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

(11) **EP 3 848 571 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
14.07.2021 Bulletin 2021/28

(21) Application number: **18932617.6**

(22) Date of filing: **07.09.2018**

(51) Int Cl.:
F02P 17/12 *(2006.01)*

(86) International application number:
PCT/JP2018/033123

(87) International publication number:
WO 2020/049704 (12.03.2020 Gazette 2020/11)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
KH MA MD TN

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(54) VEHICLE IGNITION DEVICE, IGNITION CONTROL DEVICE, AND CONTROL METHOD OF VEHICLE IGNITION DEVICE

(57) The control unit of the vehicle ignition device determines whether or not the spark plug is normally ignited, based on a voltage comparison result comparing the value of the primary voltage detected by the detector with a preset threshold voltage and/or a current comparison result comparing the value of the energizing current detected by the detector with a preset threshold current, in a preset detection period.

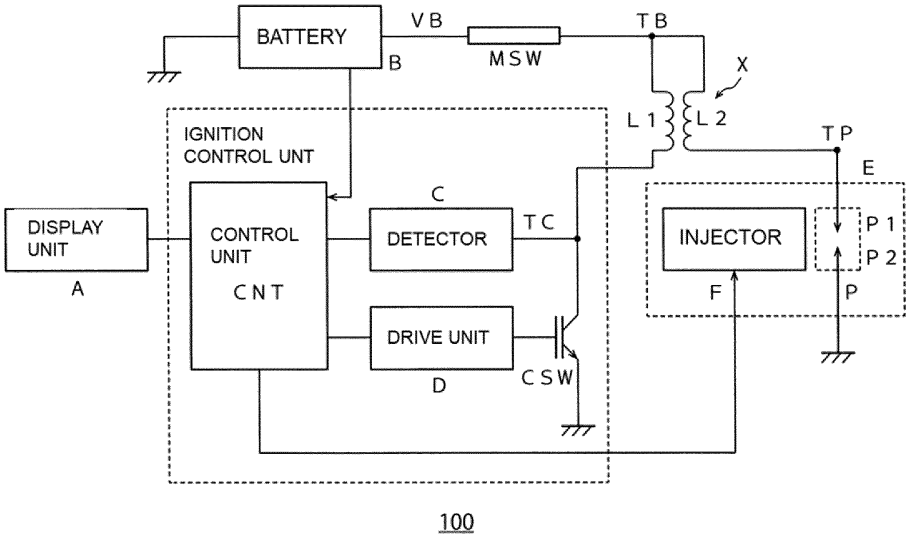

FIG.1

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Description

[0001] The present invention relates to a vehicle ignition device, an ignition control device, and a control method of vehicle ignition device.

[Background Art]

[0002] For example, in a two-wheeled vehicle system, it is necessary to determine whether the spark plug of the ignition device is ignited and discharged by supporting OBD2 (On-board diagnostics 2).

[0003] For example, it is possible to determine whether the ignition is discharged from the rotation fluctuation of the engine. In this case, it is possible to determine low rotation, but it is difficult to determine at high rotation because there is little fluctuation.

[0004] On the other hand, in the four-wheeled vehicle system, since there is a margin of cost, the secondary side of the ignition device is directly detected (see, for example, JP-A-2009-92035 and JP-A-2015-20024).

[0005] Here, if the spark plug is not ignited and discharged normally, the switching element that controls ignition takes more energy than in the normal state. Therefore, the switching element may be damaged.

[0006] And, when selecting an element that does not cause any problem even if a large amount of energy is applied so as not to break, it leads to an increase in the cost of the ignition device.

[0007] Then, in the motorcycle system described above, when determining whether the spark discharge is normal in the igniter, the voltage is read by the detection circuit to determine whether the primary side of the ignition device is a normal connection, a disconnection, a ground fault, or a ceiling fault.

[0008] The detection circuit used in such a conventional technique could not detect the state of the secondary side of the ignition device. In the detection circuit, there is a problem that even if it operates normally in terms of control, it is not known whether the spark is actually discharged.

[Disclosure of Invention]

[Problems to be Solved by the Invention]

[0009] Therefore, an object of the present invention is to provide a vehicle ignition device capable of determining whether or not spark discharge is normal, based on the voltage value (current value) and application time during ignition operation on the primary side.

[Solution to Problem]

[0010] A vehicle ignition device, according to an embodiment according to an aspect of the present invention, comprising:

a battery terminal to which an ignition voltage is supplied from a battery;

a primary side ignition coil that has one end connected to the battery terminal, and has the other end connected to the detection terminal;

a secondary side ignition coil that has one end is connected to the battery terminal, and has the other end is connected to a plug terminal, the secondary side ignition coil constituting a transformer together with the primary side ignition coil;

a spark plug that has a first electrode connected to the plug terminal, and has a second electrode connected to a fixed potential;

a control switching element that has one end connected to the detection terminal, and has the other end connected to the fixed potential;

a detector that detects a primary voltage of the detection terminal or an energizing current flowing from the detection terminal to the control switching element;

a drive unit that drives the control switching element to control the control switching element on or off; and

a control unit that controls the control switching element by the drive unit, based on a value of the primary voltage and/or a value of the energizing current detected by the detector,

wherein the control unit determines whether or not the spark plug is normally ignited, based on a voltage comparison result comparing the value of the primary voltage detected by the detector with a preset threshold voltage and/or a current comparison result comparing the value of the energizing current detected by the detector with a preset threshold current, in a preset detection period.

[0011] In the vehicle ignition device,

wherein the control unit turns off the control switching element and stops the ignition of the spark plug, if the control unit determines that the spark plug is not igniting normally, based on the voltage comparison result and/or the current comparison result.

[0012] In the vehicle ignition device,

wherein

the control unit determines that the spark plug is not igniting normally, when the period in which the detected primary voltage exceeds the threshold voltage is equal to or longer than a preset reference time, in the detection period,

on the other hand, the control unit determines that the spark plug is igniting normally, when the period in which the detected primary voltage exceeds the threshold voltage is less than the reference time, in the detection period.

[0013] In the vehicle ignition device,

wherein

the control unit determines that the spark plug is not igniting normally, if the detected primary voltage exceeds a preset first threshold voltage, when the preset first

standby time elapses after the ignition operation of the spark plug is started,
on the other hand, the control unit determines that the spark plug is igniting normally, if the detected primary voltage does not exceed the first threshold voltage after the first standby time has elapsed.

[0014] In the vehicle ignition device,
wherein
the control unit determines that the spark plug is igniting normally, if the detected primary voltage exceeds a preset second threshold voltage, when a preset second standby time longer than the first standby time elapses after the ignition operation of the spark plug is started,
on the other hand, the control unit determines that the spark plug is not igniting normally, if the detected primary voltage does not exceed the second threshold voltage when the first standby time elapses.

[0015] In the vehicle ignition device,
wherein
the control unit determines that the spark plug is igniting normally, if the detected energization current exceeds the preset threshold current, when the preset third standby time elapses after the ignition operation of the spark plug is started,
on the other hand, the control unit determines that the spark plug is not igniting normally, if the detected energizing current does not exceed the threshold current, when the third waiting time has elapsed.

[0016] In the vehicle ignition device,
wherein the control unit acquires the battery voltage of the battery and changes the threshold voltage and/or the threshold current based on the acquired battery voltage.

[0017] In the vehicle ignition device,
wherein the case where the spark plug is not ignited normally is a case where an open failure has occurred on the secondary side, a case where the gap width between the first electrode and the second electrode of the spark plug is larger than a preset value, a case where foreign matter is mixed in the gap between the first electrode and the second electrode, a case where the battery voltage of the battery is low, or a case where the primary side open chute failure has occurred.

[0018] In the vehicle ignition device,
wherein the control switching element is a bipolar transistor that has a collector is connected to the detection terminal, and has an emitter is connected to the fixed potential, a base current of the bipolar transistor being controlled by the drive unit.

[0019] In the vehicle ignition device, further comprising a display unit that is controlled by the control unit, and displays predetermined information to be provided to a user,
wherein the control unit displays a result of determining whether or not the spark plug is normally ignited on the display unit.

[0020] In the vehicle ignition device,
wherein the vehicle ignition device is loaded on a motorcycle, and
wherein the control unit controls the operation of the engine of the motorcycle.

[0021] In the vehicle ignition device,
wherein the control unit stops an operation of an injector that injects fuel into a combustion chamber of the engine, if the control unit determines that the spark plug is not igniting normally, based on the voltage comparison result and/or the current comparison result.

[0022] In the vehicle ignition device, further comprising a main switch that is connected between the positive electrode of the battery and the battery terminal, the main switch is controlled on / off by a user,
wherein, when the main switch is turned on, the control unit starts ignition control of the spark plug.

[0023] An ignition control device, according to an embodiment according to an aspect of the present invention, applied to a vehicle ignition device that includes: a battery terminal to which an ignition voltage is supplied from a battery; a primary side ignition coil that has one end connected to the battery terminal, and has the other end connected to the detection terminal; a secondary side ignition coil that has one end is connected to the battery terminal, and has the other end is connected to a plug terminal, the secondary side ignition coil constituting a transformer together with the primary side ignition coil; and a spark plug that has a first electrode connected to the plug terminal, and has a second electrode connected to a fixed potential,
the ignition control device comprising:

a control switching element that has one end connected to the detection terminal, and has the other end connected to the fixed potential;
a detector that detects a primary voltage of the detection terminal or an energizing current flowing from the detection terminal to the control switching element;
a drive unit that drives the control switching element to control the control switching element on or off; and
a control unit that controls the control switching element by the drive unit, based on a value of the primary voltage and/or a value of the energizing current detected by the detector,
wherein the control unit determines whether or not the spark plug is normally ignited, based on a voltage comparison result comparing the value of the primary voltage detected by the detector with a preset threshold voltage and/or a current comparison result comparing the value of the energizing current detected by the detector with a preset threshold current, in a preset detection period.

[0024] A control method of a vehicle ignition device, according to an embodiment according to an aspect of the present invention, the vehicle ignition device that includes: a battery terminal to which an ignition voltage is supplied from a battery; a primary side ignition coil that has one end connected to the battery terminal, and has

the other end connected to the detection terminal; a secondary side ignition coil that has one end is connected to the battery terminal, and has the other end is connected to a plug terminal, the secondary side ignition coil constituting a transformer together with the primary side ignition coil; a spark plug that has a first electrode connected to the plug terminal, and has a second electrode connected to a fixed potential; a control switching element that has one end connected to the detection terminal, and has the other end connected to the fixed potential; a detector that detects a primary voltage of the detection terminal or an energizing current flowing from the detection terminal to the control switching element; a drive unit that drives the control switching element to control the control switching element on or off; a control unit that controls the control switching element by the drive unit, based on a value of the primary voltage and/or a value of the energizing current detected by the detector, wherein the control unit determines whether or not the spark plug is normally ignited, based on a voltage comparison result comparing the value of the primary voltage detected by the detector with a preset threshold voltage and/or a current comparison result comparing the value of the energizing current detected by the detector with a preset threshold current, in a preset detection period.

[Effects of the Invention]

[0025] As described above, the ignition device, according to one aspect of the present invention, includes: a battery terminal to which an ignition voltage is supplied from a battery; a primary side ignition coil that has one end connected to the battery terminal, and has the other end connected to the detection terminal; a secondary side ignition coil that has one end is connected to the battery terminal, and has the other end is connected to the plug terminal, the secondary side ignition coil constituting a transformer together with the primary side ignition coil; a spark plug that has a first electrode (a center electrode) P1 connected to the plug terminal, and has a second electrode (a ground electrode) connected to a fixed potential (a ground potential); a control switching element that has one end connected to the detection terminal, and has the other end connected to the fixed potential; a detector that detects a primary voltage of the detection terminal or an energizing current flowing from the detection terminal to the control switching element; a drive unit that drives the control switching element to control the control switching element on or off; and a control unit that controls the control switching element by the drive unit, based on a value of the primary voltage and/or a value of the energizing current detected by the detector.

[0026] Then, the control unit determines whether or not the spark plug is normally ignited, based on the voltage comparison result comparing the value of the primary voltage detected by detector with the preset threshold voltage, and/or the current comparison result comparing the value of the energizing current detected by detector with the preset threshold current, in the preset detection period.

[0027] That is, according to the ignition device of the present invention, it is possible to determine whether or not spark discharge is normal based on the voltage value (the current value) and application time during the ignition operation on the primary side.

[Brief Description of the Drawings]

[0028]

[FIG. 1] FIG. 1 is a diagram showing an example of the configuration of the vehicle ignition device 100 according to the first embodiment.

[FIG. 2] FIG. 2 is a diagram showing an example of waveforms of the primary voltage of the detection terminal TC, the energizing current flowing through the detection terminal TC, and the secondary voltage of the plug terminal TP, when the energizing current is small, the gap width is normal, and the ignition is normal.

[FIG. 3] FIG. 3 is a diagram showing an example of waveforms of the primary voltage of the detection terminal TC, the energizing current flowing through the detection terminal TC, and the secondary voltage of the plug terminal TP, when the energizing current is large, the gap width is normal, and the ignition is normal.

[FIG. 4] FIG. 4 is a diagram showing an example of waveforms of the primary voltage of the detection terminal TC, the energizing current flowing through the detection terminal TC, and the secondary voltage of the plug terminal TP, when the energizing current is large, the gap width is large, and the ignition is normal.

[FIG. 5] FIG. 5 is a diagram showing an example of waveforms of the primary voltage of the detection terminal TC, the energizing current flowing through the detection terminal TC, and the secondary voltage of the plug terminal TP, when the energizing current is small and the ignition is poor.

[FIG. 6] FIG. 6 is a diagram showing an example of a waveform in which the time of FIG. 5 is lengthened.

[FIG. 7] FIG. 7 is a diagram showing an example of waveforms of the primary voltage of the detection terminal TC, the energizing current flowing through the detection terminal TC, and the secondary voltage of the plug terminal TP, when the energizing current is large and the ignition is poor.

[Best Mode for Carrying Out the Invention]

[0029] In the following, an embodiment of the present invention will be described with reference to the drawings.

[First embodiment]

[0030] FIG. 1 is a diagram showing an example of the configuration of the vehicle ignition device 100 according to the first embodiment.

[0031] The vehicle ignition device 100 according to the first embodiment is loaded on a two-wheeled vehicle (not shown), and the control unit CNT is designed to control the operation of the engine (internal combustion engine) E of the two-wheeled vehicle.

[0032] Note that this vehicle ignition device 100 is loaded on a four-wheeled vehicle (not shown), and the control unit CNT may control the operation of the engine (internal combustion engine) E of the four-wheeled vehicle.

[0033] For example, as shown in FIG. 1, this vehicle ignition device 100 includes a battery terminal TB, a primary side ignition coil L1, a secondary side ignition coil L2, a spark plug P, an injector E, a display unit A, a control switching element CSW, a detector C, a drive unit D, a main switch MSW, and a control unit CNT.

[0034] Note that, for example, as shown in FIG. 1, the control switching elements CSW, detector C, drive unit D, and control unit CNT constitute an ignition control unit (ignition control device) X.

[0035] Then, as shown in FIG. 1, for example, the battery terminal TB is supplied with an ignition voltage from the battery B, which is a DC power source.

[0036] Furthermore, as shown in FIG. 1, the primary side ignition coil L1 has one end that is connected to the battery terminal TB, and has the other end that is connected to the detection terminal TC.

[0037] Furthermore, as shown in FIG. 1, for example, of the secondary side ignition coil L2 has one end that is connected to the battery terminal TB, and has the other end that is connected to the plug terminal TP.

[0038] This secondary side ignition coil L2 constitutes a transformer X together with the primary side ignition coil L1.

[0039] Furthermore, for example, as shown in FIG. 1, the spark plug P has a first electrode (a center electrode) Plconnected to the plug terminal (a ground electrode) TP and a second electrode P2 connected to a fixed potential (a ground potential).

[0040] Furthermore, for example, as shown in FIG. 1, the main switch MSW is connected between the positive electrode of the battery B and the battery terminal TB. The main switch MSW is controlled to be turned on / off by the user.

[0041] For example, as described later, when this main switch MSW is turned on, the control unit CNT starts ignition control of the spark plug P by supplying electric power from the battery B. On the other hand, when the main switch MSW is turned off, the control unit CNT stops the control operation by stopping the supply of electric power from the battery B.

[0042] In addition, the display unit A is designed to display predetermined information to be provided to the user, by controlled by the control unit CNT.

[0043] As will be described later, the control unit CNT causes the display unit A to display the result of determining whether or not the spark plug P is normally ignited.

[0044] Furthermore, as shown in FIG. 1, for example, the control switching element CSW has one end that is connected to the detection terminal TC, and has the other end that is connected to the fixed potential (the ground potential).

[0045] For example, as shown in FIG. 1, this control switching element CSW is an NPN type bipolar transistor (IGBT: including an insulated gate type bipolar transistor). The NPN type bipolar transistor has a collector that is connected to the detection terminal TC, and an emitter that is connected to the fixed potential (ground potential). In the NPN type bipolar transistor, the base current is controlled by the drive unit D.

[0046] Furthermore, as shown in FIG. 1, the detector C is adapted to detect the primary voltage of the detection terminal TC or the energizing current flowing from the detection terminal TC to the control switching element CSW.

[0047] Furthermore, the drive unit D drives the control switching element CSW to control the control switching element CSW on or off, by controlling the base current supplied to the control switching element CSW.

[0048] Furthermore, the control unit CNT controls the control switching element CSW by the drive unit D, based on the value of the primary voltage detected by detector C and / or the value of the energizing current described above.

[0049] This control unit CNT is configured to determine whether or not the spark plug P is normally ignited, based on a voltage comparison result comparing the value of the primary voltage detected by detector C with a preset threshold voltage, and/or a current comparison result comparing the value of the energizing current detected by detector C with the preset threshold current, in a preset detection period.

[0050] Then, the control unit CNT is configured to stop the ignition of the spark plug P by turning off the control switching element CSW, for example, if the control unit CNT determines that the spark plug P is not igniting normally, based on the voltage comparison result and/or the current comparison result described above.

[0051] In this way, the vehicle ignition device 100 is configured to stop ignition in the event of an abnormality.

[0052] Note that, as will be described later, the values of the threshold voltage and/or the threshold current described above may be changed, depend on the energizing current or battery voltage value, by monitoring the energizing current or battery voltage at the same time. As a result, the accuracy of abnormality detection (the accuracy of the detection of ignition failure) can be improved.

[0053] Here, for example, the control unit CNT may determine that the spark plug P is not igniting normally, if the period during which the detected primary voltage exceeds the threshold voltage is equal to or longer than

the preset reference time, in the detection period.

[0054] On the other hand, the control unit CNT may determine that the spark plug P is igniting normally, if the period during which the detected primary voltage exceeds the above-mentioned threshold voltage is less than the reference time in the detection period.

[0055] Furthermore, for example, the control unit CNT may determine that the spark plug P is not igniting normally, if the detected primary voltage exceeds the preset first threshold voltage (for example, 400V) when the preset first standby time has elapsed after the ignition operation of the spark plug P is started.

[0056] On the other hand, the control unit CNT may determine that the spark plug P is igniting normally, if the detected primary voltage does not exceed the first threshold voltage when the first standby time has elapsed.

[0057] Furthermore, for example, the control unit CNT may determine that the spark plug P is normally ignited, when the detected primary voltage exceeds the preset second threshold voltage (for example, 0V), at the timing when the preset second standby time longer than the first standby time elapses after the ignition operation of the spark plug P is started.

[0058] On the other hand, the control unit CNT may determine that the spark plug P is not igniting normally, if the detected primary voltage does not exceed the second threshold voltage, when the first waiting time has elapsed.

[0059] Furthermore, for example, the control unit CNT may determine that the spark plug P is normally ignited, if the detected energizing current exceeds a preset threshold current, when the preset third standby time has elapsed after the ignition operation of the spark plug P is started.

[0060] On the other hand, the control unit CNT may determine that the spark plug P is not igniting normally, if the detected energizing current does not exceed the above-mentioned threshold current, when the third waiting time has elapsed.

[0061] Furthermore, the control unit CNT may acquire the battery voltage of the battery B and change the above-mentioned threshold voltage and/or the above-mentioned threshold current, based on the acquired battery voltage.

[0062] The case where the spark plug P is not igniting normally (ignition failure) is, for example, a case where an open failure has occurred on the secondary side, a case where the gap width between the first electrode P1 and the second electrode P2 of the spark plug P is larger than the preset value, or a case where the foreign matter (the insulating material) is mixed in the gap between the first electrode P1 and the second electrode P2.

[0063] As described above, when the main switch MSW is turned on, this control unit CNT starts ignition control of the spark plug P by supplying electric power from the battery B.

[0064] Further, as described above, the control unit CNT displays, the result of determining whether or not the spark plug P is normally ignited, on the display unit A.

[0065] Note that the control unit CNT is designed to stop the operation of the injector F that injects fuel into the combustion chamber of the engine E, if the control unit CNT determines that the spark plug P is not igniting normally, based on the voltage comparison result and/or the current comparison result.

[0066] As described above, the vehicle ignition device 100 according to the first embodiment can determine whether or not the spark is normally discharged, based on the voltage value (the current value) and application time during ignition operation on the primary side.

[0067] Next, an example of a control method for the vehicle ignition device 100 having the above configuration will be described. Here, FIG. 2 is a diagram showing an example of waveforms of the primary voltage of the detection terminal TC, the energizing current flowing through the detection terminal TC, and the secondary voltage of the plug terminal TP, when the energizing current is small, the gap width is normal, and the ignition is normal. FIG. 3 is a diagram showing an example of waveforms of the primary voltage of the detection terminal TC, the energizing current flowing through the detection terminal TC, and the secondary voltage of the plug terminal TP, when the energizing current is large, the gap width is normal, and the ignition is normal. FIG. 4 is a diagram showing an example of waveforms of the primary voltage of the detection terminal TC, the energizing current flowing through the detection terminal TC, and the secondary voltage of the plug terminal TP, when the energizing current is large, the gap width is large, and the ignition is normal. FIG. 5 is a diagram showing an example of waveforms of the primary voltage of the detection terminal TC, the energizing current flowing through the detection terminal TC, and the secondary voltage of the plug terminal TP, when the energizing current is small and the ignition is poor. FIG. 6 is a diagram showing an example of a waveform in which the time of FIG. 5 is lengthened. FIG. 7 is a diagram showing an example of waveforms of the primary voltage of the detection terminal TC, the energizing current flowing through the detection terminal TC, and the secondary voltage of the plug terminal TP, when the energizing current is large and the ignition is poor.

[0068] Note that, in FIGS. 2 to 7, the time t0 is the time when the control unit CNT starts the ignition operation by turning on the control switching element CSW by the drive unit D.

[0069] Furthermore, in FIGS. 2 to 7, the threshold voltage is the same value as the first threshold voltage TH1 for the sake of simplicity. However, the threshold voltage may be set to a value different from the first threshold voltage TH1.

[0070] As described above, the case where the spark plug P is not ignited normally (the ignition failure has occurred) is, for example, a case where an open failure has occurred on the secondary side, a case where the gap width between the first electrode P1 and the second electrode P2 of the spark plug P is larger than a preset value,

a case where foreign matter (insulating material) is mixed in the gap between the first electrode P1 and the second electrode P2, a case where the battery voltage of battery B is low, or a case where the primary side open chute failure has occurred.

[0071] As described above, the control unit CNT controls the control switching element CSW by the drive unit D, based on the value of the primary voltage detected by detector C and/or the value of the energizing current.

[0072] This control unit CNT determines whether or not the spark plug P is normally ignited, based on A voltage comparison result comparing the value of the primary voltage detected by detector C with the preset threshold voltage, and/or the current comparison result comparing the value of the energizing current detected by detector C with the preset threshold current (not shown), in the preset detection period (for example, time t0 to time t1).

[0073] Note that the control unit CNT acquires the battery voltage of the battery B and changes the above-mentioned threshold voltage and/or the above-mentioned threshold current, based on the acquired battery voltage.

[0074] Then, the control unit CNT stops the ignition of the spark plug P by turning off the control switching element CSW, if the control unit CNT determines that the spark plug P is not igniting normally, for example, based on the voltage comparison result and / or the current comparison result described above.

[0075] In this way, the vehicle ignition device 100 stops ignition when an abnormality occurs.

[0076] As described above, when the main switch MSW is turned on, this control unit CNT starts ignition control of the spark plug P by supplying electric power from the battery B.

[0077] Furthermore, as described above, the control unit CNT displays the result of judging whether or not the spark plug P is normally ignited, on the display unit A.

[0078] Note that the control unit CNT stops the operation of the injector F that injects fuel into the combustion chamber of the engine E, if the control unit CNT determines that the spark plug is not igniting normally, based on the voltage comparison result and/or the current comparison result.

[0079] Here, for example, the control unit CNT determines that the spark plug P is not igniting normally (Fig. 5, Fig. 6, and Fig. 7), if the period during which the detected primary voltage exceeds the threshold voltage is equal to or longer than the preset reference time, in the detection period (for example, time t0 to time t1).

[0080] On the other hand, the control unit CNT determines that the spark plug P is igniting normally (Fig. 2, Fig. 3, and Fig. 4), if the period during which the detected primary voltage exceeds the above-mentioned threshold voltage is less than the reference time, in the detection period (for example, time t0 to time t1).

[0081] Also, for example, the control unit CNT determines that the spark plug P is not igniting normally (Fig. 5, Fig. 6, and Fig. 7), if the detected primary voltage exceeds the preset first threshold voltage TH1 (for example, 400 V), when the preset first standby time (for example, 30 psec) elapses (for example, time t1) after the ignition operation of the spark plug P is started.

[0082] On the other hand, the control unit CNT determines that the spark plug P is igniting normally (Fig. 2, Fig. 3, and Fig. 4), if the detected primary voltage does not exceed the first threshold voltage, when the first waiting time has elapsed.

[0083] . In this case, the hardware configuration of the vehicle ignition device 100 can be facilitated, since it is possible to determine by voltage ("High" level / "Low" level) instead of determining by continuous time.

[0084] Note that the control unit CNT may change the first standby time according to, for example, the value of the energizing current (or the battery voltage).

[0085] Also, for example, the control unit CNT determines that the spark plug P is igniting normally (Fig. 2, Fig. 3, and Fig. 4), if the detected primary voltage exceeds the preset second threshold voltage (for example, 0V)TH2, when a preset second standby time (for example, 80 psec) longer than the first standby time has elapsed (for example, time t2) after the ignition operation of the spark plug P is started (the time t0).

[0086] On the other hand, the control unit CNT determines that the spark plug P is not igniting normally (Fig. 5, Fig. 6, and Fig. 7), if the detected primary voltage does not exceed the second threshold voltage when the first standby time has elapsed.

[0087] In this case, if the detected primary voltage is negative, it is determined that the spark plug P is not igniting normally. When ignition is defective, the current flows in the negative direction, thereby the detection is possible in this way.

[0088] Note that the control unit CNT may change the second standby time according to, for example, the value of the energizing current (or the battery voltage).

[0089] Also, for example, the control unit CNT determines that the spark plug P is igniting normally (FIG. 2), if the detected energizing current exceeds the preset threshold current (for example, 0A) THX (the detected energizing current is a positive current), when the preset third standby time (the time t3) elapses after the ignition operation of the spark plug P is started.

[0090] On the other hand, the control unit CNT determines that the spark plug P is not igniting normally (Fig. 5 and Fig. 6), if the detected energizing current does not exceed the above-mentioned threshold current (the detected energizing current is a negative current) when the third standby time (the time t3) elapses.

[0091] In this way, by checking the energizing current after ignition, when ignition is defective, current flows in the negative direction, so it can be detected.

[0092] Note that the control unit CNT may change the third standby time according to, for example, the value of the energizing current (or the battery voltage).

[0093] As described above, as shown in Fig. 1, the vehicle ignition device 100 includes: a battery terminal

TB to which an ignition voltage is supplied from a battery B; a primary side ignition coil L1 that has one end connected to the battery terminal TB, and has the other end connected to the detection terminal TC; a secondary side ignition coil L2 that has one end is connected to the battery terminal TB, and has the other end is connected to the plug terminal TP, the secondary side ignition coil L2 constituting a transformer together with the primary side ignition coil L1; a spark plug P that has a first electrode (a center electrode) P1 connected to the plug terminal, and has a second electrode (a ground electrode) P2 connected to a fixed potential (a ground potential); a control switching element CSW that has one end connected to the detection terminal TC, and has the other end connected to the fixed potential; a detector C that detects a primary voltage of the detection terminal TC or an energizing current flowing from the detection terminal to the control switching element CSW; a drive unit D that drives the control switching element to control the control switching element on or off; and a control unit CNT that controls the control switching element CSW by the drive unit D, based on a value of the primary voltage and/or a value of the energizing current detected by the detector C.

[0094] Then, the control unit CNT determines whether or not the spark plug P is normally ignited, based on the voltage comparison result comparing the value of the primary voltage detected by detector C with the preset threshold voltage, and/or the current comparison result comparing the value of the energizing current detected by detector C with the preset threshold current, in the preset detection period.

[0095] That is, according to the vehicle ignition device 100 according to the first embodiment, it is possible to determine whether or not the spark is normally discharged, based on the voltage value (the current value) and application time during ignition operation on the primary side.

[Second embodiment]

[0096] In the above-described first embodiment, the example in which the control switching element CSW is an NPN type bipolar transistor has been described (FIG. 1), but other semiconductor elements may be applied.

[0097] That is, the control switching element CSW may be replaced with, for example, a PNP type bipolar transistor MOSFET (including IGBT: Insulated gate type bipolar transistor), or another semiconductor element so that the same function can be performed.

[0098] Note that the configuration of the other vehicle ignition device in the second embodiment is the same as that in the first embodiment.

[0099] As described above, the ignition device, according to one aspect of the present invention, includes: a battery terminal TB to which an ignition voltage is supplied from a battery B; a primary side ignition coil L1 that has one end connected to the battery terminal TB, and has the other end connected to the detection terminal TC; a secondary side ignition coil L2 that has one end is connected to the battery terminal TB, and has the other end is connected to the plug terminal TP, the secondary side ignition coil L2 constituting a transformer together with the primary side ignition coil L1; a spark plug P that has a first electrode (a center electrode) P1 connected to the plug terminal, and has a second electrode (a ground electrode) P2 connected to a fixed potential (a ground potential); a control switching element CSW that has one end connected to the detection terminal TC, and has the other end connected to the fixed potential; a detector C that detects a primary voltage of the detection terminal TC or an energizing current flowing from the detection terminal to the control switching element CSW; a drive unit D that drives the control switching element to control the control switching element on or off; and a control unit CNT that controls the control switching element CSW by the drive unit D, based on a value of the primary voltage and/or a value of the energizing current detected by the detector C.

[0100] Then, the control unit CNT determines whether or not the spark plug P is normally ignited, based on the voltage comparison result comparing the value of the primary voltage detected by detector C with the preset threshold voltage, and/or the current comparison result comparing the value of the energizing current detected by detector C with the preset threshold current, in the preset detection period.

[0101] That is, according to the ignition device of the present invention, it is possible to determine whether or not spark discharge is normal based on the voltage value (the current value) and application time during the ignition operation on the primary side.

[0102] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. The embodiments may be embodied in a variety of other forms. Furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein may be made without departing from the spirit of the inventions. The embodiments and their modifications are included in the scope and the subject matter of the invention, and at the same time included in the scope of the claimed inventions and their equivalents.

[Explanation of References]

[0103]

100 vehicle ignition device
TB battery terminal
L1 primary side ignition coil
L2 secondary side ignition coil
P spark plug
A display unit
CSW control switching element

C detector
D drive unit
MSW main switch
CNT control unit
E engine
F injector
TP plug terminal
P1 first electrode (center electrode)
P2 second electrode (ground electrode)
X transformer
B battery

Claims

1. A vehicle ignition device, comprising:

a battery terminal to which an ignition voltage is supplied from a battery;
a primary side ignition coil that has one end connected to the battery terminal, and has the other end connected to the detection terminal;
a secondary side ignition coil that has one end is connected to the battery terminal, and has the other end is connected to a plug terminal, the secondary side ignition coil constituting a transformer together with the primary side ignition coil;
a spark plug that has a first electrode connected to the plug terminal, and has a second electrode connected to a fixed potential;
a control switching element that has one end connected to the detection terminal, and has the other end connected to the fixed potential;
a detector that detects a primary voltage of the detection terminal or an energizing current flowing from the detection terminal to the control switching element;
a drive unit that drives the control switching element to control the control switching element on or off; and
a control unit that controls the control switching element by the drive unit, based on a value of the primary voltage and/or a value of the energizing current detected by the detector,
wherein the control unit determines whether or not the spark plug is normally ignited, based on a voltage comparison result comparing the value of the primary voltage detected by the detector with a preset threshold voltage and/or a current comparison result comparing the value of the energizing current detected by the detector with a preset threshold current, in a preset detection period.

2. The vehicle ignition device according to claim 1, wherein the control unit turns off the control switching element and stops the ignition of the spark plug, if the control unit determines that the spark plug is not igniting normally, based on the voltage comparison result and/or the current comparison result.

3. The vehicle ignition device according to claim 2, wherein
the control unit determines that the spark plug is not igniting normally, when the period in which the detected primary voltage exceeds the threshold voltage is equal to or longer than a preset reference time, in the detection period,
on the other hand, the control unit determines that the spark plug is igniting normally, when the period in which the detected primary voltage exceeds the threshold voltage is less than the reference time, in the detection period.

4. The vehicle ignition device according to claim 2, wherein
the control unit determines that the spark plug is not igniting normally, if the detected primary voltage exceeds a preset first threshold voltage, when the preset first standby time elapses after the ignition operation of the spark plug is started,
on the other hand, the control unit determines that the spark plug is igniting normally, if the detected primary voltage does not exceed the first threshold voltage after the first standby time has elapsed.

5. The vehicle ignition device according to claim 2, wherein
the control unit determines that the spark plug is igniting normally, if the detected primary voltage exceeds a preset second threshold voltage, when a preset second standby time longer than the first standby time elapses after the ignition operation of the spark plug is started,
on the other hand, the control unit determines that the spark plug is not igniting normally, if the detected primary voltage does not exceed the second threshold voltage when the first standby time has elapsed.

6. The vehicle ignition device according to claim 2, wherein
the control unit determines that the spark plug is igniting normally, if the detected energization current exceeds the preset threshold current, when the preset third standby time elapses after the ignition operation of the spark plug is started,
on the other hand, the control unit determines that the spark plug is not igniting normally, if the detected energizing current does not exceed the threshold current, when the third waiting time has elapsed.

7. The vehicle ignition device according to claim 2, wherein the control unit acquires the battery voltage of the battery and changes the threshold voltage and/or the threshold current based on the acquired

battery voltage.

8. The vehicle ignition device according to claim 2, wherein the case where the spark plug is not ignited normally is a case where an open failure has occurred on the secondary side, a case where the gap width between the first electrode and the second electrode of the spark plug is larger than a preset value, a case where foreign matter is mixed in the gap between the first electrode and the second electrode, a case where the battery voltage of the battery is low, or a case where the primary side open chute failure has occurred.

9. The vehicle ignition device according to claim 2, wherein the control switching element is a bipolar transistor that has a collector is connected to the detection terminal, and has an emitter is connected to the fixed potential, a base current of the bipolar transistor being controlled by the drive unit.

10. The vehicle ignition device according to claim 2, further comprising a display unit that is controlled by the control unit, and displays predetermined information to be provided to a user,
wherein the control unit displays a result of determining whether or not the spark plug is normally ignited on the display unit.

11. The vehicle ignition device according to claim 2, wherein the vehicle ignition device is loaded on a motorcycle, and wherein the control unit controls the operation of the engine of the motorcycle.

12. The vehicle ignition device according to claim 11, wherein the control unit stops an operation of an injector that injects fuel into a combustion chamber of the engine, if the control unit determines that the spark plug is not igniting normally, based on the voltage comparison result and/or the current comparison result.

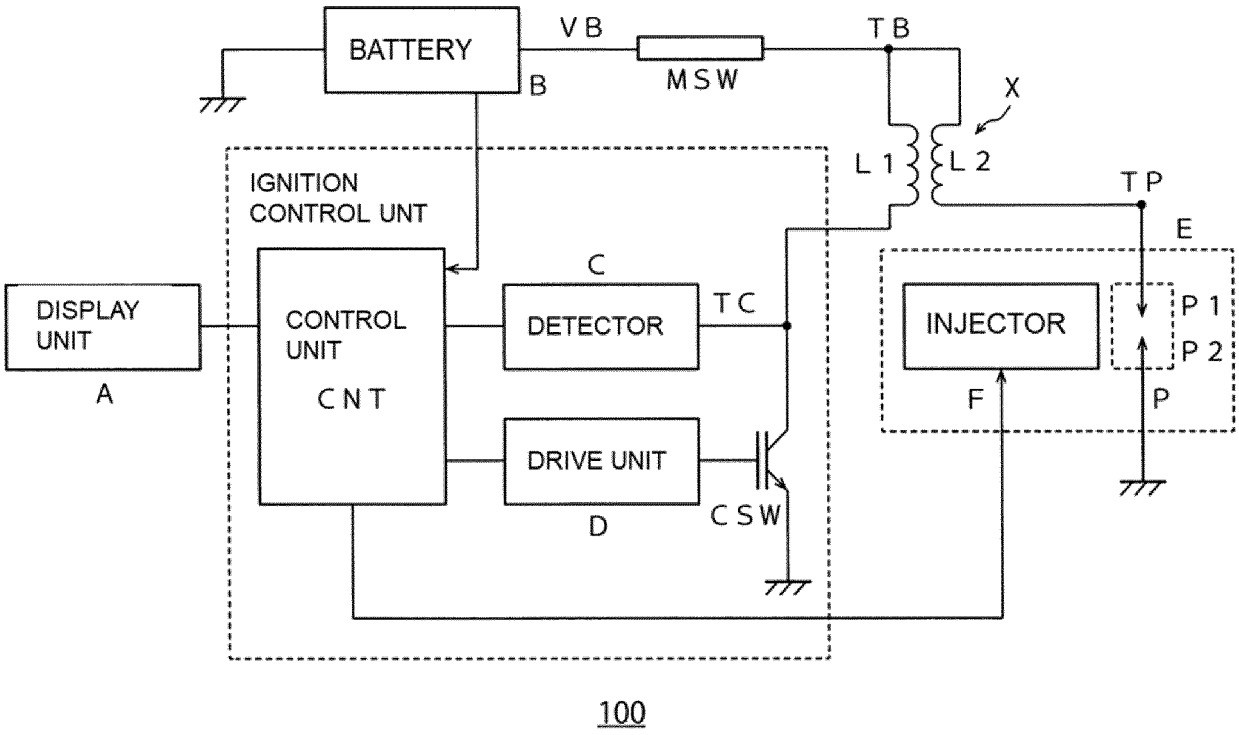
13. The vehicle ignition device according to claim 2, further comprising a main switch that is connected between the positive electrode of the battery and the battery terminal, the main switch is controlled on / off by a user,
wherein, when the main switch is turned on, the control unit starts ignition control of the spark plug.

14. An ignition control device applied to a vehicle ignition device that includes: a battery terminal to which an ignition voltage is supplied from a battery; a primary side ignition coil that has one end connected to the battery terminal, and has the other end connected to the detection terminal; a secondary side ignition coil that has one end is connected to the battery terminal, and has the other end is connected to a plug terminal, the secondary side ignition coil constituting a transformer together with the primary side ignition coil; and a spark plug that has a first electrode connected to the plug terminal, and has a second electrode connected to a fixed potential,
the ignition control device comprising:

a control switching element that has one end connected to the detection terminal, and has the other end connected to the fixed potential;
a detector that detects a primary voltage of the detection terminal or an energizing current flowing from the detection terminal to the control switching element;
a drive unit that drives the control switching element to control the control switching element on or off; and
a control unit that controls the control switching element by the drive unit, based on a value of the primary voltage and/or a value of the energizing current detected by the detector,
wherein the control unit determines whether or not the spark plug is normally ignited, based on a voltage comparison result comparing the value of the primary voltage detected by the detector with a preset threshold voltage and/or a current comparison result comparing the value of the energizing current detected by the detector with a preset threshold current, in a preset detection period.

15. A control method of a vehicle ignition device that includes: a battery terminal to which an ignition voltage is supplied from a battery; a primary side ignition coil that has one end connected to the battery terminal, and has the other end connected to the detection terminal; a secondary side ignition coil that has one end is connected to the battery terminal, and has the other end is connected to a plug terminal, the secondary side ignition coil constituting a transformer together with the primary side ignition coil; a spark plug that has a first electrode connected to the plug terminal, and has a second electrode connected to a fixed potential; a control switching element that has one end connected to the detection terminal, and has the other end connected to the fixed potential; a detector that detects a primary voltage of the detection terminal or an energizing current flowing from the detection terminal to the control switching element; a drive unit that drives the control switching element to control the control switching element on or off; a control unit that controls the control switching element by the drive unit, based on a value of the primary voltage and/or a value of the energizing current detected by the detector,
wherein the control unit determines whether or not the spark plug is normally ignited, based on a voltage comparison result comparing the value of the prima-

ry voltage detected by the detector with a preset threshold voltage and/or a current comparison result comparing the value of the energizing current detected by the detector with a preset threshold current, in a preset detection period.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B
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UNIT
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DETECTOR
TC
INJECTOR
P1
P2
F
P
DRIVE UNIT
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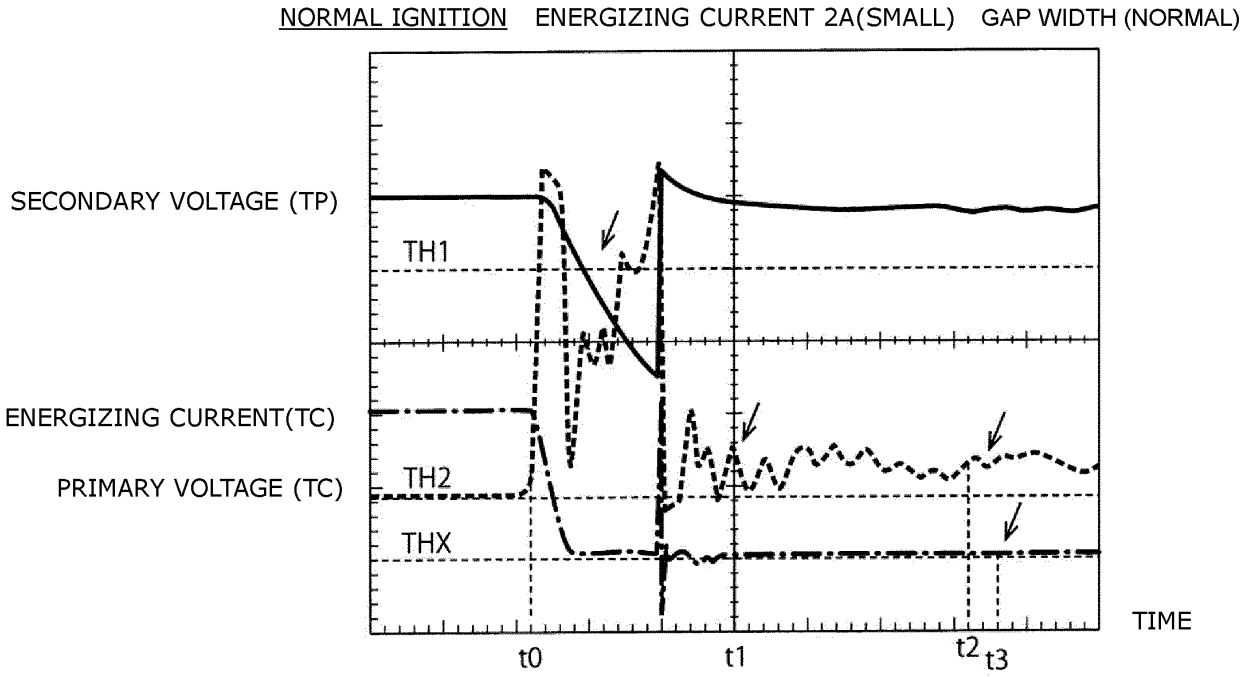
CSW
100

FIG.1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TH1
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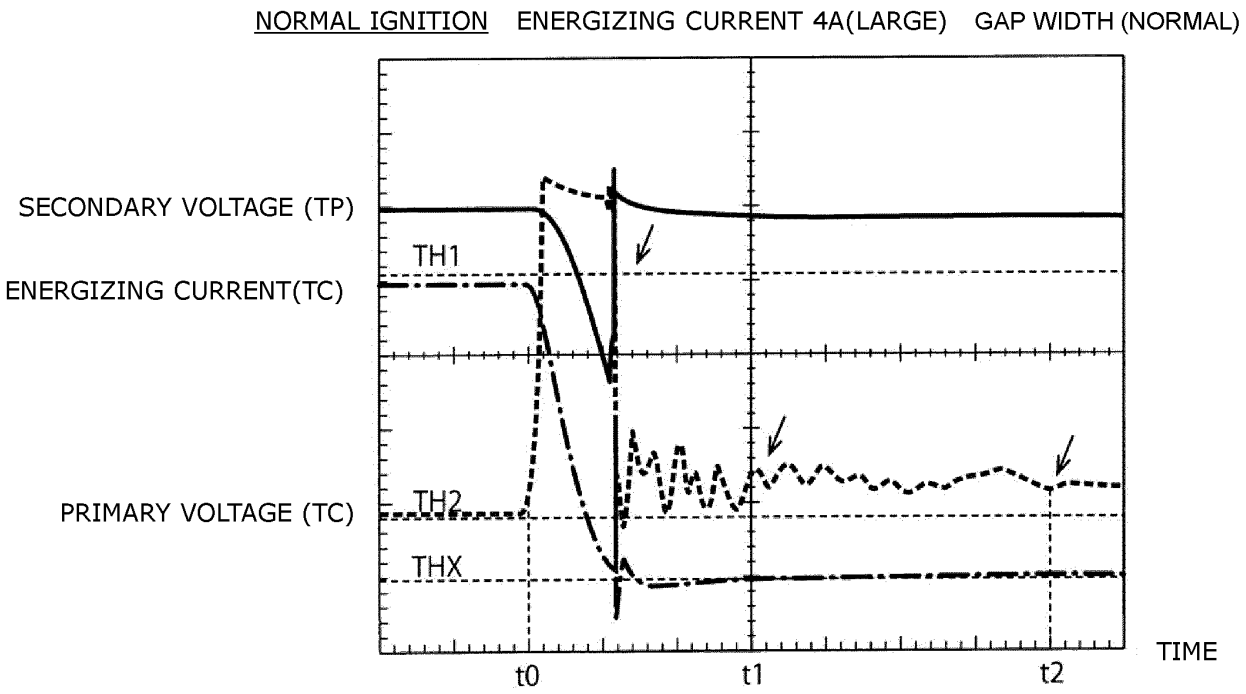
PRIMARY VOLTAGE (TC)
TH2
THX
TIME
t0
t1
t2
t3

FIG.2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PRIMARY VOLTAGE (TC)
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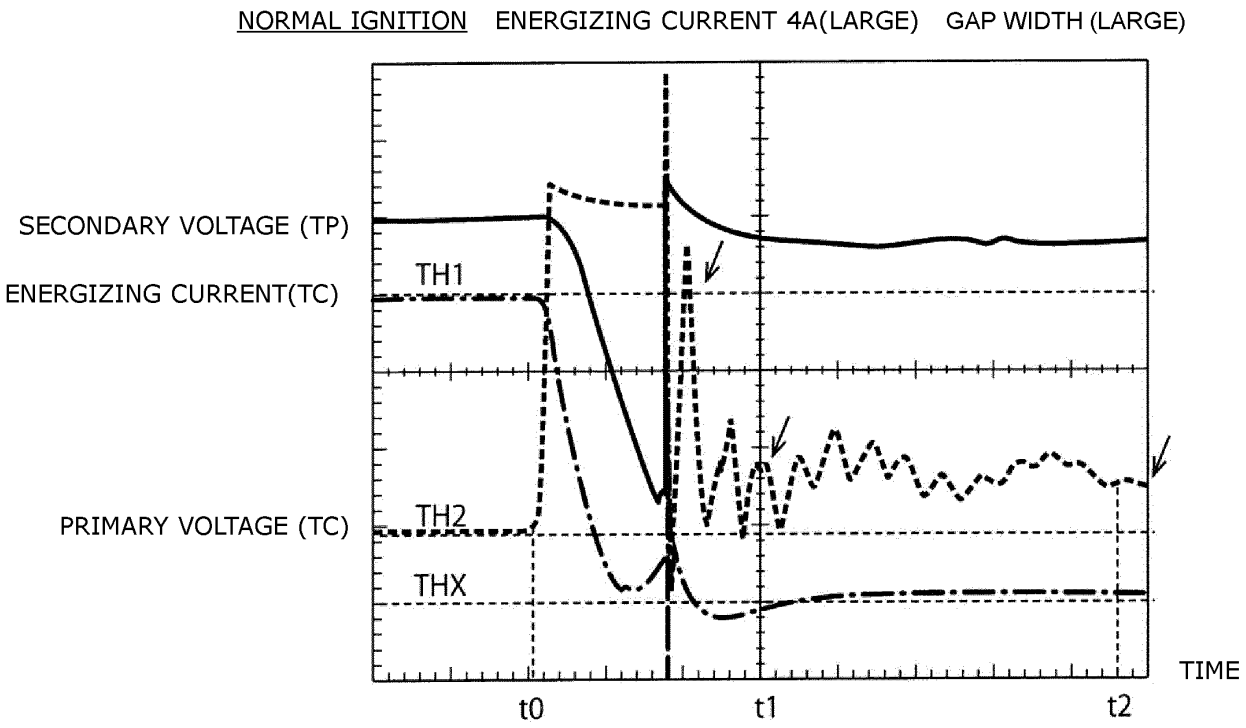
TH2
THX
t0
t1
t2
TIME

FIG.3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GAP WIDTH (LARGE)
SECONDARY VOLTAGE (TP)
ENERGIZING CURRENT(TC)
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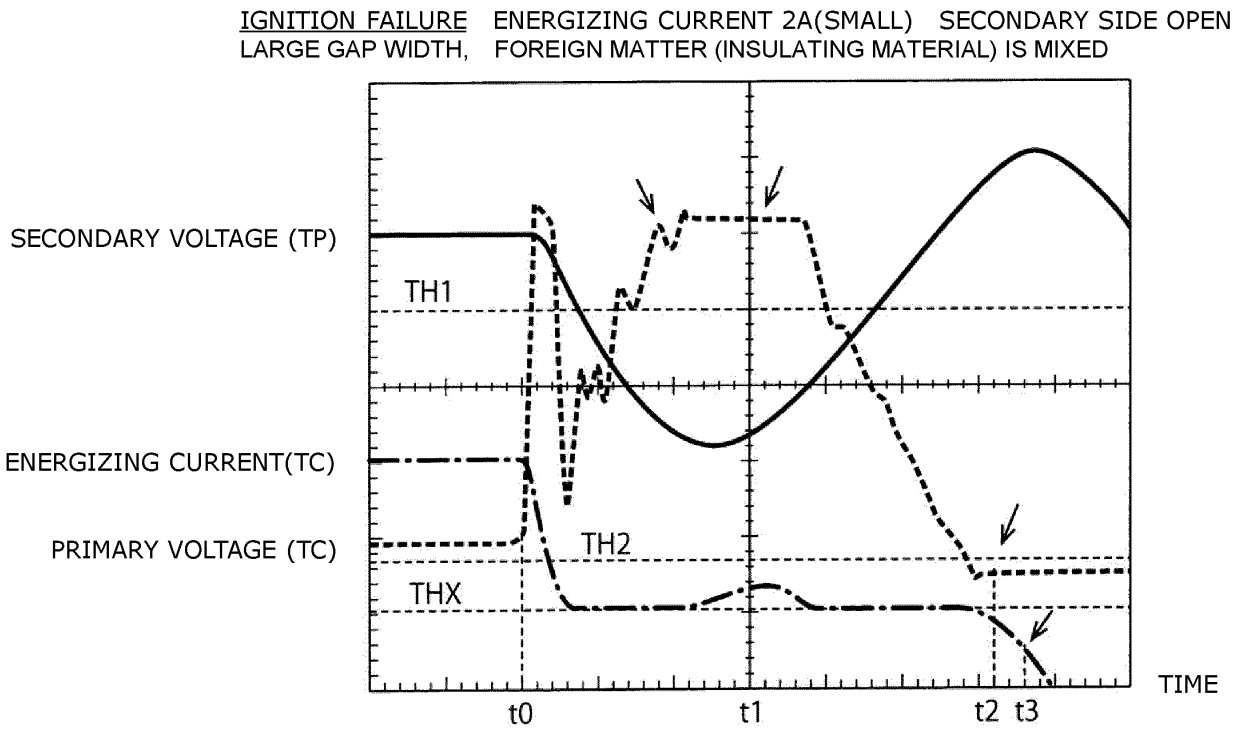
TH2
THX
TIME
t0
t1
t2

FIG.4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LARGE GAP WIDTH, FOREIGN MATTER (INSULATING MATERIAL) IS MIXED
SECONDARY VOLTAGE (TP)
ENERGIZING CURRENT(TC)
PRIMARY VOLTAGE (TC)
TH1
TH2
THX
t0
t1
t2
t3
TIME

FIG.5

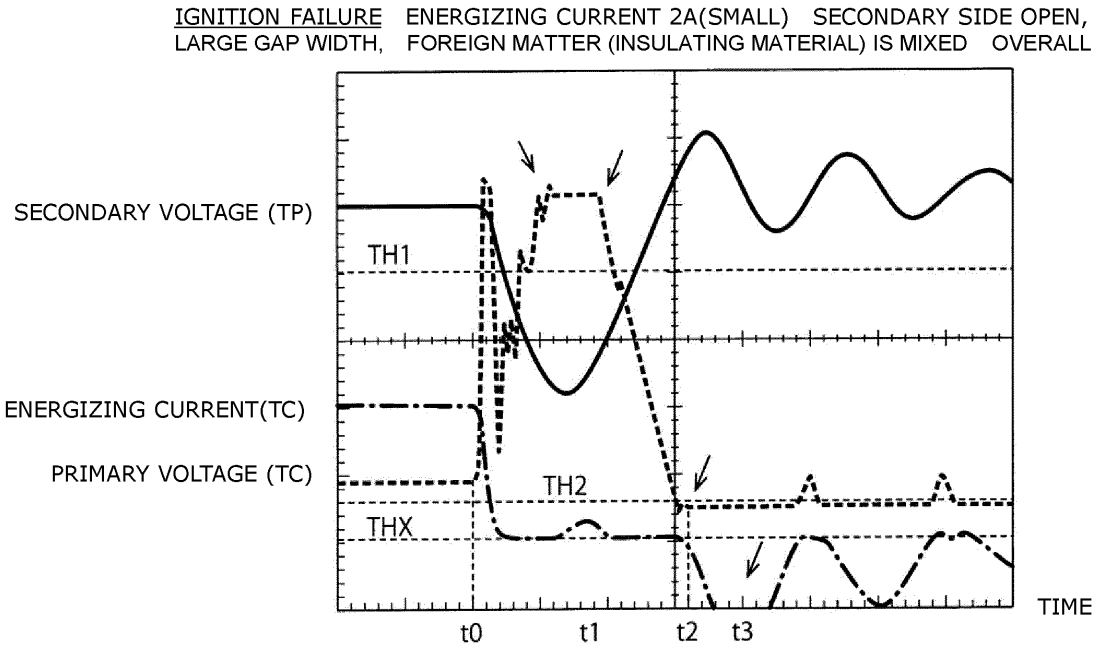
IGNITION FAILURE ENERGIZING CURRENT 2A(SMALL) SECONDARY SIDE OPEN,
LARGE GAP WIDTH, FOREIGN MATTER (INSULATING MATERIAL) IS MIXED OVERALL WAVEFORMS
SECONDARY VOLTAGE (TP)
TH1
ENERGIZING CURRENT(TC)
PRIMARY VOLTAGE (TC)
TH2
THX
TIME
t0
t1
t2
t3

FIG.6

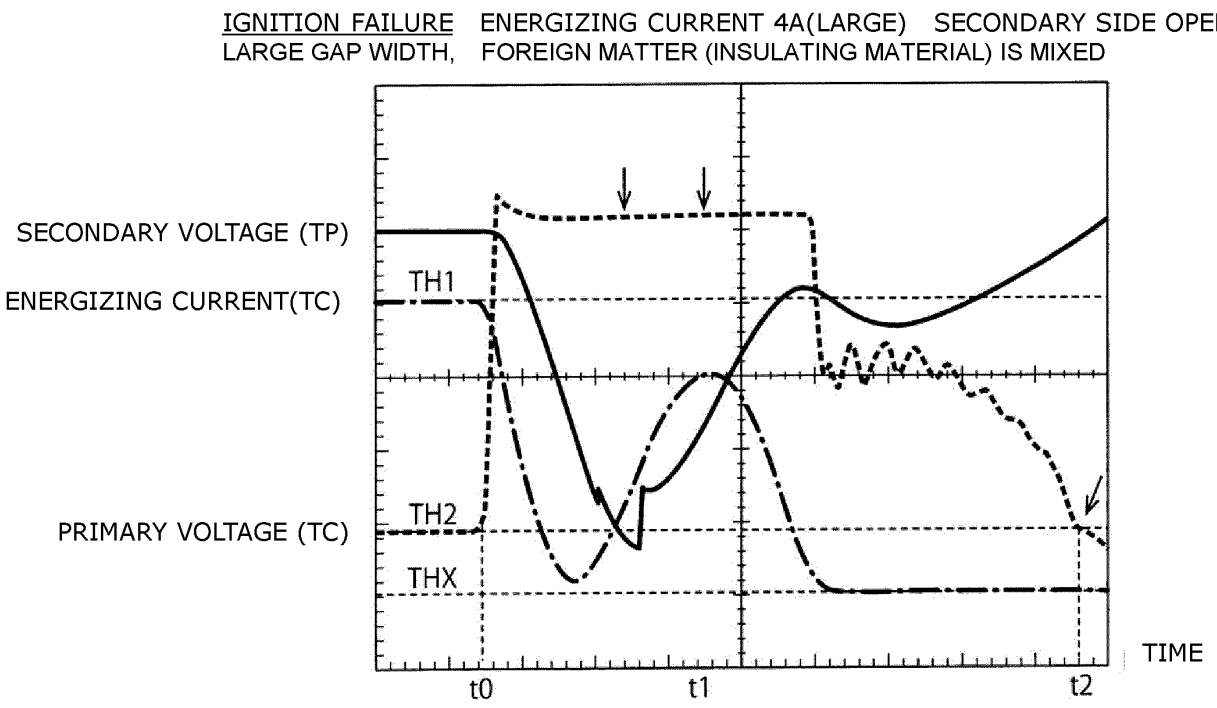
IGNITION FAILURE ENERGIZING CURRENT 4A(LARGE) SECONDARY SIDE OPEN,
LARGE GAP WIDTH, FOREIGN MATTER (INSULATING MATERIAL) IS MIXED
SECONDARY VOLTAGE (TP)
ENERGIZING CURRENT(TC)
PRIMARY VOLTAGE (TC)
TH1
TH2
THX
t0
t1
t2
TIME

FIG.7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/033123

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F02P17/12(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

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 Y	JP 2-241987 A (AISAN INDUSTRY CO., LTD.) 26 September 1990, page 2, upper left column, lines 16-20, page 4, upper left column, line 2 to upper right column, line 1, fig. 1 (Family: none)	1, 14-15 2-13
Y	JP 2007-162619 A (TOYOTA MOTOR CORP.) 28 June 2007, paragraphs [0017], [0040], [0055] (Family: none)	2-13

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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	Date of mailing of the international search report
13.11.2018	27.11.2018
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)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/033123

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 33223/1989 (Laid-open No. 126077/1990) (MITSUBISHI ELECTRIC CORP.) 17 October 1990, page 6, line 20 to page 7, line 13 & DE 4009451 A1 & US 5019779 A, column 3, lines 45-57	5
Y	JP 9-100772 A (DENSO CORP.) 15 April 1997, paragraphs [0011], [0014], [0017], [0021], fig. 7 (Family: none)	6

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009092035 A **[0004]**
- JP 2015020024 A **[0004]**