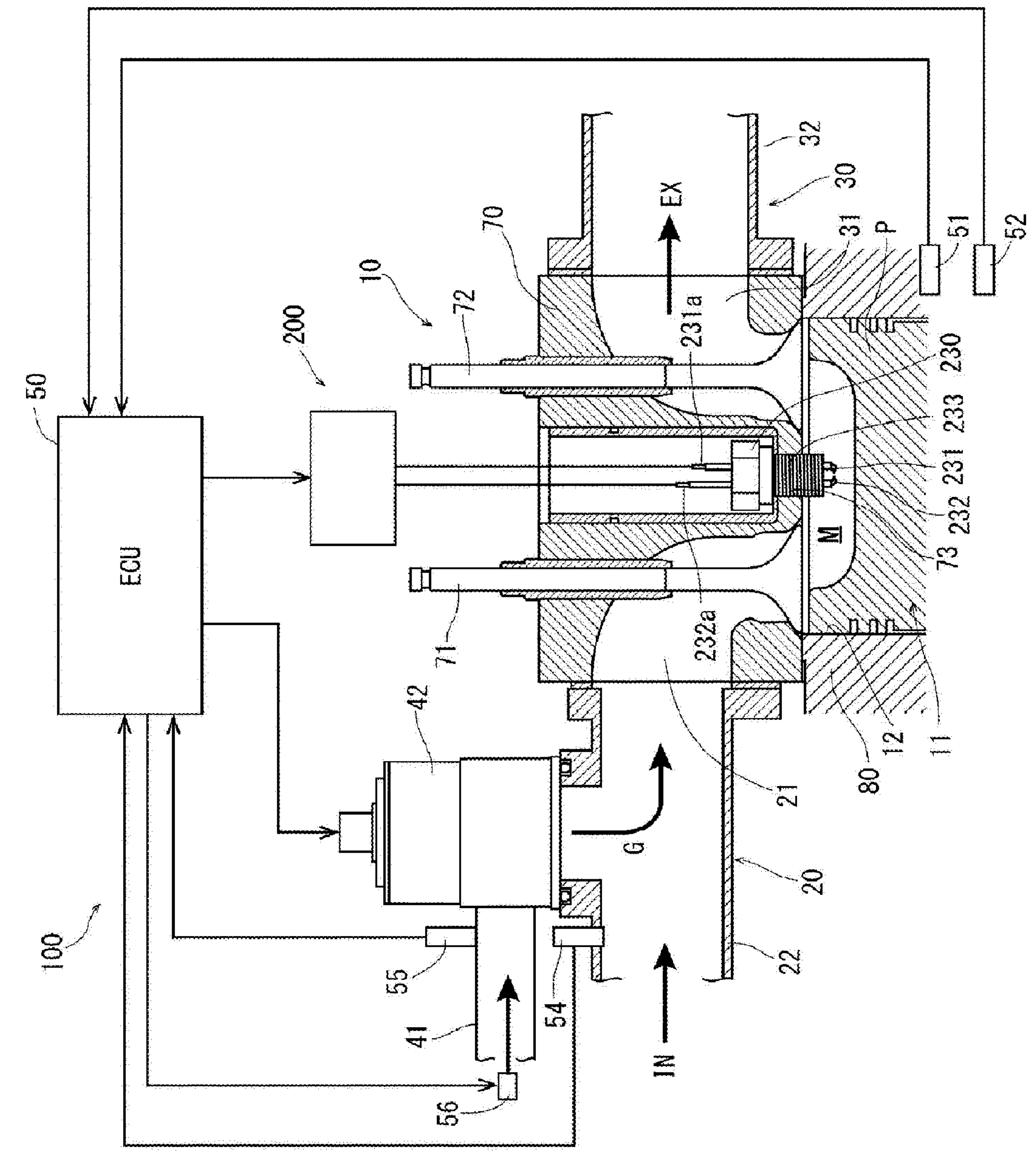
10. The engine according to claim 6, further comprising a cylinder head including an attachment hole for attaching a spark plug including the center electrode and the ground electrode,
wherein the response delay generation unit includes a resistor and a winding part arranged between the resistor and the cylinder head, and
wherein the spark plug includes a conductive housing formed with the ground electrode, and is attached to the attachment hole via the resistor.

11. The engine according to claim 6 or claim 7, further comprising a cylinder head including an attachment hole for attaching a spark plug including the center electrode and the ground electrode,
wherein the spark plug including the center electrode and the ground electrode includes a conductive housing formed with the ground electrode, and
wherein the response delay generation unit is arranged between the housing and the attachment hole.

12. The engine according to claim 6 or claim 7, further comprising a cylinder head including an attachment hole for attaching a spark plug including the center electrode and the ground electrode,
wherein the spark plug includes a conductive housing formed with the ground electrode and attached to the attachment hole, and
wherein the ground electrode is connected to the housing via the response delay generation unit.

13. The engine according to claim 6 or claim 7, further comprising a cylinder head including an attachment hole for attaching a spark plug including the center electrode and the ground electrode,
wherein the spark plug includes a housing insulated from the center electrode and the ground electrode, and is attached to the attachment hole via the housing, and
wherein a terminal of the ground electrode and the cylinder head are connected via the response delay generation unit.

Fig.1


ECU
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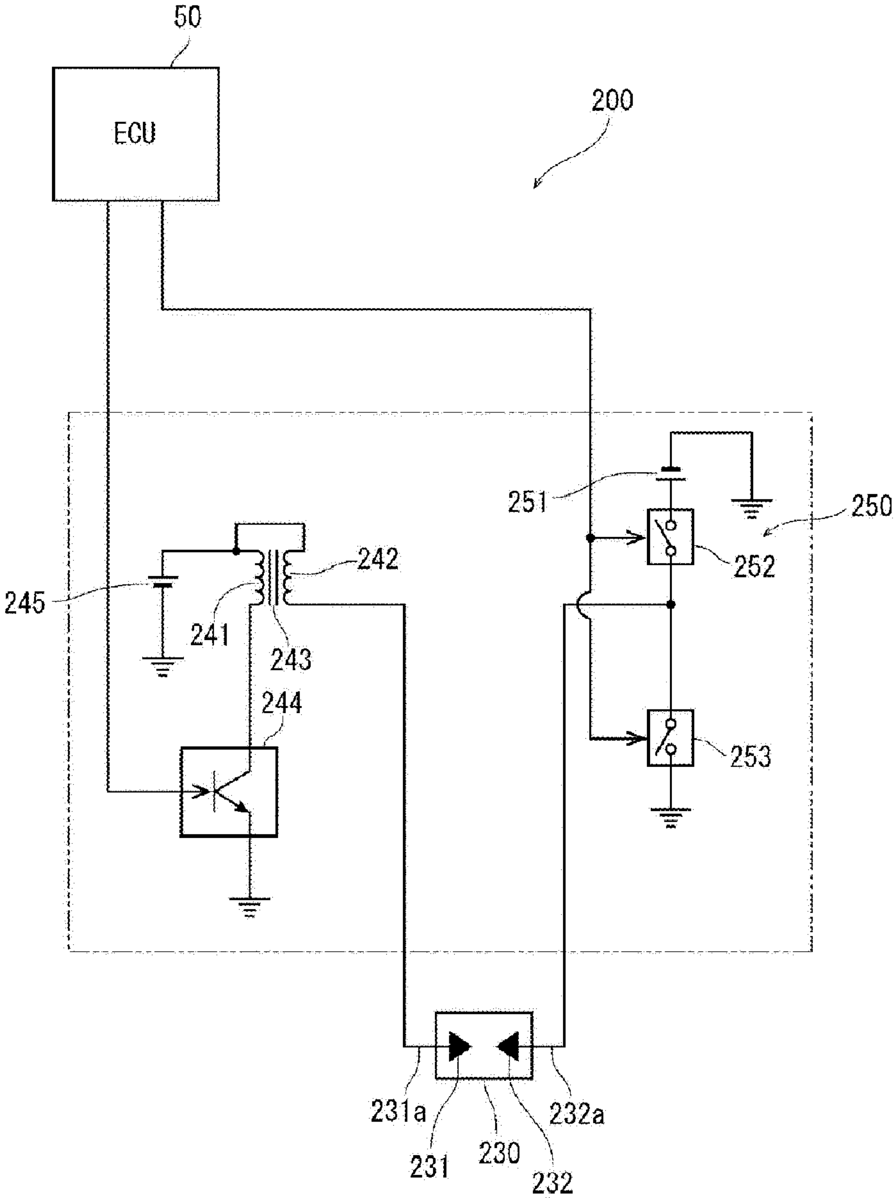
100
200
10
70
72
71
73
42
41
54
55
56
32
30
31
P
51
52
231a
230
233
231
232
232a
M
21
20
22
80
12
11
EX
IN
G

Fig.2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ECU
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251
250
252
245
242
241
243
244
253
231a
232a
231
230
232

Fig.3

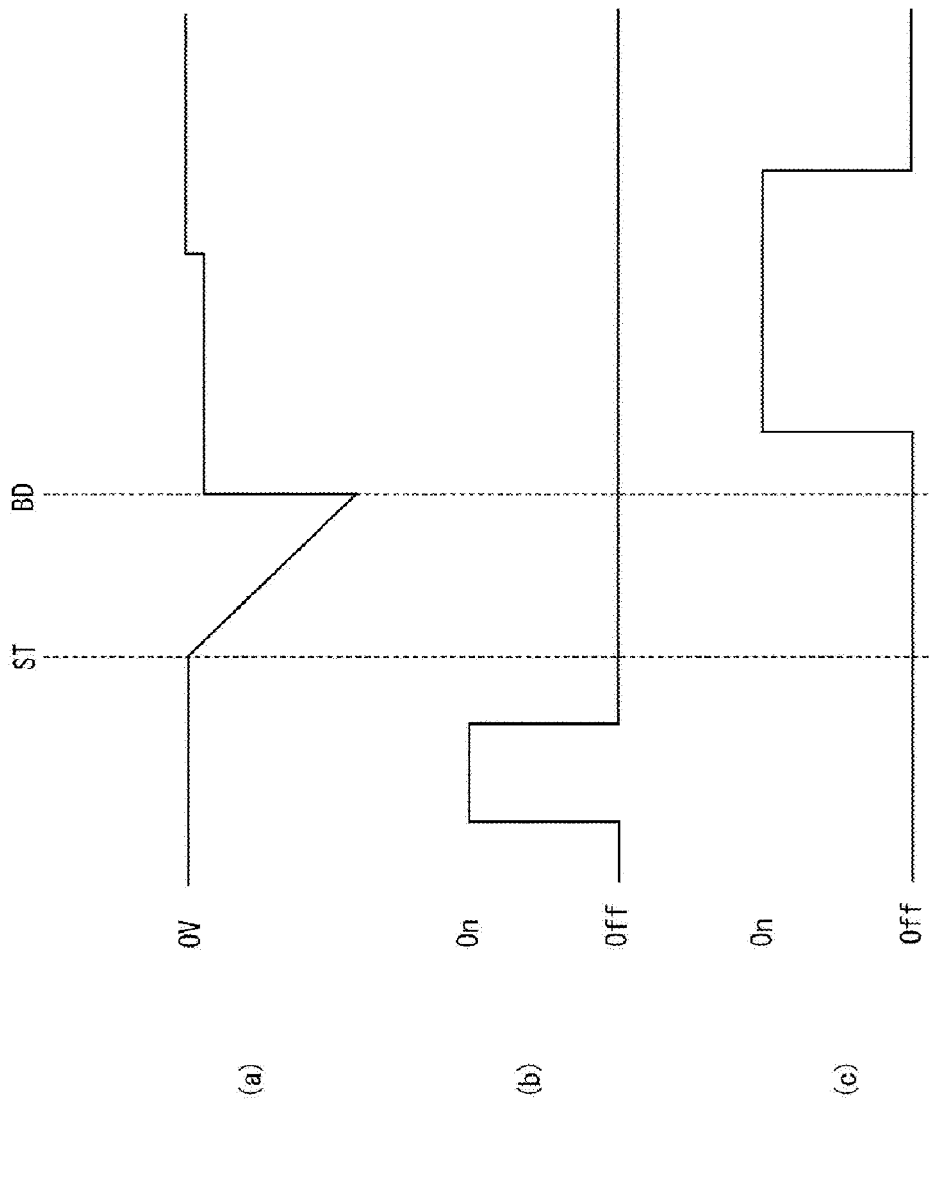


Fig.4

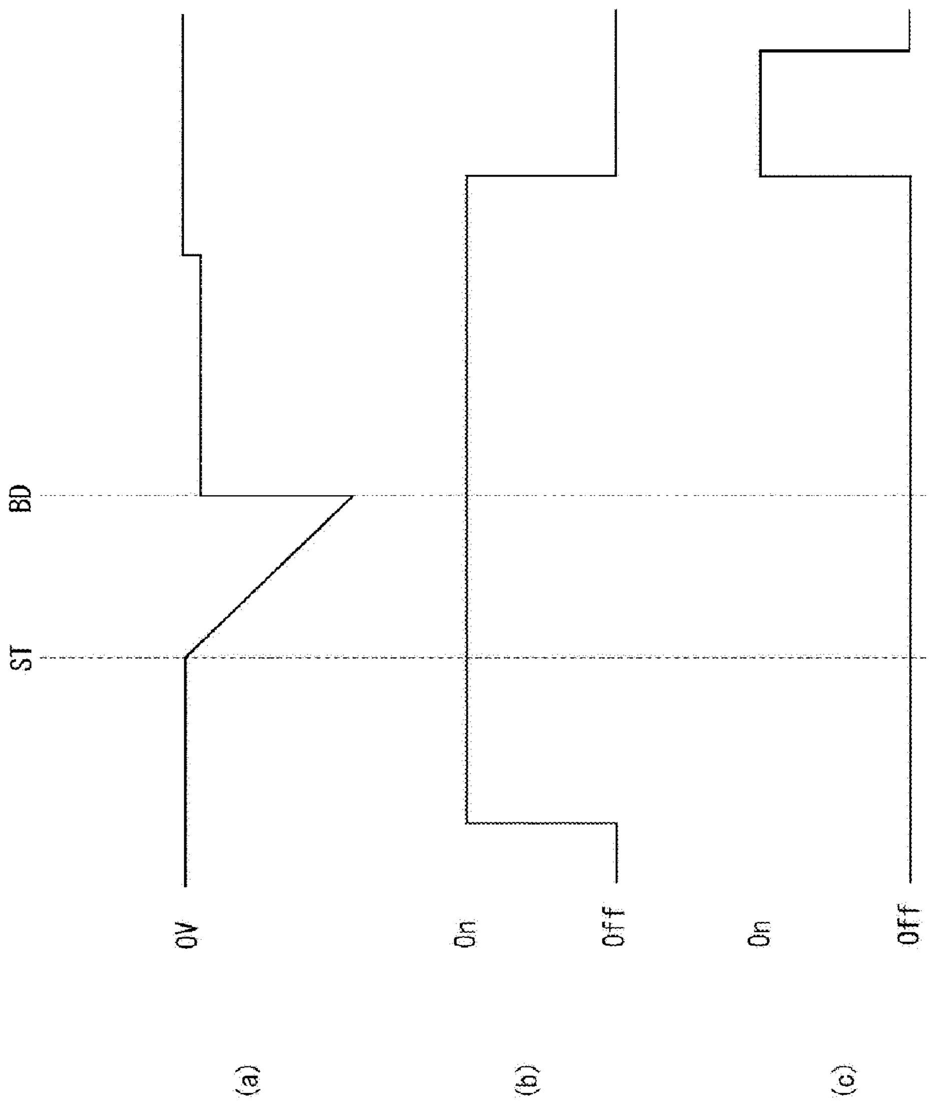


Fig.5

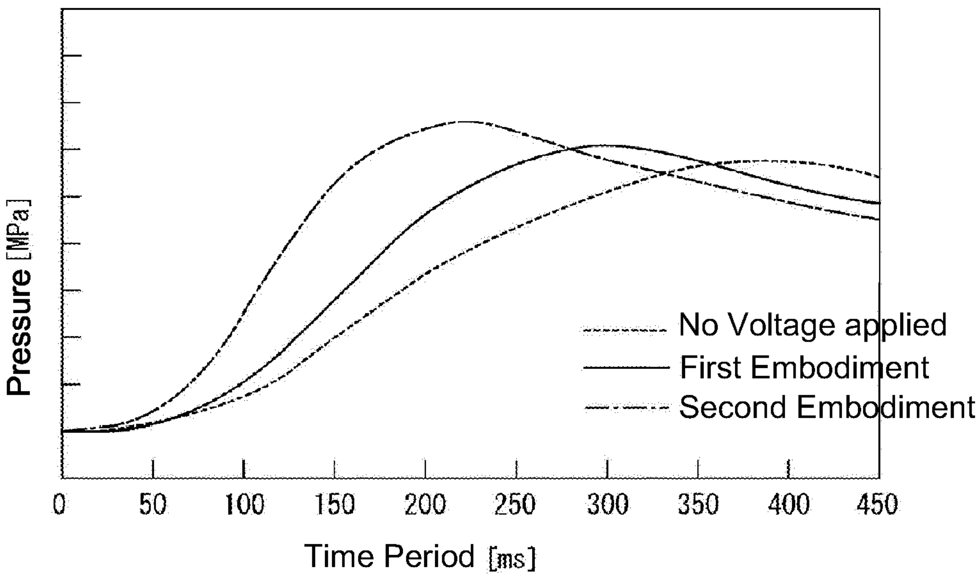

Pressure [MPa]
0
50
100
150
200
250
300
350
400
450
Time Period [ms]
No Voltage applied
First Embodiment
Second Embodiment

Fig.6

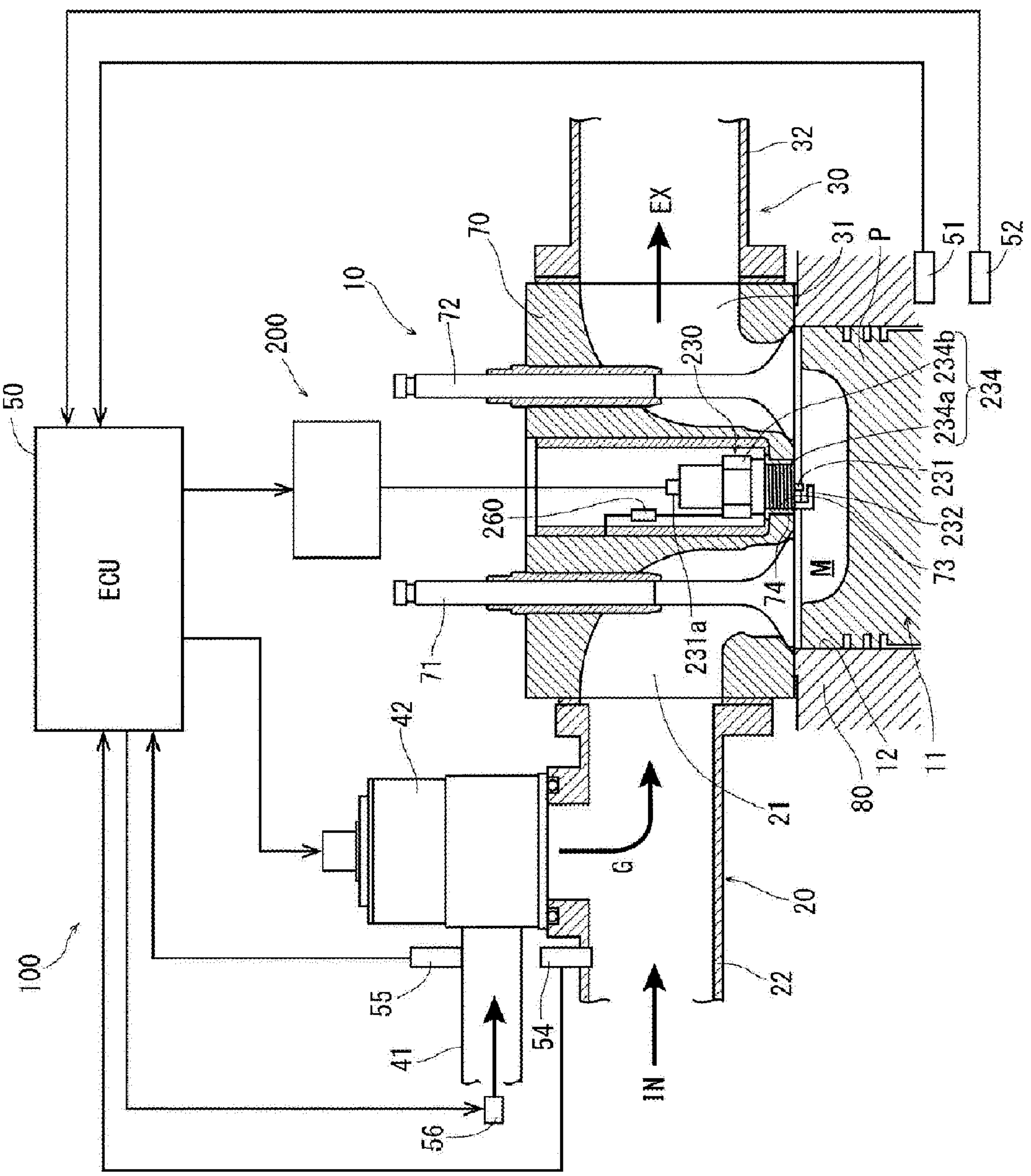

ECU
50
100
200
10
70
72
71
30
31
32
EX
IN
G
M
P
51
52
230
234b
234a
234
231
232
73
74
260
231a
21
80
12
11
42
20
22
55
54
41
56

Fig.7

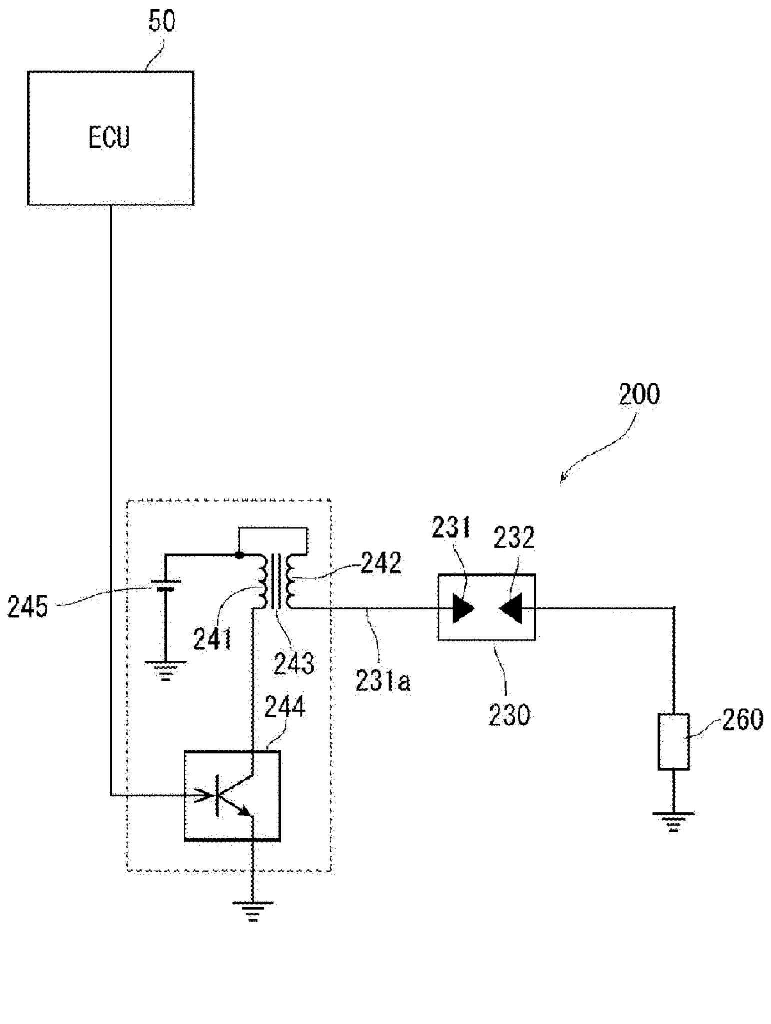


Fig.8

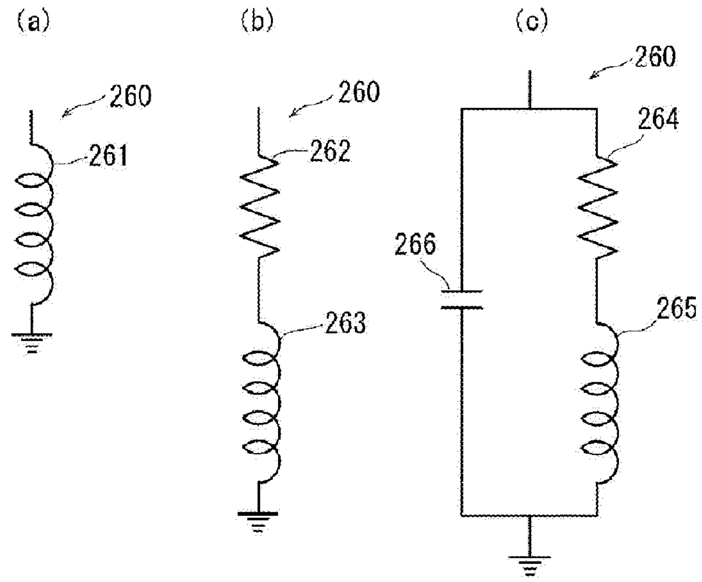
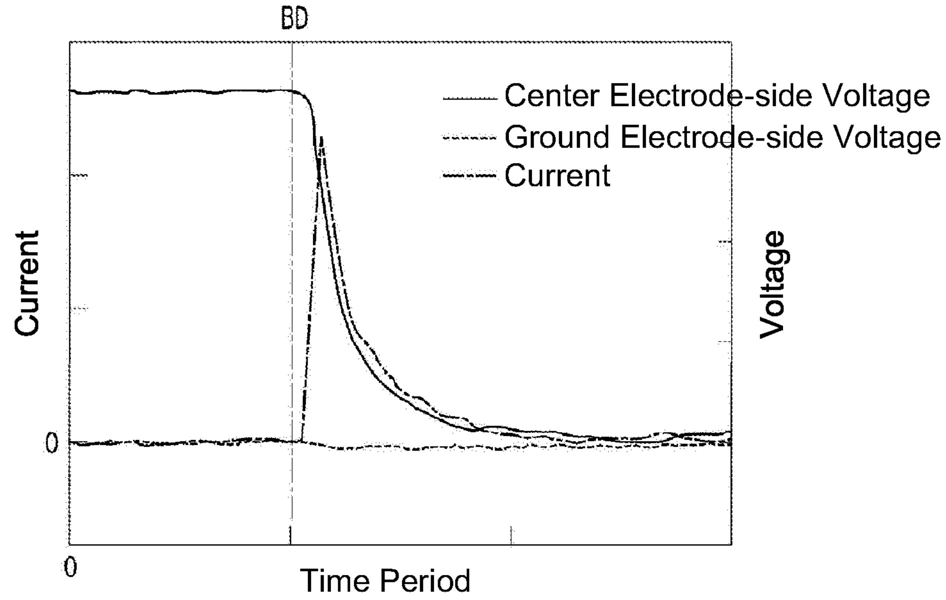


Fig.9

(a)


BD
Center Electrode-side Voltage
Ground Electrode-side Voltage
Current
Current
Voltage
0
0
Time Period

(b)

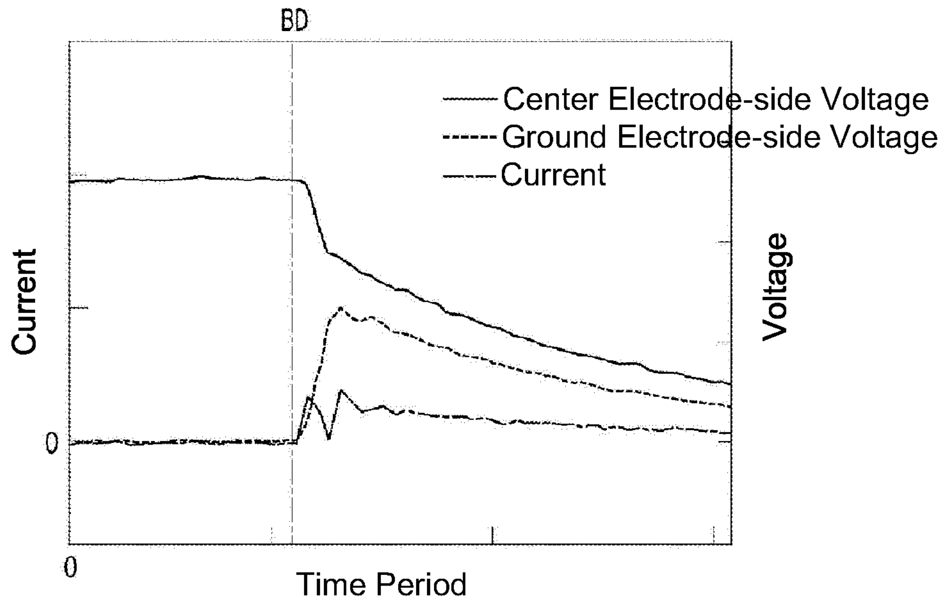

BD
Center Electrode-side Voltage
Ground Electrode-side Voltage
Current
Current
Voltage
0
0
Time Period

Fig.10

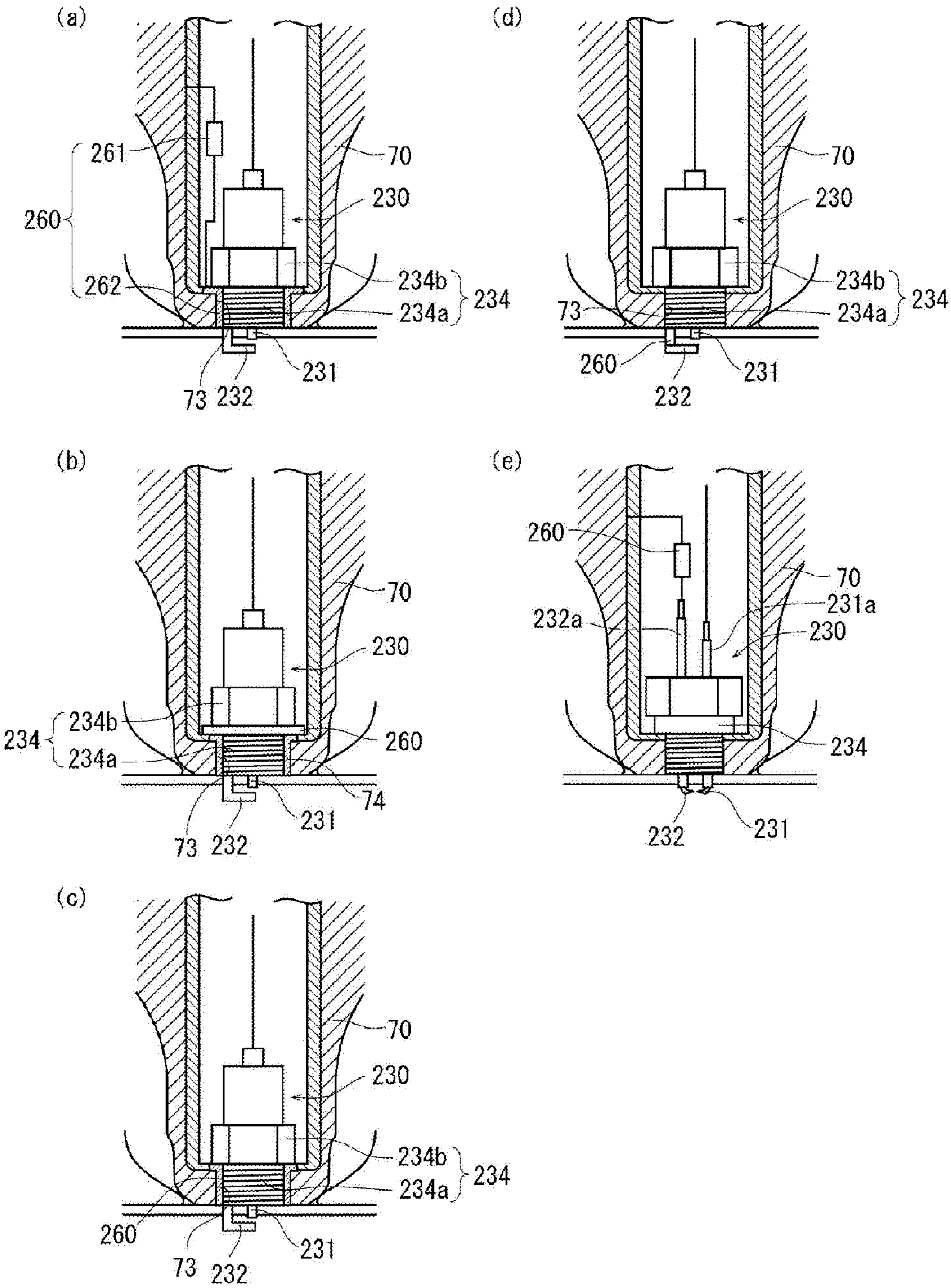
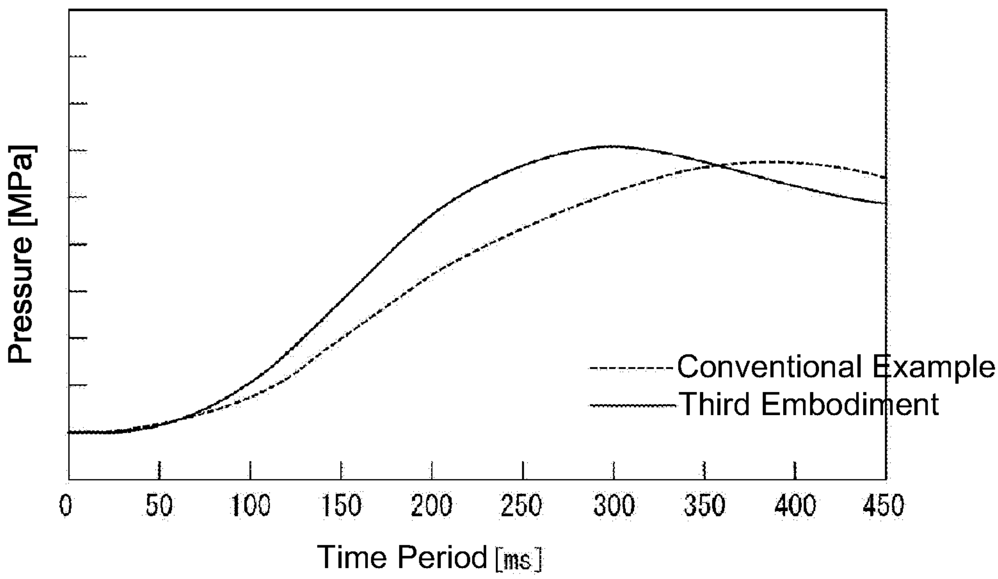

(a)
261
260
262
70
230
234b
234a
234
73
232
231
(d)
70
230
234b
234a
234
73
260
232
231
(b)
70
230
234b
234a
234
260
74
73
232
231
(e)
260
70
232a
231a
230
234
232
231
(c)
70
230
234b
234a
234
260
73
232
231

Fig.11


Pressure [MPa]
Conventional Example
Third Embodiment
0
50
100
150
200
250
300
350
400
450
Time Period [ms]

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2018/038844

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F02P15/00(2006.01)i

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)

Int.Cl. F02P1/00-3/12, 7/00-17/12, H01T13/00-13/60

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 4182/1984 (Laid-open No. 118378/1985) (HANSHIN ELECTRIC CO., LTD.) 10 August 1985, page 1, lines 12-15, page 3, lines 3-7, fig. 2 (Family: none)	1, 6-8 2-5, 9-13
A	JP 8-273950 A (MITSUBISHI ELECTRIC CORP.) 18 October 1996, fig. 1 & US 5603307 A, fig. 1 & DE 19603113 A1	1-13

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

☐ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 10 December 2018 (10.12.2018)	Date of mailing of the international search report 25 December 2018 (25.12.2018)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

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Patent documents cited in the description

- JP 2007032349 A **[0005]**
- JP 2005185027 A **[0005]**