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Takaoka

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(54) **ON-VEHICLE EQUIPMENT CONTROL SYSTEM AND VEHICLE**

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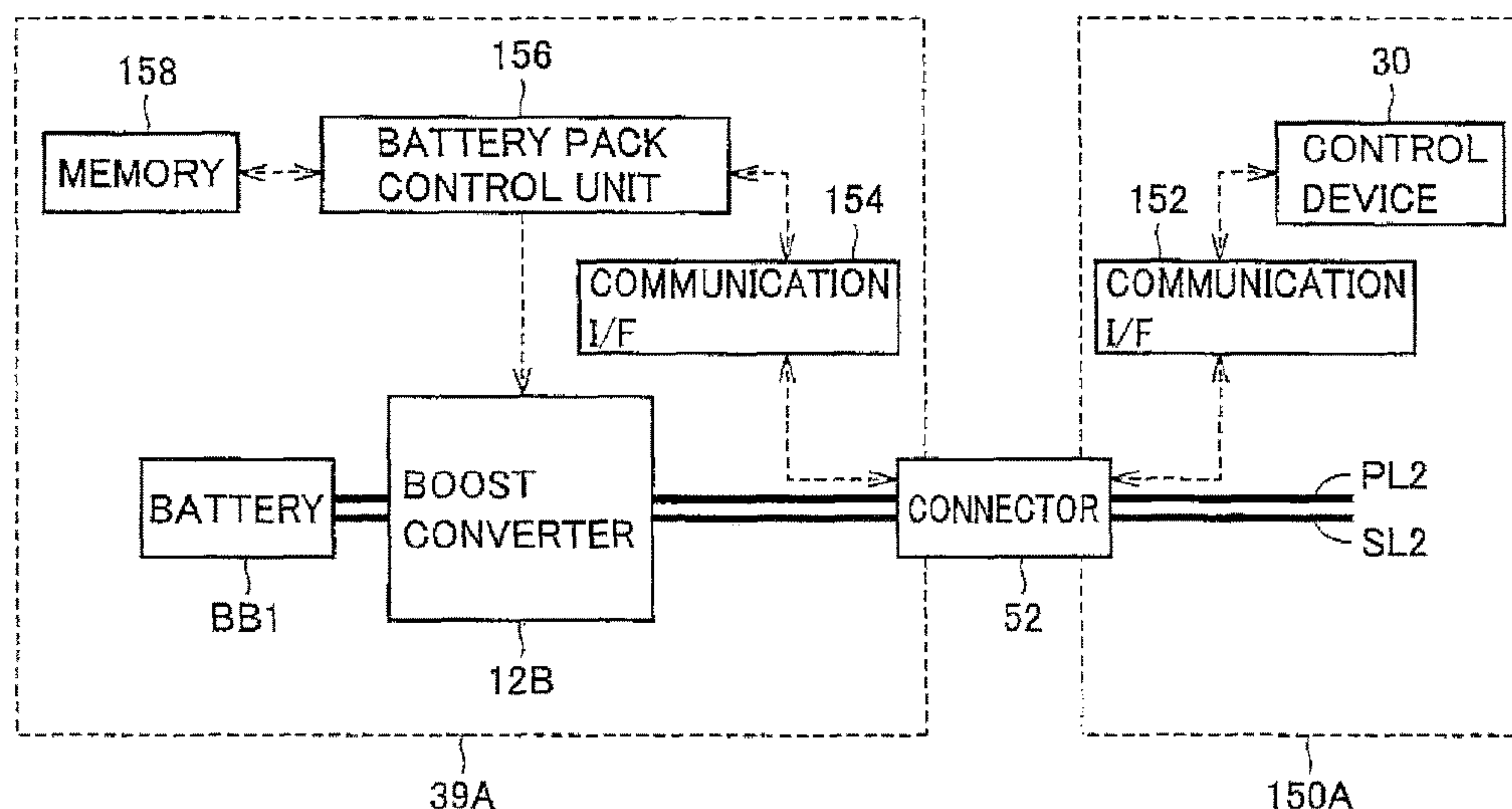
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(57) **ABSTRACT**

A power supply device for a vehicle that is chargeable from an external power supply provided external to the vehicle, including a main battery and a battery pack that is attachable to and detachable from the vehicle. The battery pack includes a sub battery for driving electric loads common to the main battery and the sub battery, and a connector provided with a first storage unit storing information related to the sub battery. The power supply device for the vehicle further includes a control device performing control related to the main battery, and reading the information from the first storage unit and performing control related to the sub battery.

2 Claims, 9 Drawing Sheets



- (51) **Int. Cl.**
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- (58) **Field of Classification Search**
- USPC 701/501
- See application file for complete search history.

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FIG.1

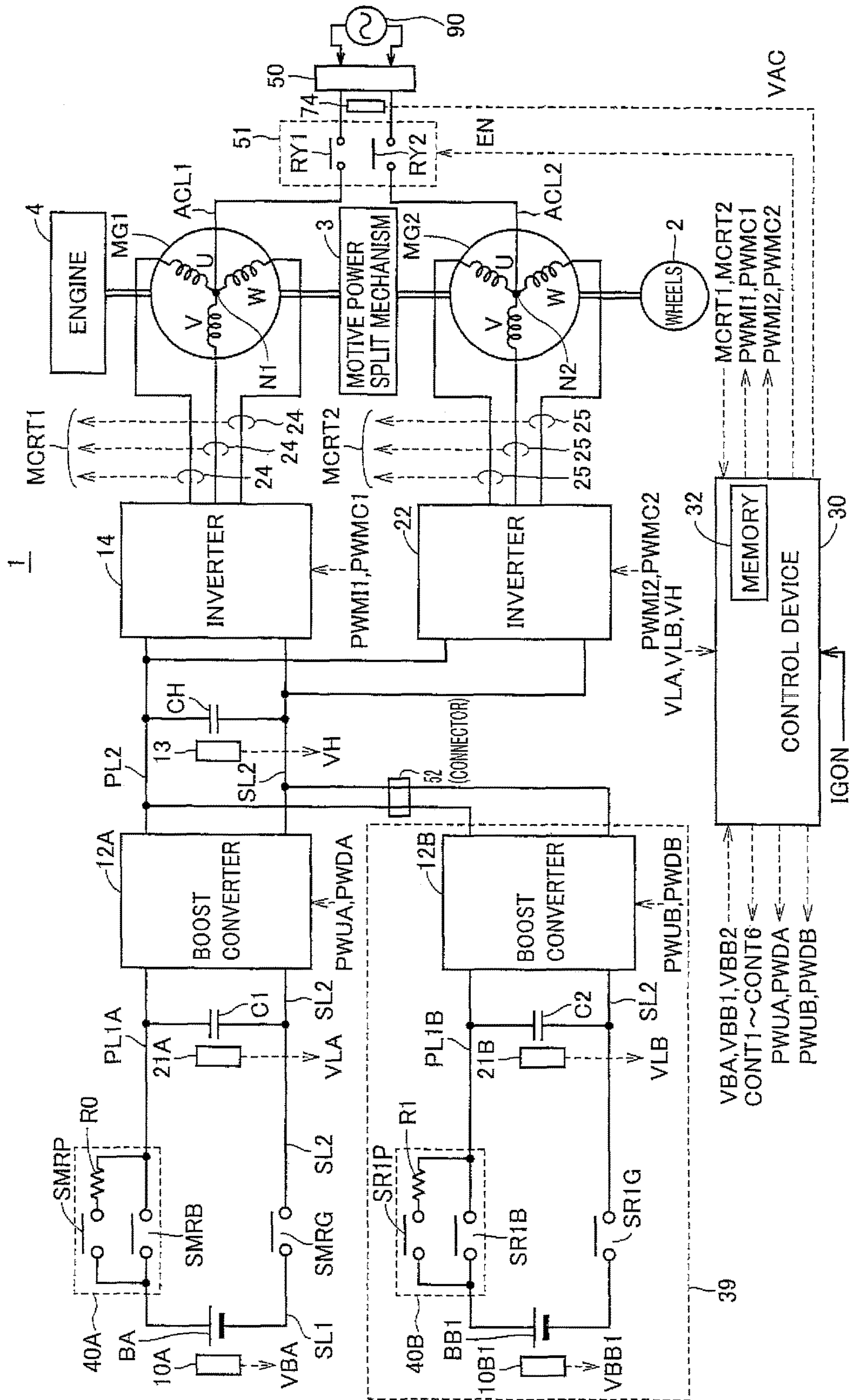


FIG.2

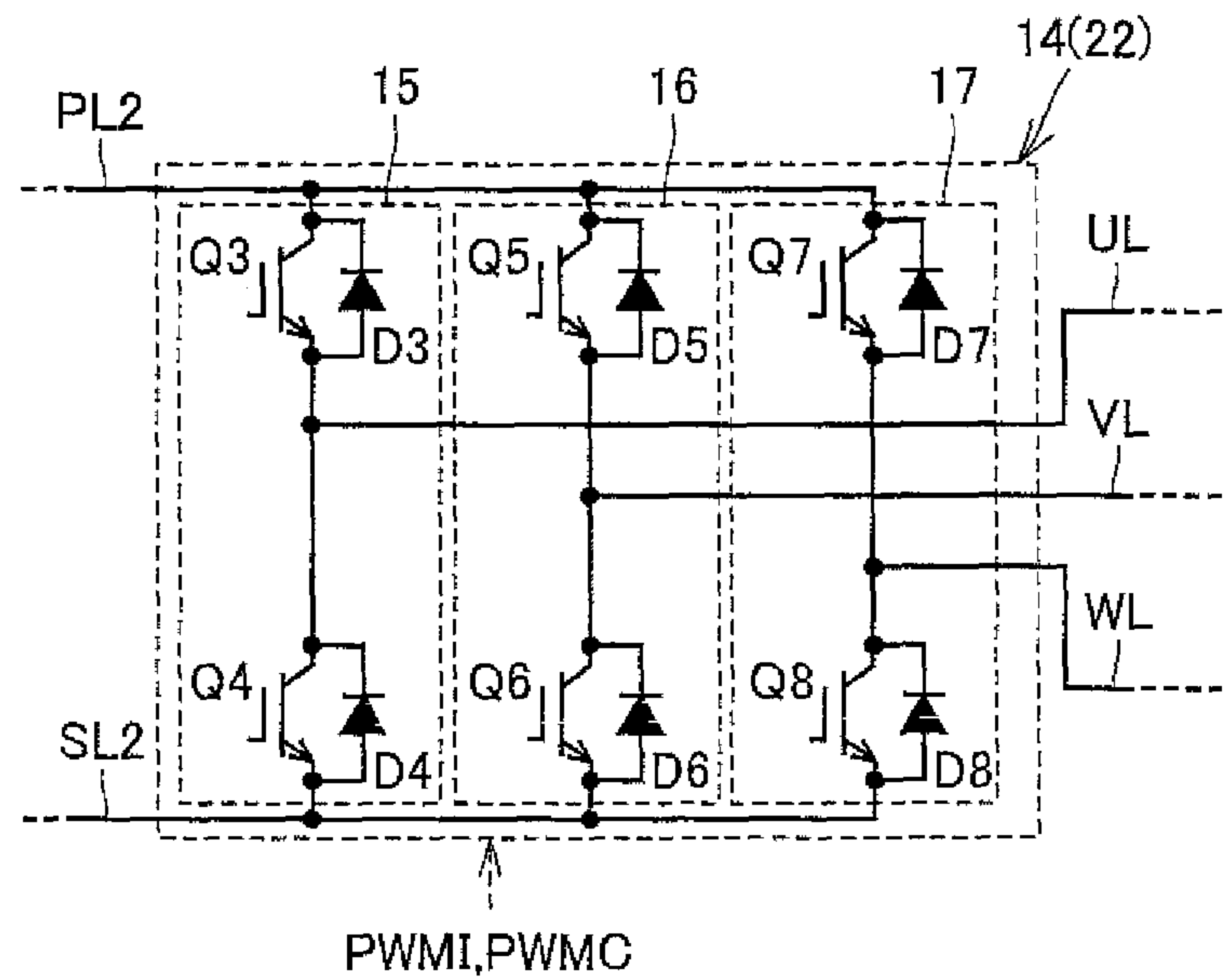


FIG.3

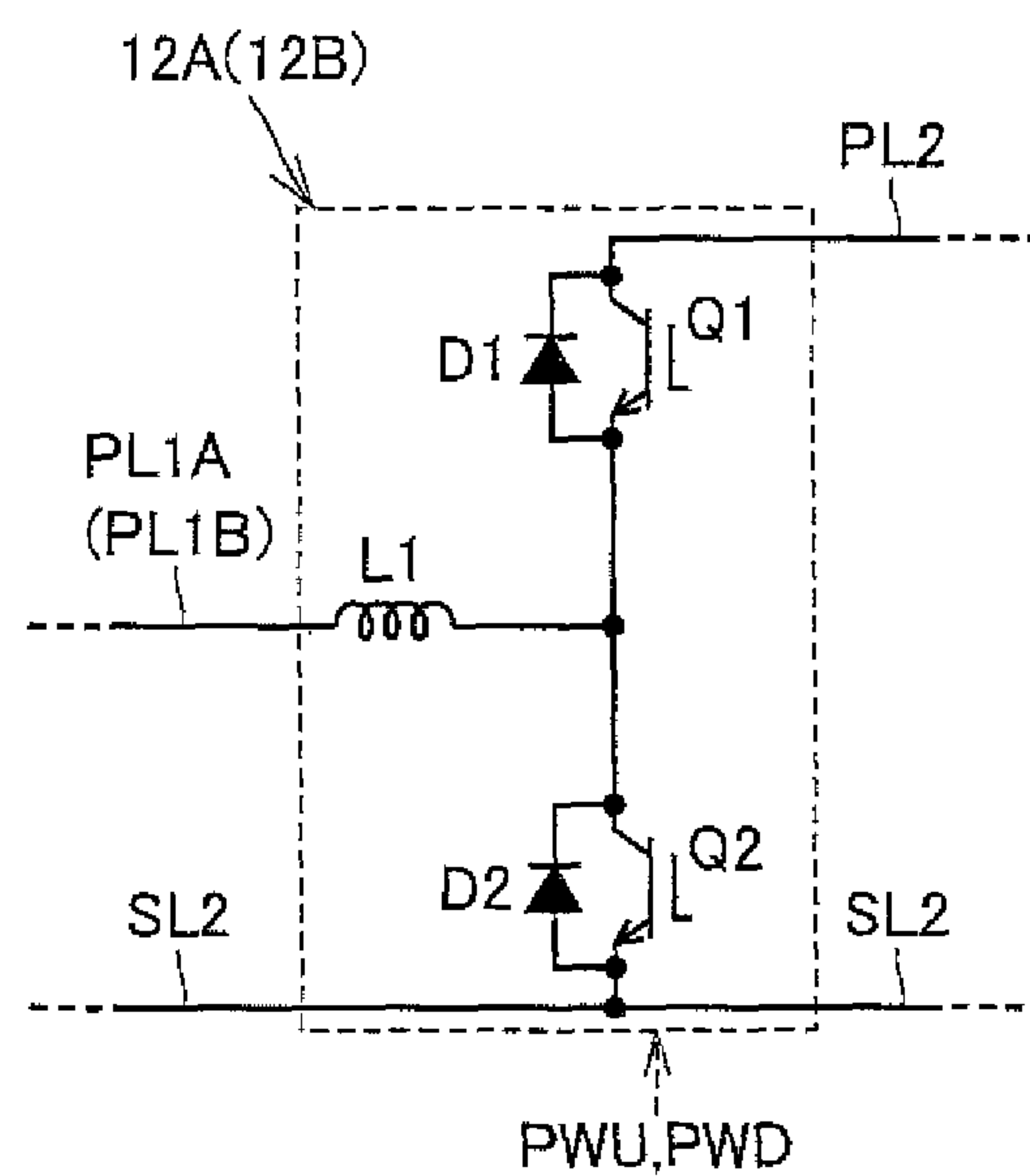


FIG.4

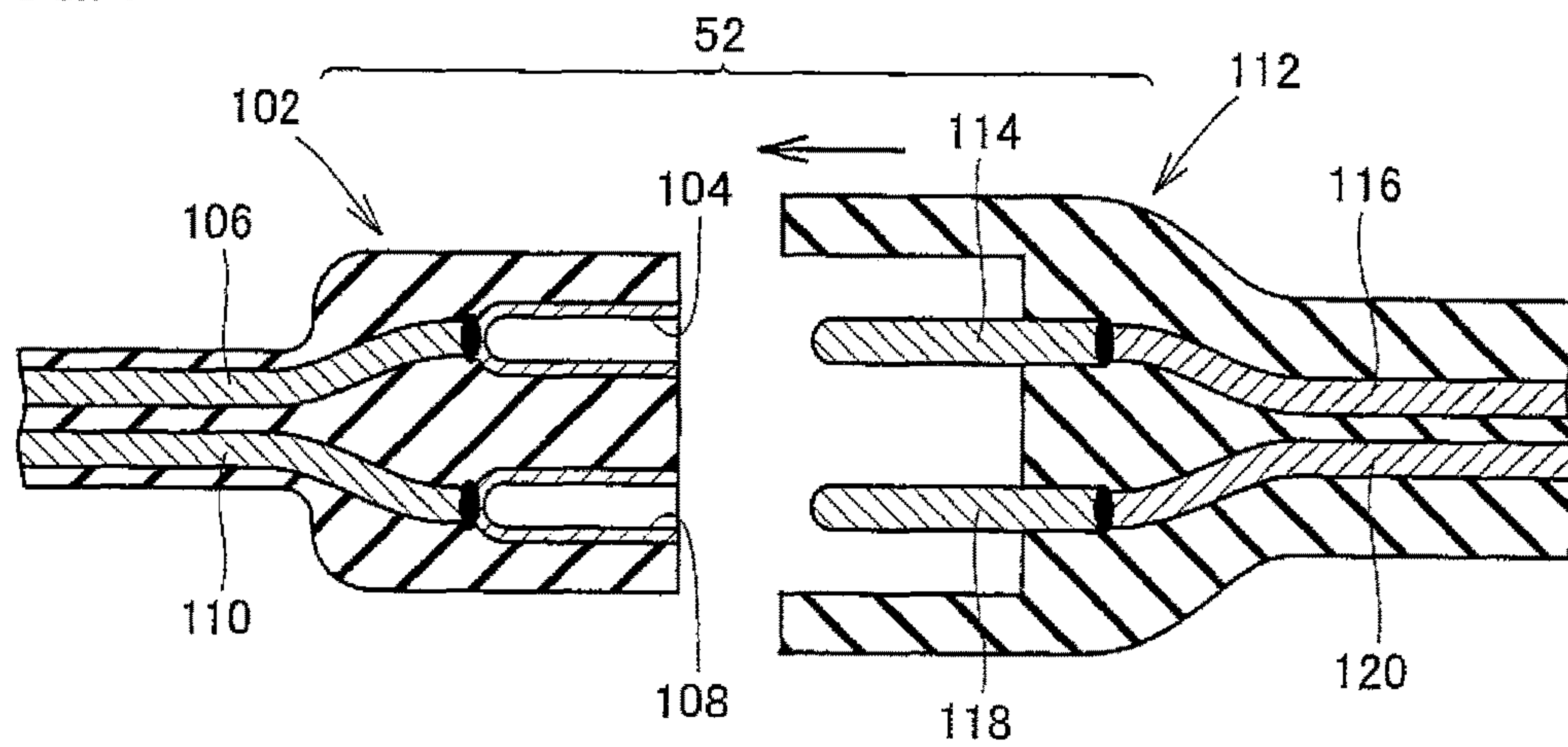


FIG.5

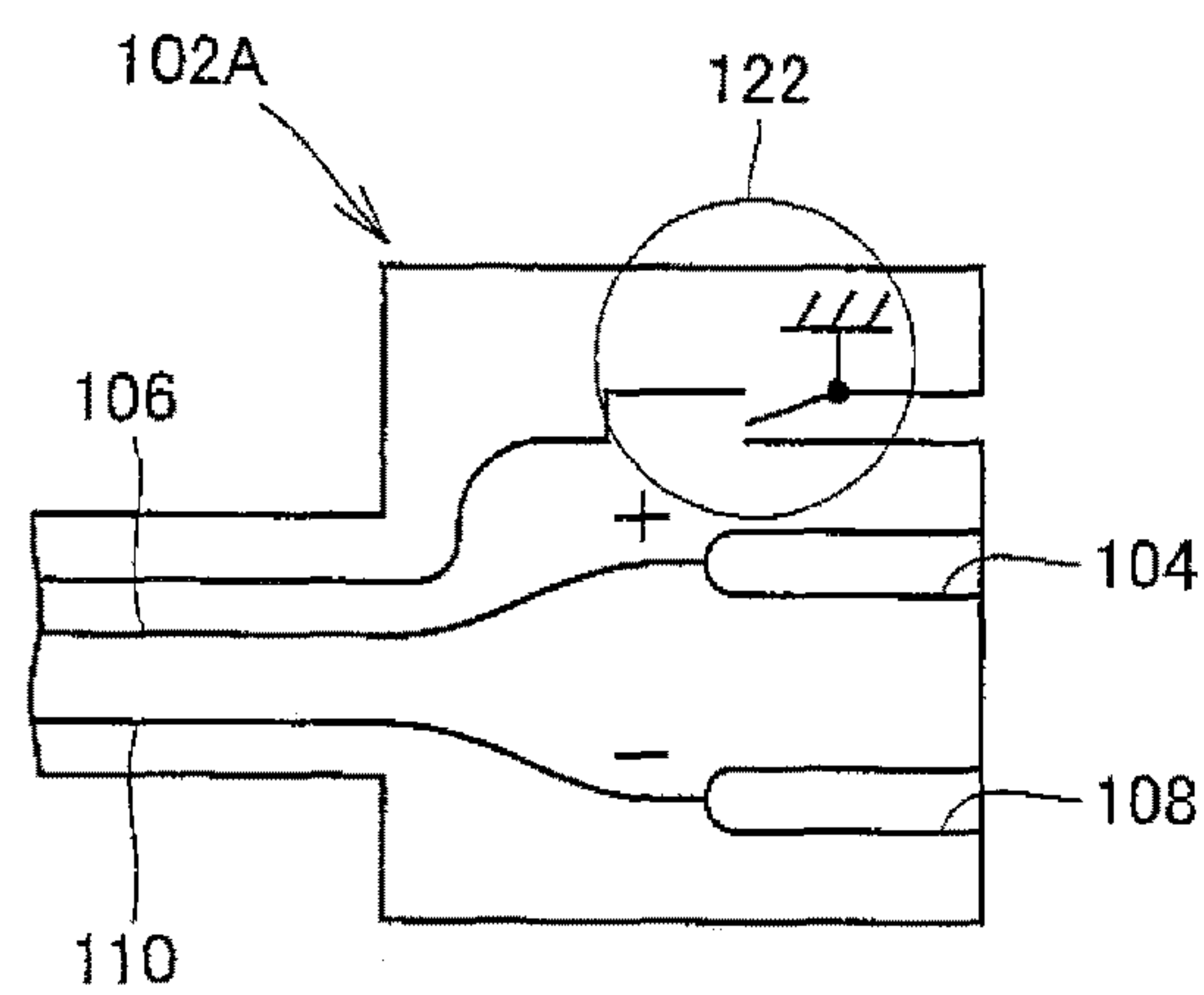


FIG.6

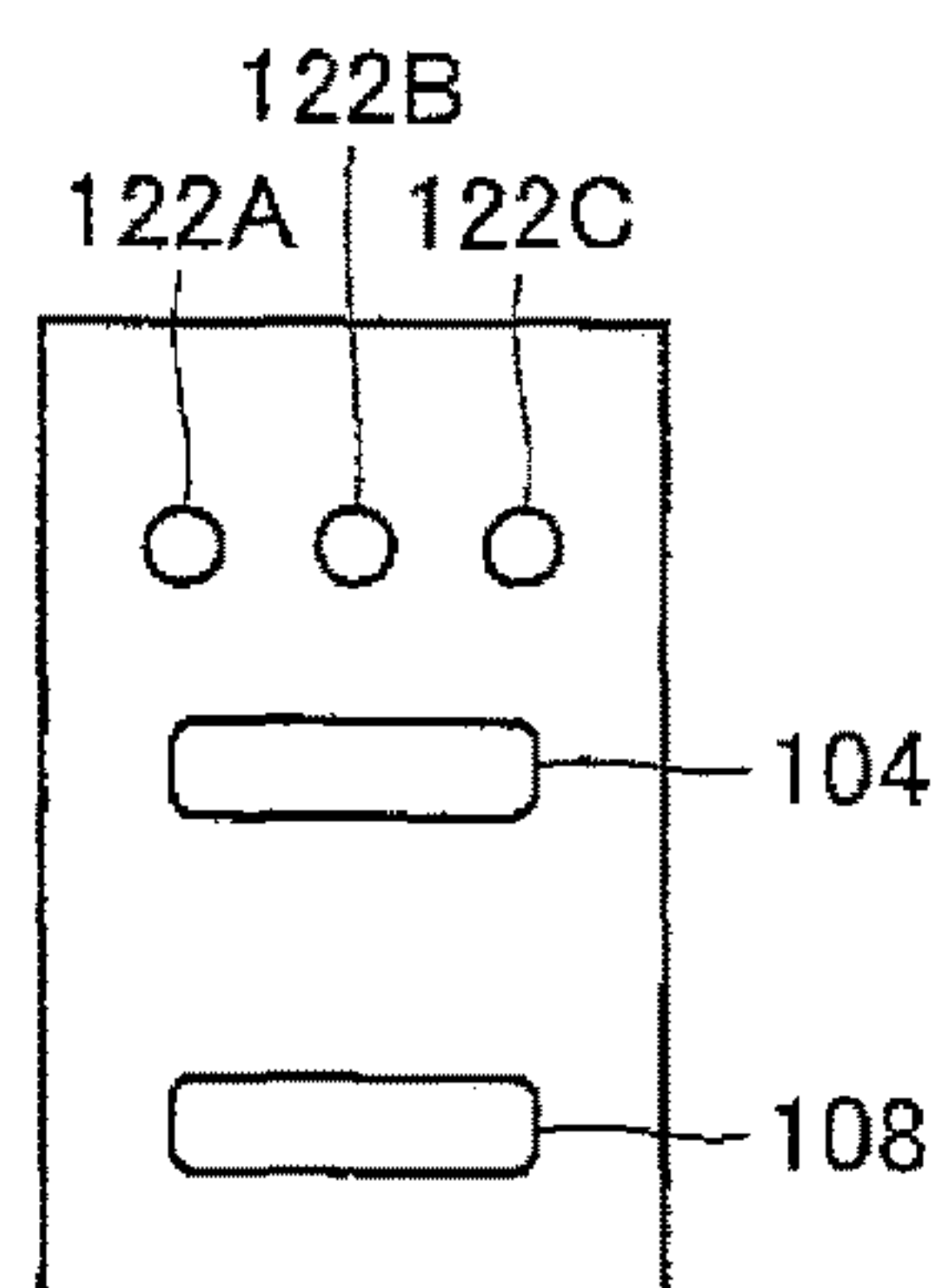


FIG.7

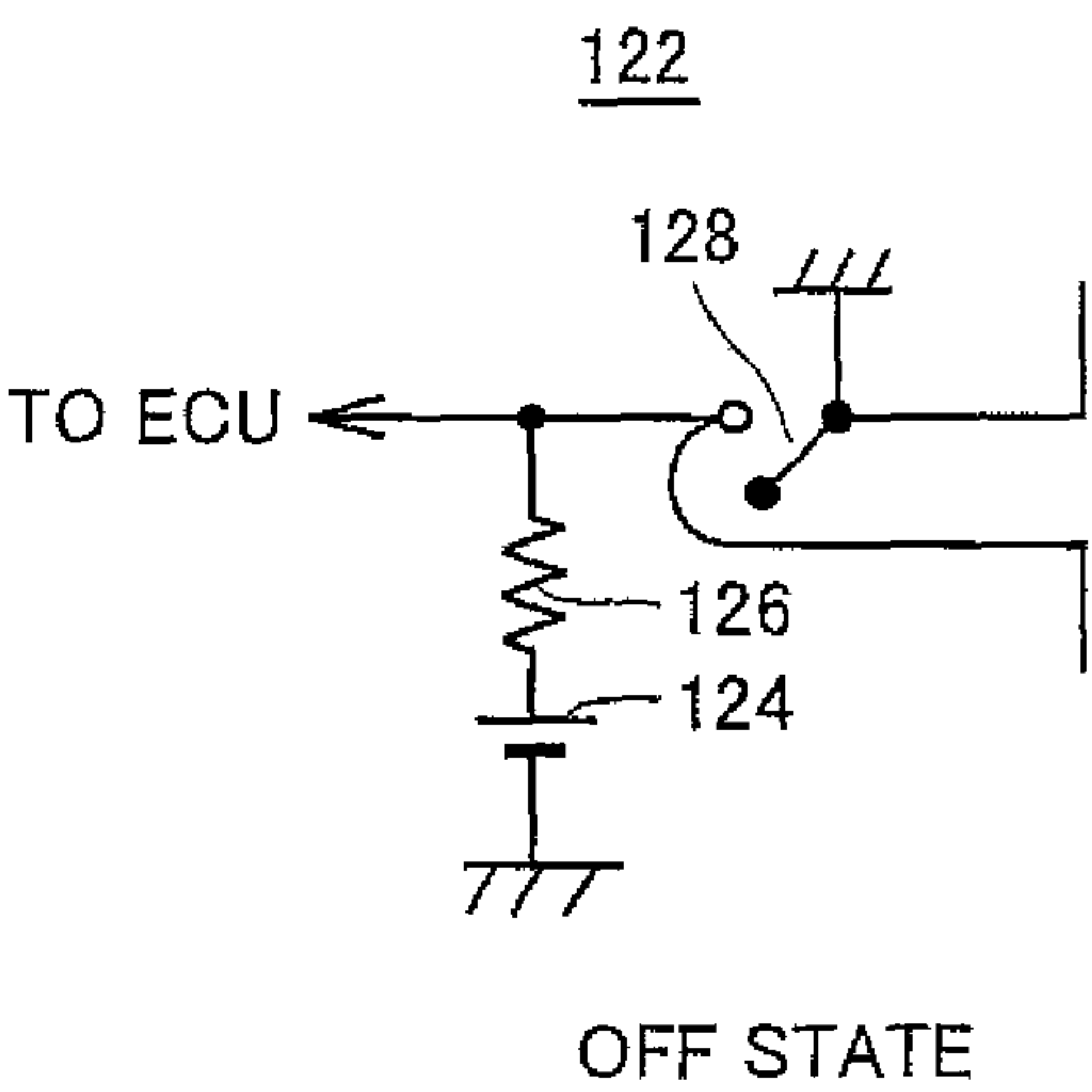


FIG.8

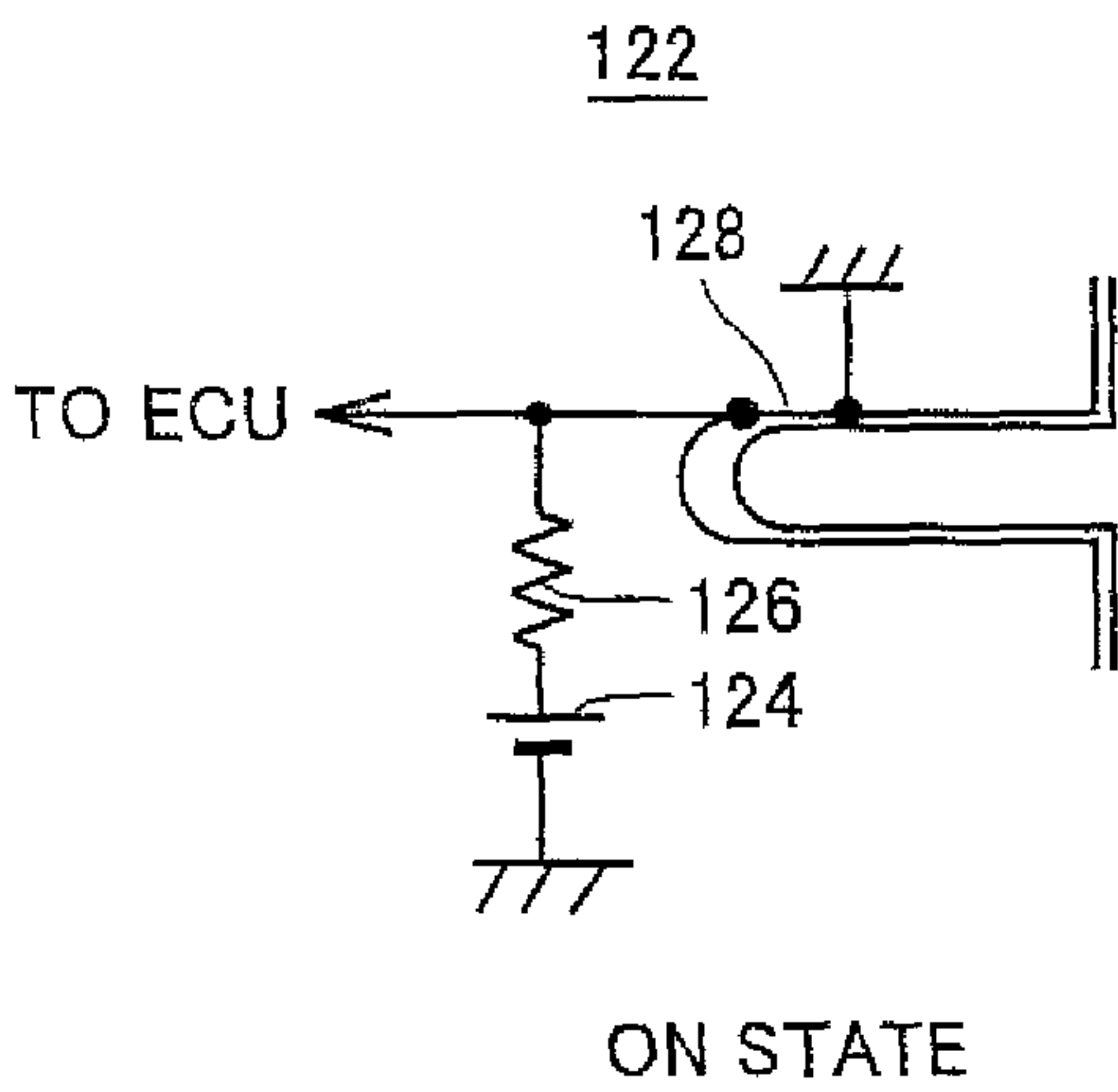


FIG. 9

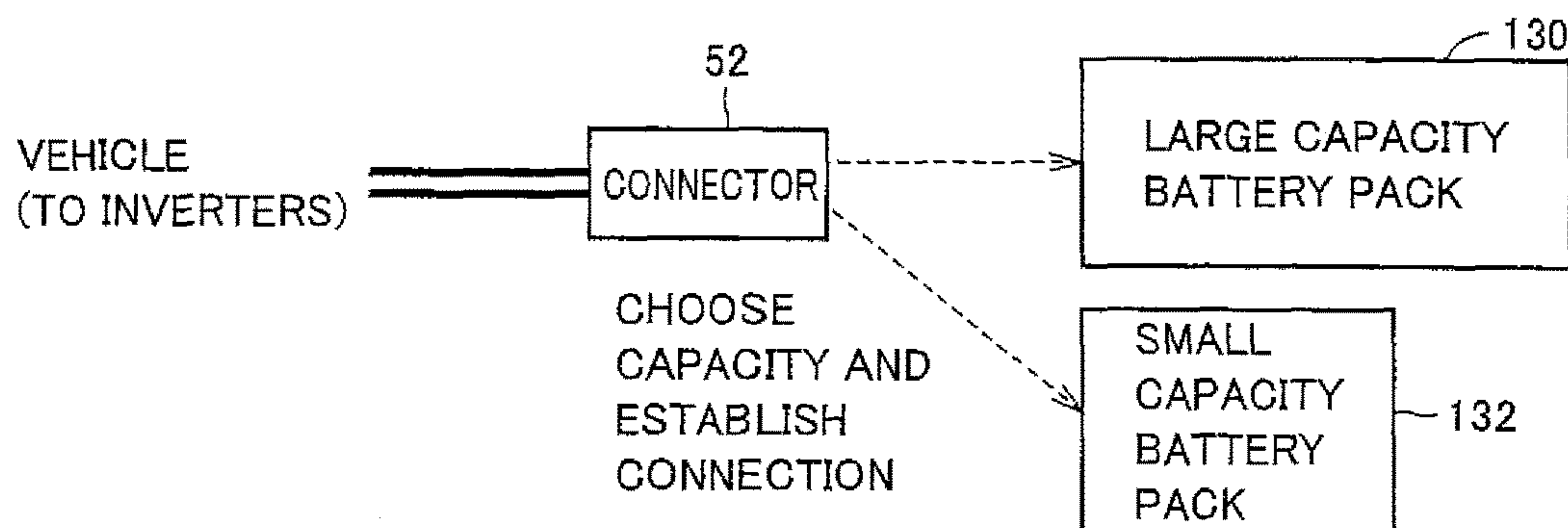


FIG. 10

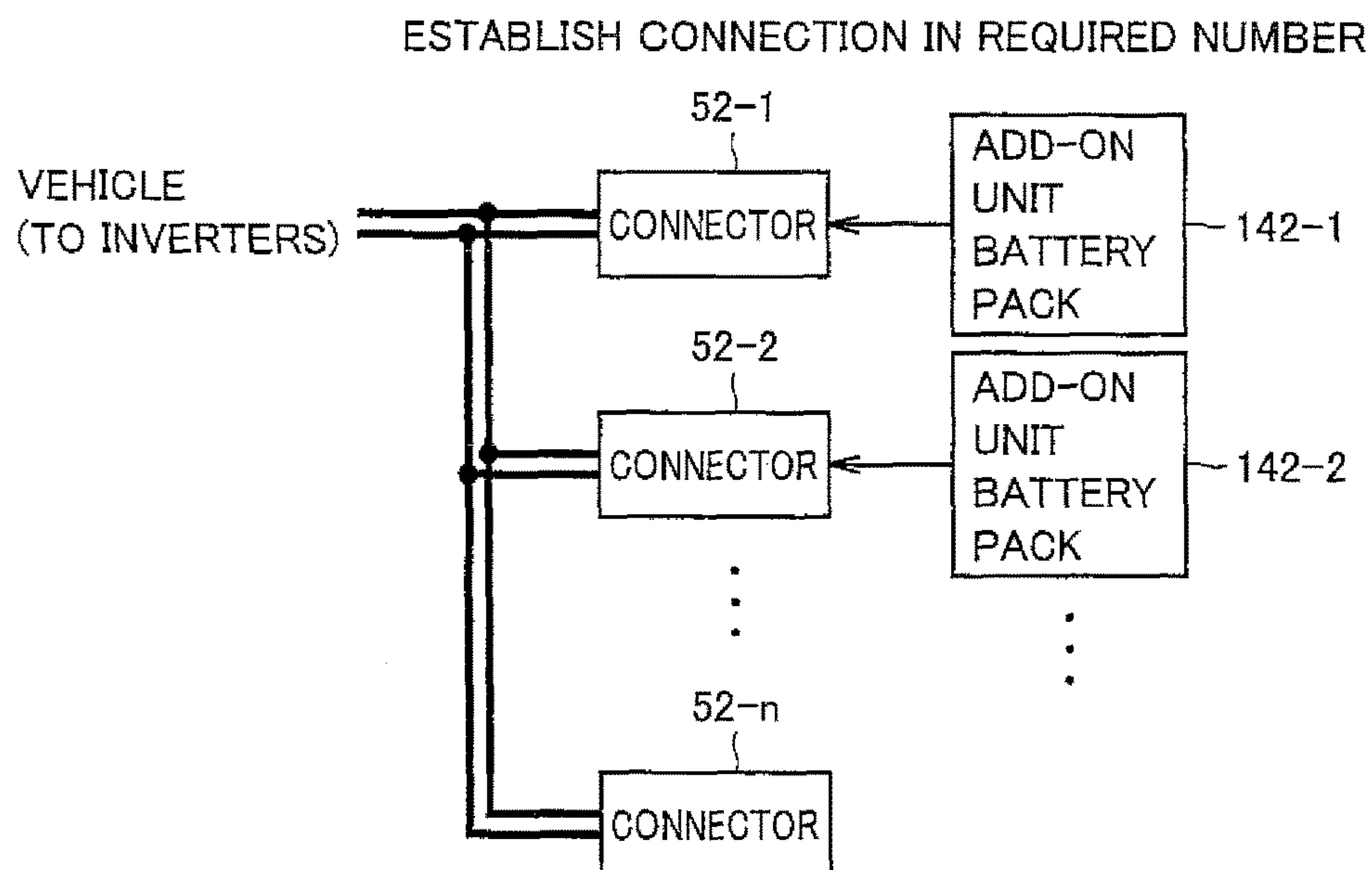


FIG.11

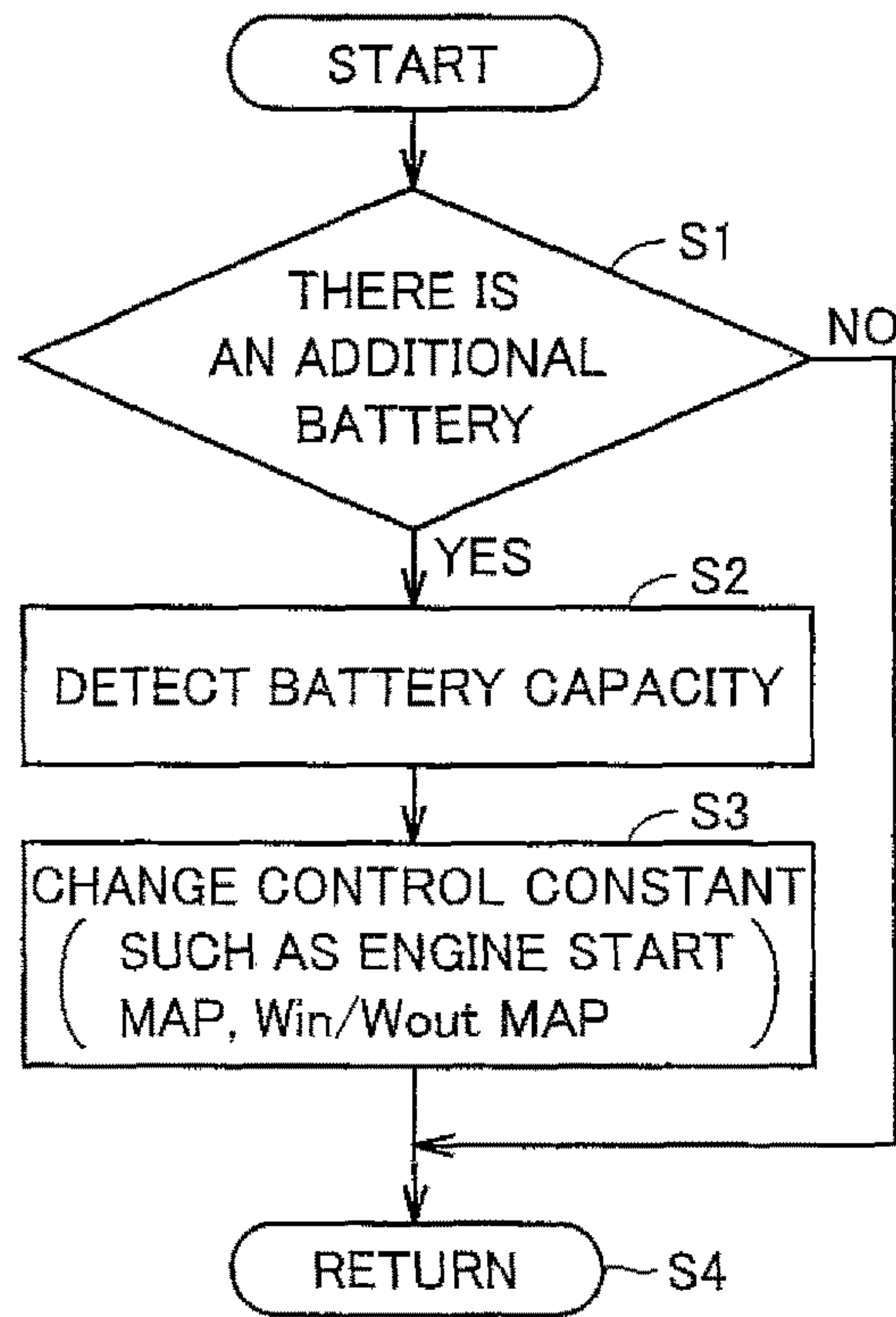


FIG.12

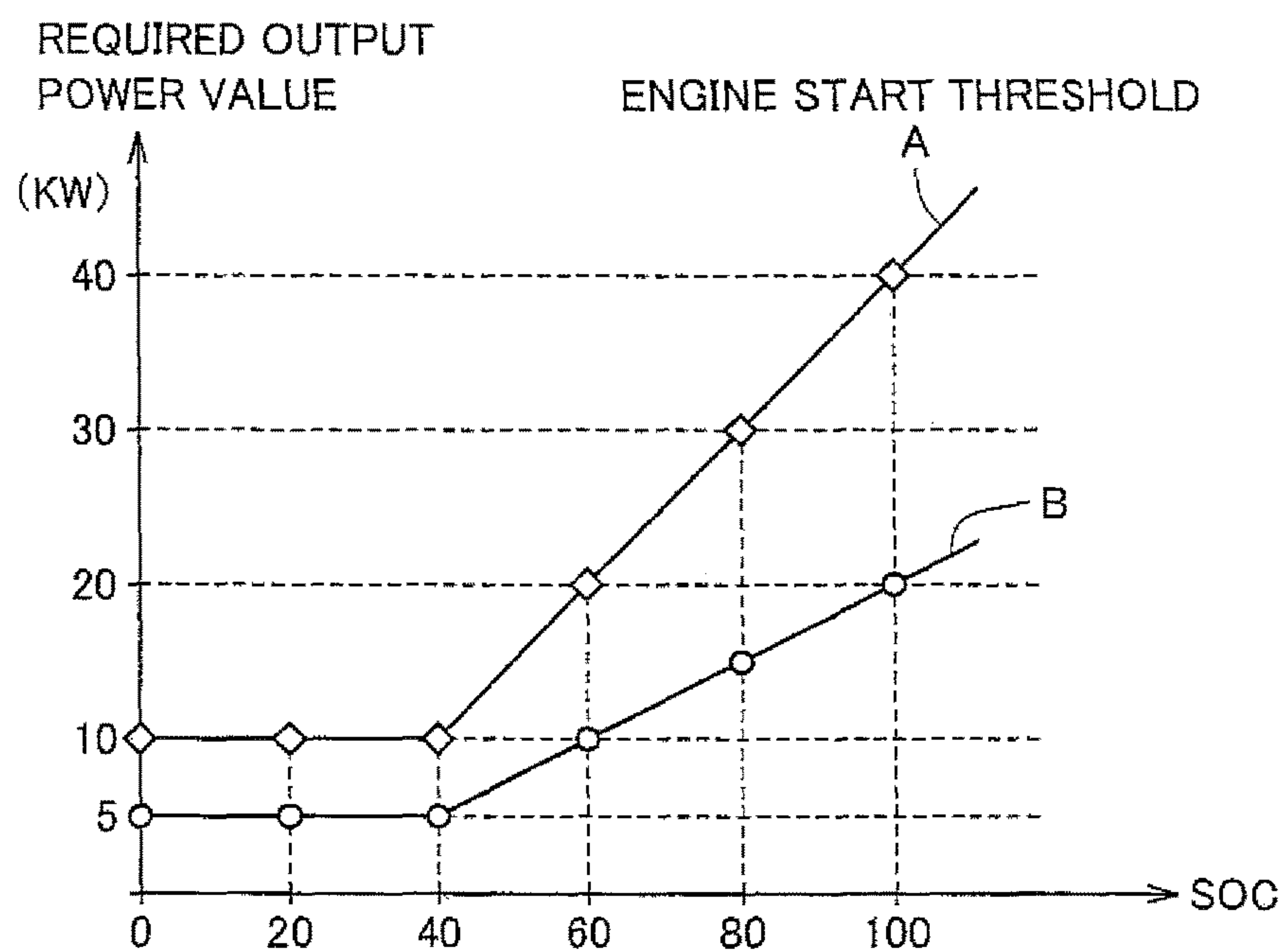


FIG.13

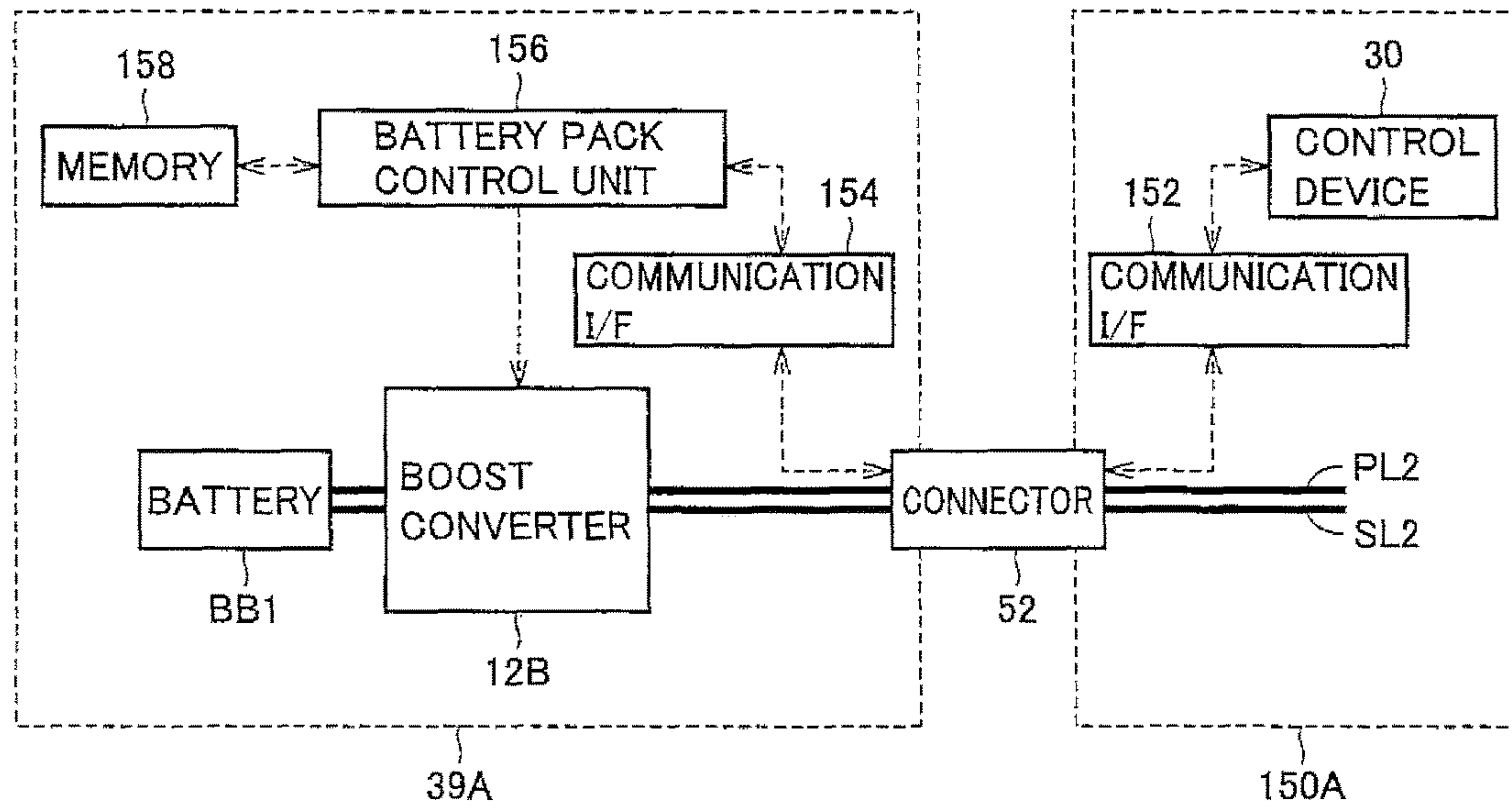


FIG.14

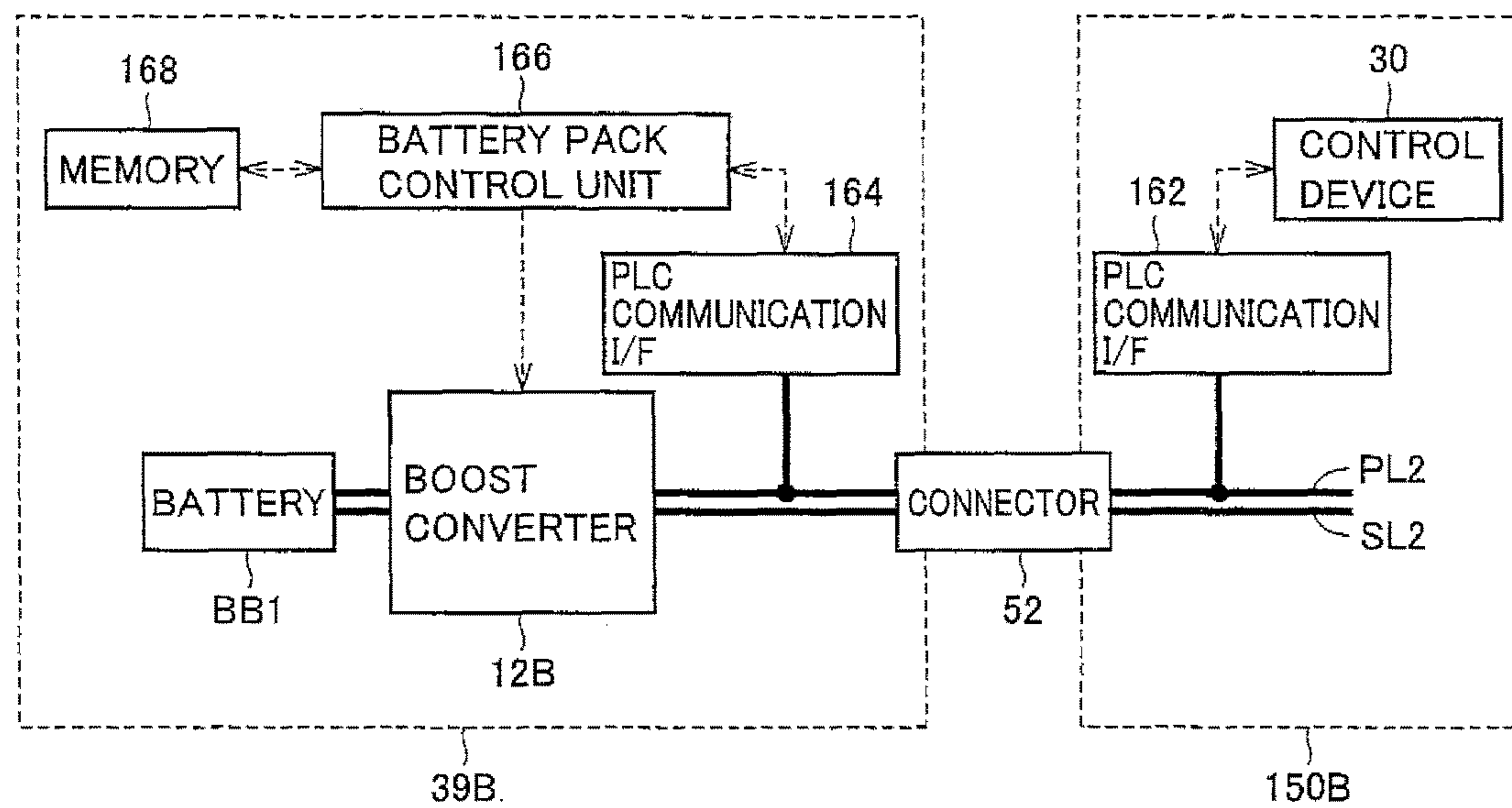


FIG.15

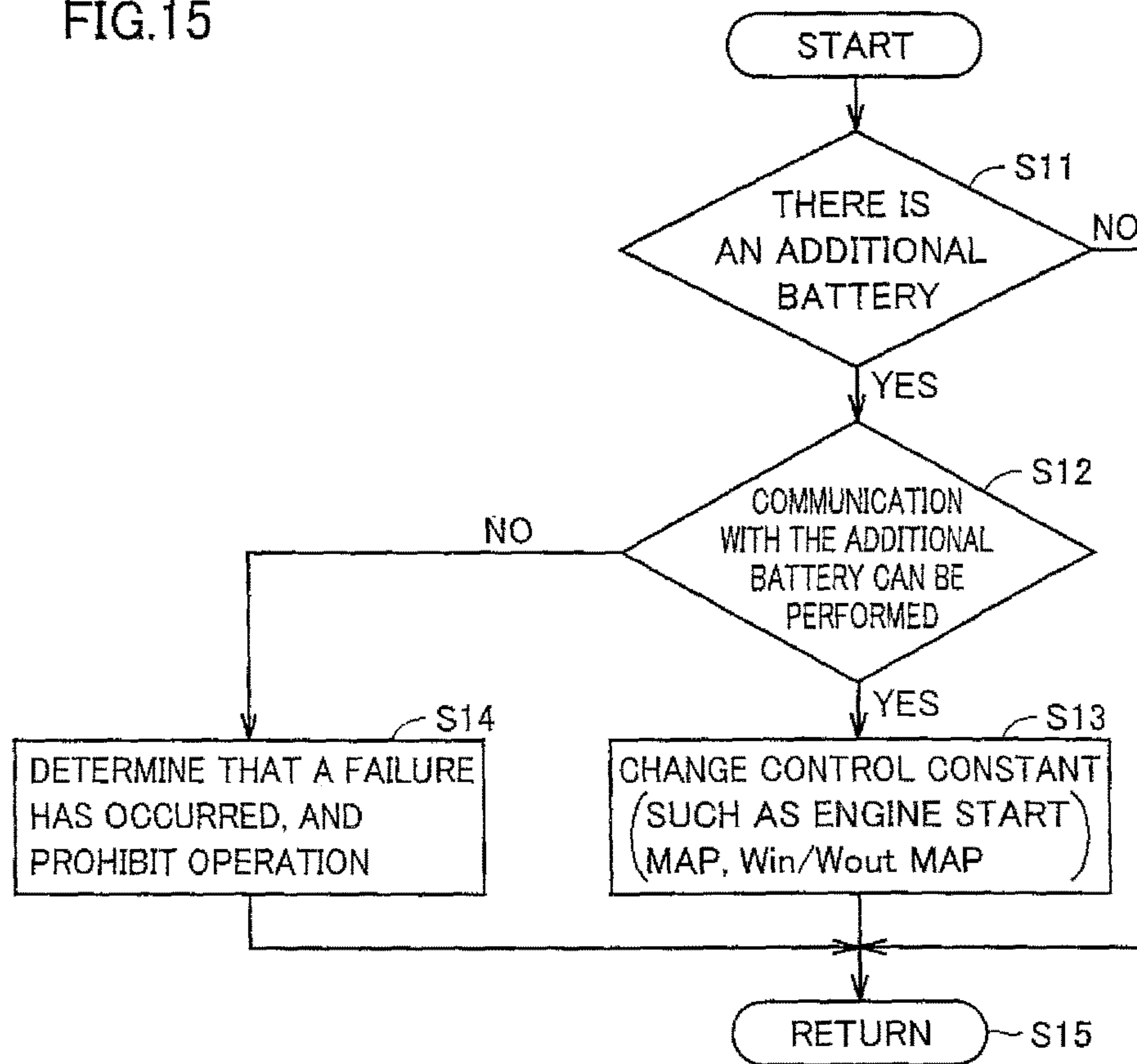


FIG.16

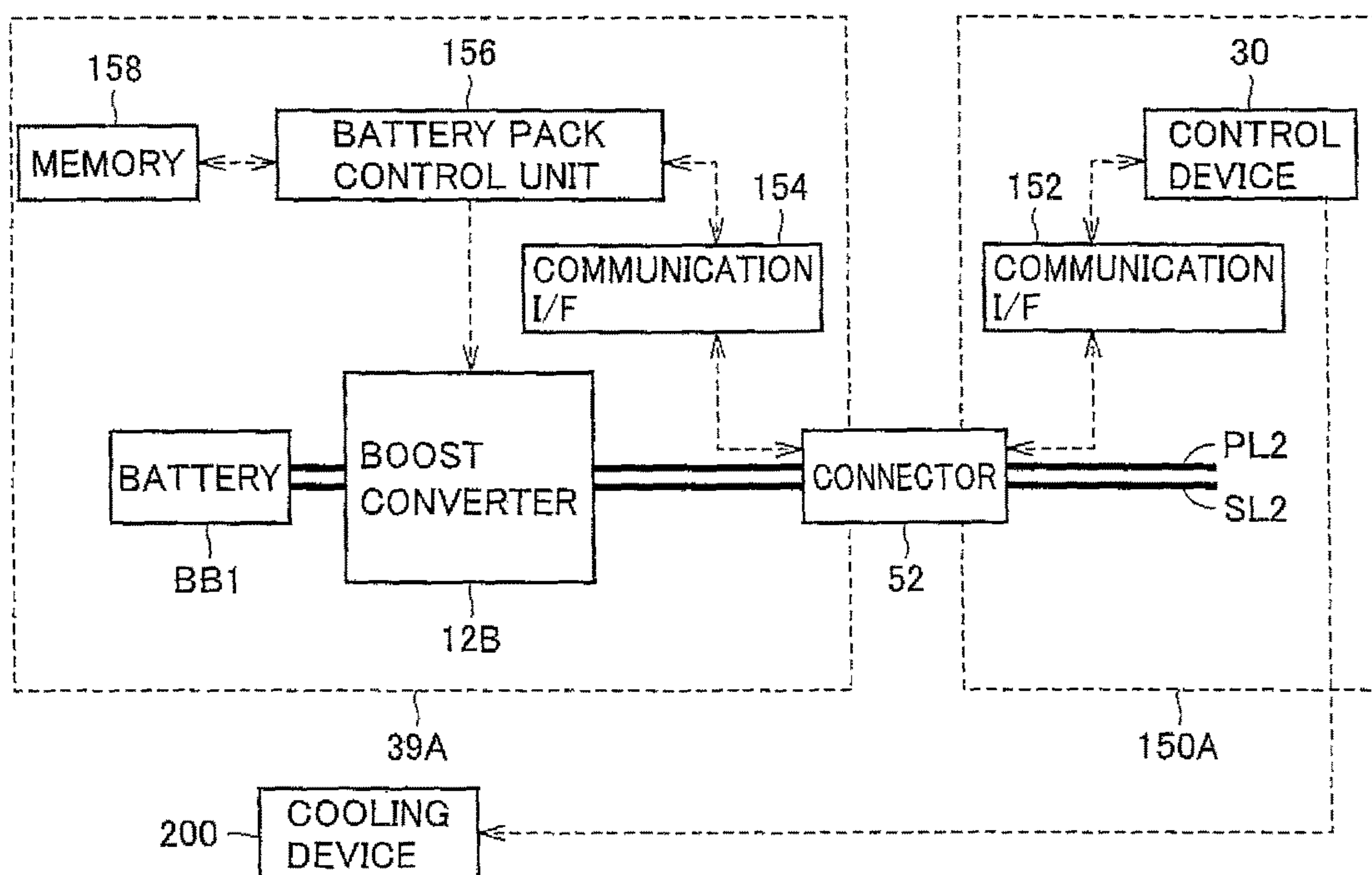
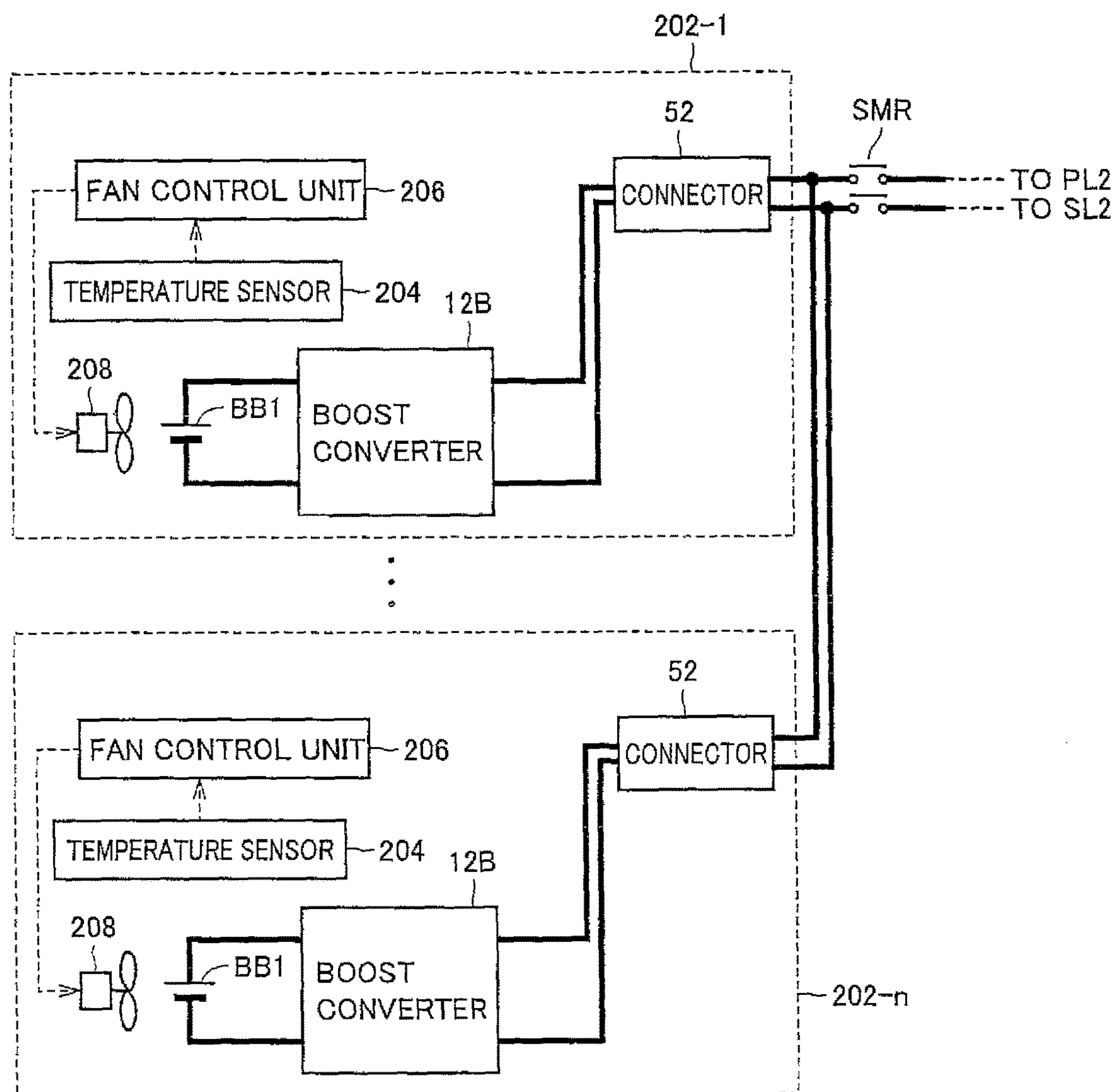


FIG.17



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**ON-VEHICLE EQUIPMENT CONTROL
SYSTEM AND VEHICLE**

This is a Division of application Ser. No. 12/450,801 filed Oct. 14, 2009, which in turn is a National Phase of Appli-
cation No. PCT/JP2008/058442 filed Apr. 24, 2008. The
disclosure of the prior applications is hereby incorporated by
reference herein in its entirety.

TECHNICAL FIELD

The present invention relates to an on-vehicle equipment
control system and a vehicle, and in particular, to an
on-vehicle equipment control system for a vehicle that is
externally chargeable and the vehicle.

BACKGROUND ART

In recent years, vehicles equipped with a power supply
device and using its electric power to drive a motor, such as
electric cars, hybrid cars, fuel cell cars, and the like, have
been attracting attention as environmentally-friendly cars.

In such a vehicle, employing an externally chargeable
configuration has also been under consideration. Japanese
Patent Laying-Open No. 8-154307 discloses a hybrid elec-
tric car including a battery that is chargeable by external
charging means, a drive motor that can drive wheels using
electric power from the battery, control means controlling
operation of the motor, and an internal combustion engine
directly or indirectly used to drive the wheels.

To extend travel distance that can be achieved by charged
electric power, it is necessary to increase the capacity of a
power storage device. However, increasing the capacity of a
power storage device results in an increase in cost and an
increase in the weight of a vehicle, leading to bad mileage.
Therefore, it is desirable to match the capacity of a battery
to a usage pattern of a purchasing user.

Specifically, since travel distance per charge is not nec-
essarily the same for each user of externally chargeable
hybrid vehicles, there arises a desire to change the capacity
of a mounted battery for each purchasing user. For example,
it is conceivable to select optimal battery capacity based on
the distance between a home and an office of the user.

However, preparing vehicles with various battery capaci-
ties results in an increase in manufacturing cost and difficult
manufacturing management. Further, it is more preferable
that the capacity of a battery owned by a user can be changed
when there is a change in the user's usage environment
because of a move, job transfer, or the like.

Disclosure of the Invention

One object of the present invention is to provide an
on-vehicle equipment control system and a vehicle capable
of easily changing battery capacity.

In summary, the present invention is an on-vehicle equip-
ment control system, including: a battery pack configured to
be attachable to and detachable from a vehicle and including
a storage unit storing information; and a control device
controlling on-vehicle equipment based on the information
stored in the storage unit when the battery pack is connected
to the vehicle, and controlling the on-vehicle equipment
based on information other than the information stored in the
storage unit when the battery pack is not connected to the
vehicle.

Preferably, the control device controls charge and dis-
charge of the battery pack based on the information stored
in the storage unit.

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Preferably, the on-vehicle equipment control system fur-
ther includes a cooling device cooling the battery pack. The
control device controls the cooling device based on the
information stored in the storage unit.

Preferably, the on-vehicle equipment control system fur-
ther includes a first battery supplying electric power to the
on-vehicle equipment. The battery pack further includes a
second battery supplying electric power to the on-vehicle
equipment. The control device causes the on-vehicle equip-
ment to perform control related to the first battery and
control related to the second battery based on the informa-
tion stored in the storage unit.

More preferably, the control device performs processing
related to the first battery and the second battery based on a
prescribed control constant, and changes the control con-
stant based on the information read from the storage unit.

Preferably, the control device determines whether or not
the battery pack is an authorized product based on the
information read from the storage unit.

Preferably, the battery pack further includes a battery
supplying electric power to the on-vehicle equipment, and a
cooling device cooling the battery.

According to another aspect, the present invention is an
on-vehicle equipment control system, including: a battery
pack having a connection unit for attachably and detachably
connecting to a vehicle; a shape detection unit provided to
the vehicle for detecting a shape of the connection unit; and
a control device controlling on-vehicle equipment based on
a detection result of the shape detection unit.

Preferably, the control device controls charge and dis-
charge of the battery pack based on the detection result of the
shape detection unit.

Preferably, the on-vehicle equipment control system fur-
ther includes a cooling device cooling the battery pack. The
control device controls the cooling device based on the
detection result of the shape detection unit.

Preferably, the on-vehicle equipment control system fur-
ther includes a first battery supplying electric power to the
on-vehicle equipment. The battery pack further includes a
second battery supplying electric power to the on-vehicle
equipment. The control device causes the on-vehicle equip-
ment to perform control related to the first battery and
control related to the second battery based on the detection
result of the shape detection unit.

More preferably, the control device performs processing
related to the first battery and the second battery based on a
prescribed control constant, and changes the control con-
stant based on the detection result of the shape detection
unit.

Preferably, the battery pack further includes a battery
supplying electric power to the on-vehicle equipment, and a
cooling device cooling the battery.

According to still another aspect of the present invention,
provided is a vehicle configured such that a battery pack
having a connection unit connecting to the vehicle is attach-
able and detachable from the vehicle, including a control
device controlling on-vehicle equipment based on informa-
tion read from the battery pack when the battery pack is
connected to the vehicle, and controlling the on-vehicle
equipment based on information stored in the vehicle when
the battery pack is not connected to the vehicle.

Preferably, the control device controls charge and dis-
charge of the battery pack based on the information read
from the battery pack.

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Preferably, the vehicle further includes a cooling device cooling the battery pack. The control device controls the cooling device based on the information read from the battery pack.

Preferably, the vehicle further includes a first battery supplying electric power to the on-vehicle equipment. The battery pack further includes a second battery supplying electric power to the on-vehicle equipment. The control device causes the on-vehicle equipment to perform control related to the first battery and control related to the second battery based on the information read from the battery pack.

More preferably, the control device performs processing related to the first battery and the second battery based on a prescribed control constant, and changes the control constant based on the information read from the battery pack.

Preferably, the control device determines whether or not the battery pack is an authorized product based on the information read from the battery pack.

Preferably, the battery pack further includes a battery supplying electric power to the on-vehicle equipment, and a cooling device cooling the battery.

According to still another aspect of the present invention, provided is a vehicle configured such that a battery pack having a connection unit connecting to the vehicle is attachable and detachable from the vehicle, including: a shape detection unit provided to the vehicle for detecting a shape of the connection unit; and a control device controlling on-vehicle equipment based on a detection result of the shape detection unit.

Preferably, the control device controls charge and discharge of the battery pack based on the detection result of the shape detection unit.

Preferably, the vehicle further includes a cooling device cooling the battery pack. The control device controls the cooling device based on the detection result of the shape detection unit.

Preferably, the vehicle further includes a first battery supplying electric power to the on-vehicle equipment. The battery pack further includes a second battery supplying electric power to the on-vehicle equipment. The control device causes the on-vehicle equipment to perform control related to the first battery and control related to the second battery based on the detection result the shape detection unit.

More preferably, the control device performs processing related to the first battery and the second battery based on a prescribed control constant, and changes the control constant based on the detection result of the shape detection unit.

Preferably, the battery pack further includes a battery supplying electric power to the on-vehicle equipment, and a cooling device cooling the battery.

According to the present invention, battery capacity of a power supply device for a vehicle can be easily changed. Further, optimal battery capacity can be determined for each user.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a main configuration of a vehicle 1 in accordance with an embodiment of the present invention.

FIG. 2 is a circuit diagram showing a detailed configuration of inverters 14 and 22 of FIG. 1.

FIG. 3 is a circuit diagram showing a detailed configuration of boost converters 12A and 12B of FIG. 1.

FIG. 4 shows a structure of a connector provided between a vehicle and a battery pack used in a first embodiment.

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FIG. 5 shows a connector member 102A provided with a switch for determining a battery type.

FIG. 6 is a view of connector member 102A shown in FIG. 5 as seen from a direction of a plug insertion surface.

FIG. 7 shows an OFF state of a switch 122.

FIG. 8 shows an ON state of switch 122.

FIG. 9 is a view for illustrating battery pack types.

FIG. 10 shows an example of capacity increase and decrease in a case where there is one type of battery pack.

FIG. 11 is a flowchart for illustrating control associated with connection of an additional battery pack performed by a control device 30.

FIG. 12 is a view for illustrating switching of maps of engine start thresholds as an example of a control constant.

FIG. 13 shows connection between a vehicle and a battery pack in a second embodiment.

FIG. 14 shows a modification of a configuration shown in FIG. 13.

FIG. 15 is a flowchart for illustrating control associated with connection of an additional battery pack performed by control device 30 in the second embodiment.

FIG. 16 is a block diagram for illustrating a cooling device in a third embodiment.

FIG. 17 shows a modification of a configuration of a battery pack used in the third embodiment.

BEST MODES FOR CARRYING OUT THE INVENTION

Embodiments of the present invention will now be described in detail with reference to the drawings, in which identical or corresponding parts will be designated by the same reference numerals, and the description thereof will not be repeated.

[Overall Configuration of Vehicle]

FIG. 1 shows a main configuration of a vehicle 1 in accordance with an embodiment of the present invention.

Referring to FIG. 1, vehicle 1 includes a main battery BA serving as a power storage device, a boost converter 12A, a smoothing capacitor C1, and a voltage sensor 21A.

Vehicle 1 further includes a smoothing capacitor CH, voltage sensors 10A, 10B1, and 13, inverters 14 and 22, an engine 4, motor generators MG1 and MG2, a motive power split mechanism 3, wheels 2, and a control device 30.

Vehicle 1 further includes a connector 52, and a battery pack 39 attachably and detachably connected to vehicle 1 by connector 52. Total capacity of batteries mounted on vehicle 1 can be adjusted by mounting battery pack 39 on vehicle 1 or removing battery pack 39 from vehicle 1.

Battery pack 39 includes a sub battery BB1, a boost converter 12B, a smoothing capacitor C2, and voltage sensors 10B1 and 21B.

A power storage device mounted on this vehicle is externally chargeable. For this end, vehicle 1 further includes electric power input lines ACL1 and ACL2, a relay circuit 51, an input terminal 50, and a voltage sensor 74.

Relay circuit 51 includes relays RY1 and RY2. As relays RY1 and RY2, for example, mechanical contact relays can be used, and semiconductor relays may also be used. Electric power input line ACL1 has one end connected to one end of relay RY1, and the other end connected to a neutral point N1 of a three-phase coil of motor generator MG1. Electric power input line ACL2 has one end connected to one end of relay RY2, and the other end connected to a neutral point N2 of a three-phase coil of motor generator MG2. Further, input terminal 50 is connected to the other ends of relays RY1 and RY2.

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When an input enable signal EN from control device **30** is activated, relay circuit **51** electrically connects input terminal **50** with electric power input lines ACL1 and ACL2. Specifically, when input enable signal EN is activated, relay circuit **51** turns on relays RY1 and RY2, and when input enable signal EN is deactivated, relay circuit **51** turns off relays RY1 and RY2.

Input terminal **50** is a terminal for connecting a commercial external power supply **90** to hybrid vehicle **1**. In hybrid vehicle **1**, battery BA or BB1 can be charged from external power supply **90** connected to input terminal **50**.

It is to be noted that the configuration described above utilizes neutral points of stator coils of two rotating electric machines, and instead of such a configuration, for example, a battery charging device mounted on a vehicle or external to a vehicle may be used for connection with a commercial AC 100 V power supply, or a technique of causing boost converters **12A** and **12B** together to serve as an alternating current (AC) to direct current (DC) conversion device may be used when optional battery pack **39** is mounted.

Smoothing capacitor **C1** is connected between a power supply line PL1A and a ground line SL2. Voltage sensor **21A** detects a voltage VLA across smoothing capacitor **C1**, and outputs voltage VLA to control device **30**. Boost converter **12A** boosts the voltage across terminals of smoothing capacitor **C1**.

Smoothing capacitor **C2** is connected between a power supply line PL1B and ground line SL2. Voltage sensor **21B** detects a voltage VLB across smoothing capacitor **C2**, and outputs voltage VLB to control device **30**. Boost converter **12B** boosts the voltage across terminals of smoothing capacitor **C2**.

Smoothing capacitor **CH** smoothes the voltages boosted by boost converters **12A** and **12B**. Voltage sensor **13** detects a voltage VH across terminals of smoothing capacitor **CH**, and outputs voltage VH to control device **30**.

Inverter **14** converts a DC voltage supplied from boost converter **12B** or **12A** into a three-phase AC voltage, and outputs the three-phase AC voltage to motor generator MG1. Inverter **22** converts a DC voltage supplied from boost converter **12B** or **12A** into a three-phase AC voltage, and outputs the three-phase AC voltage to motor generator MG2.

Motive power split mechanism **3** is a mechanism coupled to engine **4** and motor generators MG1 and MG2 to split motive power therebetween. For example, a planetary gear mechanism having three rotation axes of a sun gear, a planetary carrier, and a ring gear can be used as the motive power split mechanism. When rotations of two of the three rotation axes are determined in the planetary gear mechanism, rotation of the other one rotation axis is inevitably determined. These three rotation axes are connected to rotation axes of engine **4**, motor generator MG1, and motor generator MG2, respectively. The rotation axis of motor generator MG2 is coupled to wheels **2** by a reduction gear and a differential gear not shown. A decelerator for the rotation axis of motor generator MG2 may be further incorporated or an automatic transmission may be incorporated into motive power split mechanism **3**.

In relation to main battery BA, vehicle **1** further includes a connection unit **40A** provided on a positive electrode side, and a system main relay SMRG serving as a connection unit provided on a negative electrode side. Connection unit **40A** includes a system main relay SMRB connected between a positive electrode of main battery BA and power supply line PL1A, and a system main relay SMRP and a limiting resistor **R0** connected in series with each other and connected in parallel with system main relay SMRB. System main relay

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SMRG is connected between a negative electrode of main battery BA (a ground line SL1) and ground line SL2.

Conductive/nonconductive states of system main relays SMRP, SMRB, and SMRG are controlled by control signals CONT1 to CONT3 supplied from control device **30**, respectively.

Voltage sensor **10A** measures a voltage VA across terminals of main battery BA. Although not shown, a current sensor sensing a current flowing into main battery BA is provided to monitor the state of charge of main battery BA together with voltage sensor **10A**. As main battery BA, for example, a secondary battery such as a lead-acid battery, a nickel hydride battery, or a lithium ion battery, or a large-capacity capacitor such as an electric double layer capacitor can be used.

Battery pack **39** includes a connection unit **40B** provided on a positive electrode side, and a system main relay SR1G serving as a connection unit provided on a negative electrode side. Connection unit **40B** includes a system main relay SR1B connected between a positive electrode of sub battery BB1 and power supply line PL1B, and a system main relay SR1P and a limiting resistor **R1** connected in series with each other and connected in parallel with system main relay SR1B. System main relay SR1G is connected between a negative electrode of sub battery BB1 and ground line SL2.

Conductive/nonconductive states of system main relays SR1P, SR1B, and SR1G are controlled by control signals CONT4 to CONTE supplied from control device **30**, respectively.

Ground line SL2 extends through boost converters **12A** and **12B** to inverters **14** and **22**, as described below.

Voltage sensor **10B1** measures a voltage VBB1 across terminals of sub battery BB1. Although not shown, a current sensor sensing a current flowing into each battery is provided to monitor the state of charge of sub battery BB1 together with voltage sensor **10B1**. As sub battery BB1, for example, a secondary battery such as a lead-acid battery, a nickel hydride battery, or a lithium ion battery, or a large-capacity capacitor such as an electric double layer capacitor can be used.

It is to be noted that sub battery BB1 is an optional battery added or removed according to a user's usage status, whereas main battery BA is a base battery mounted on the vehicle as a minimum necessary battery.

Inverter **14** is connected to a power supply line PL2 and ground line SL2. Inverter **14** receives the boosted voltages from boost converters **12A** and **12B**, and drives motor generator MG1 to, for example, start engine **4**. Inverter **14** also returns electric power generated in motor generator MGT by motive power transmitted from engine **4**, to boost converters **12A** and **12B**. On this occasion, boost converters **12A** and **12B** are controlled by control device **30** to operate as step-down circuits.

A current sensor **24** detects a current flowing into motor generator MG1 as a motor current value MCRT1, and outputs motor current value MCRT1 to control device **30**.

Inverter **22** is connected to power supply line PL2 and ground line SL2 in parallel with inverter **14**. Inverter **22** converts the DC voltages output from boost converters **12A** and **12B** into three-phase AC voltages, and outputs the three-phase AC voltages to motor generator MG2 driving wheels **2**. Inverter **22** also returns electric power generated in motor generator MG2 by regenerative braking, to boost converters **12A** and **12B**. On this occasion, boost converters **12A** and **12B** are controlled by control device **30** to operate as step-down circuits.

A current sensor **25** detects a current flowing into motor generator **MG2** as a motor current value **MCRT2**, and outputs motor current value **MCRT2** to control device **30**.

Control device **30** receives torque command values and rotation speeds of motor generators **MG1** and **MG2**, values of voltages **VBA**, **VBB1**, **VBB2**, **VLA**, **VLB**, and **VH**, motor current values **MCRT1** and **MCRT2**, and an activation signal **IGON**. Then, control device **30** outputs to boost converter **12B** a control signal **PWUB** giving an instruction to boost a voltage, a control signal **PWDB** giving an instruction to step down a voltage, and a shut-down signal giving an instruction to prohibit operation.

Further, control device **30** outputs to inverter **14** a control signal **PWMI1** giving a drive instruction to convert the DC voltages output from boost converters **12A** and **12B** into AC voltages for driving motor generator **MG1**, and a control signal **PWMC1** giving a regenerative instruction to convert an AC voltage generated in motor generator **MG1** into a DC voltage and return the DC voltage to boost converters **12A** and **12B**.

Similarly, control device **30** outputs to inverter **22** a control signal **PWMI2** giving a drive instruction to convert the DC voltages into AC voltages for driving motor generator **MG2**, and a control signal **PWMC2** giving a regenerative instruction to convert an AC voltage generated in motor generator **MG2** into a DC voltage and return the DC voltage to boost converters **12A** and **12B**.

Control device **30** includes a memory **32** storing various maps for controlling inverters **14** and **22** and boost converters **12A** and **12B**, and the like.

FIG. 2 is a circuit diagram showing a detailed configuration of inverters **14** and **22** of FIG. 1.

Referring to FIGS. 1 and 2, inverter **14** includes a U-phase arm **15**, a V-phase arm **16**, and a W-phase arm **17**. U-phase arm **15**, V-phase arm **16**, and W-phase arm **17** are connected in parallel between power supply line **PL2** and ground line **SL2**.

U-phase arm **15** includes IGBT (Insulated Gate Bipolar Transistor) elements **Q3** and **Q4** connected in series between power supply line **PL2** and ground line **SL2**, and diodes **D3** and **D4** connected in parallel with IGBT elements **Q3** and **Q4**, respectively. A cathode of diode **D3** is connected with a collector of IGBT element **Q3**, and an anode of diode **D3** is connected with an emitter of IGBT element **Q3**. A cathode of diode **D4** is connected with a collector of IGBT element **Q4**, and an anode of diode **D4** is connected with an emitter of IGBT element **Q4**.

V-phase arm **16** includes IGBT elements **Q5** and **Q6** connected in series between power supply line **PL2** and ground line **SL2**, and diodes **D5** and **D6** connected in parallel with IGBT elements **Q5** and **Q6**, respectively. A cathode of diode **D5** is connected with a collector of IGBT element **Q5**, and an anode of diode **D5** is connected with an emitter of IGBT element **Q5**. A cathode of diode **D6** is connected with a collector of IGBT element **Q6**, and an anode of diode **D6** is connected with an emitter of IGBT element **Q6**.

W-phase arm **17** includes IGBT elements **Q7** and **Q8** connected in series between power supply line **PL2** and ground line **SL2**, and diodes **D7** and **D8** connected in parallel with IGBT elements **Q7** and **Q8**, respectively. A cathode of diode **D7** is connected with a collector of IGBT element **Q7**, and an anode of diode **D7** is connected with an emitter of IGBT element **Q7**. A cathode of diode **D8** is connected with a collector of IGBT element **Q8**, and an anode of diode **D8** is connected with an emitter of IGBT element **Q8**.

Intermediate points of the respective phase arms are connected to phase ends of respective phase coils of motor generator **MG1**. Specifically, motor generator **MG1** is a three-phase permanent magnet synchronous motor, and one ends of three U-, V- and W-phase coils are connected together to the neutral point. The other end of the U-phase coil is connected to a line **UL** drawn from a connection node between IGBT elements **Q3** and **Q4**. The other end of the V-phase coil is connected to a line **VL** drawn from a connection node between IGBT elements **Q5** and **Q6**. The other end of the W-phase coil is connected to a line **WL** drawn from a connection node between IGBT elements **Q7** and **Q8**.

Although inverter **22** of FIG. 1 is different from inverter **14** in that it is connected to motor generator **MG2**, its internal circuit configuration is the same as that of inverter **14**, and thus the detailed description thereof will not be repeated. Further, although FIG. 2 shows that control signals **PWMI** and **PWMC** are supplied to the inverter, this illustration is given so as not to make the description complicated, and, as shown in FIG. 1, control signals **PWMI1** and **PWMC1** are supplied to inverter **14**, and control signals **PWMI2** and **PWMC2** are supplied to inverter **22**.

FIG. 3 is a circuit diagram showing a detailed configuration of boost converters **12A** and **12B** of FIG. 1.

Referring to FIGS. 1 and 3, boost converter **12A** includes a reactor **L1** having one end connected to power supply line **PL1A**, IGBT elements **Q1** and **Q2** connected in series between power supply line **PL2** and ground line **SL2**, and diodes **D1** and **D2** connected in parallel with IGBT elements **Q1** and **Q2**, respectively.

The other end of reactor **L1** is connected to an emitter of IGBT element **Q1** and a collector of IGBT element **Q2**. A cathode of diode **D1** is connected with a collector of IGBT element **Q1**, and an anode of diode **D1** is connected with the emitter of IGBT element **Q1**. A cathode of diode **D2** is connected with the collector of IGBT element **Q2**, and an anode of diode **D2** is connected with an emitter of IGBT element **Q2**.

Although boost converter **12B** of FIG. 1 is different from boost converter **12A** in that it is connected to power supply line **PL1B** instead of power supply line **PL1A**, its internal circuit configuration is the same as that of boost converter **12A**, and thus the detailed description thereof will not be repeated. Further, although FIG. 3 shows that control signals **PWU** and **PWD** are supplied to the boost converter, this illustration is given so as not to make the description complicated, and, as shown in FIG. 1, control signals **PWUA** and **PWDA** are supplied to inverter **14**, and control signals **PWUB** and **PWDB** are supplied to inverter **22**.

[Power Supply Device Capable of being Equipped with Sub Battery]

Referring to FIG. 1 again, a power supply device for a vehicle in an embodiment of the present application is a power supply device for a vehicle that is chargeable from external power supply **90** provided external to vehicle **1**, including main battery **BA** and battery pack **39** that is attachable to and detachable from the vehicle. Battery pack **39** includes sub battery **BB1** for driving electric loads (inverters **14** and **22**) common to main battery **BA** and sub battery **BB1**, and connector **52** provided with a projection (pin) having a shape corresponding to information related to sub battery **BB1**. The power supply device for the vehicle further includes control device **30** performing control related to main battery **BA**, and detecting information from the shape of the connector and performing control related to sub battery **BB1**.

The information detected from the shape of the connector includes, for example, the capacity of sub battery BB1. When there is a change in the capacity of the sub battery, control device 30 can perform appropriate control according to the change. It is to be noted that the power storage capacity of the main battery is not necessarily greater than that of the sub battery. A sub battery having a capacity greater than that of the main battery may be connected. Further, the sub battery may be used preferentially to the main battery.

Preferably, the power supply device for the vehicle further includes connector 52 for connecting battery pack 39. Battery pack 39 further includes boost converter 12B serving as a voltage conversion circuit converting a power supply voltage of sub battery BB1 based on a control signal supplied from control device 30 via the connector.

By incorporating boost converter 12B into battery pack 39, independent charge/discharge control can be performed on main battery BA and sub battery BB1 even when they have different voltages.

As a method for matching the voltages, the voltage of sub battery BB1 may be matched to the voltage of main battery BA by boost converter 12B, or conversely, the voltage of main battery BA may be matched to the voltage of sub battery BB1 by boost converter 12A.

Further, boost converter 12A may be eliminated, and the voltage of sub battery BB1 may be matched to the voltage of main battery BA by boost converter 12B. In this case, the number of cells may be set and charge/discharge management may be performed such that the power supply voltage of sub battery BB1 is lower than a power supply voltage of main battery BA. Conversely, boost converter 12B may be eliminated, and the voltage of main battery BA may be matched to the voltage of sub battery BB1 by boost converter 12A. In this case, the number of cells may be set and charge/discharge management may be performed such that the power supply voltage of main battery BA is lower than the power supply voltage of sub battery BB1.

Preferably, the power supply device for the vehicle further includes a charging device for charging main battery BA and sub battery BB1 by external power supply 90. The charging device is configured of inverters 14 and 22 and the stator coils of motor generators MG1 and MG2.

First Embodiment

FIG. 4 shows a structure of a connector provided between a vehicle and a battery pack used in a first embodiment.

Referring to FIG. 4, connector 52 is a combination of a connector member 102 connected to a vehicle side (inverter side) and a connector member 112 connected to a battery pack side.

Connector member 112 includes power cables 116 and 120 connected to the battery, plug pieces 114 and 118 connected to power cables 116 and 120, respectively, and an insulating cover. Plug piece 114 is a positive terminal, and plug piece 118 is a negative terminal.

Connector member 102 includes power cables 106 and 110 connected to the inverters of the vehicle, insertion fittings 104 and 108 connected to power cables 106 and 110, respectively, and an insulating cover. Plug piece 114 is inserted into insertion fitting 104, and plug piece 118 is inserted into insertion fitting 108. Since the insulating covers are provided, an operator is prevented from touching the plug piece.

FIG. 5 shows a connector member 102A provided with a switch for determining a battery type.

FIG. 6 is a view of connector member 102A shown in FIG. 5 as seen from a direction of a plug insertion surface.

Referring to FIGS. 5 and 6, connector member 102A provided with a battery type determining switch 122 is shown as an example of connector member 102. Switch 122 is provided, for example, inside each of three pin insertion ports 122A, 122B, and 122C. The connector member connected to a battery side is provided with a pin at a position corresponding to a battery type. When there is a pin, switch 122 is pushed by the pin and set to an ON state. When there is no pin, switch 122 is set to an OFF state.

FIG. 7 shows an OFF state of switch 122.

FIG. 8 shows an ON state of switch 122.

Referring to FIGS. 7 and 8, switch 122 includes a resistor 126 for coupling a line transmitting a signal to a control device such as an ECU to a positive voltage of 5 V or 14 V, and a movable piece 128. When no pin is inserted into pin insertion ports 122A, 122B, and 122C, piece 128 is opened, and thus a voltage at an H (logical high) level is supplied to the control device such as an ECU. When a pin is inserted into any of pin insertion ports 122A, 122B, and 122C, piece 128 of switch 122 inside the insertion port into which the pin is inserted is closed, and thus a signal at an L (logical low) level is transmitted to the control device.

In a case where there are three insertion ports, the cube of 2, that is, 8 states can be indicated. Therefore, by indicating the capacity of a currently connected battery pack with the position of the pin, the control device on the vehicle side can determine the capacity.

FIG. 9 is a view for illustrating battery pack types.

Referring to FIG. 9, a battery pack with a large capacity and a battery pack with a small capacity are prepared as options. It is necessary to choose either one of a large capacity battery pack 130 and a small capacity battery pack 132 and connect it to connector 52. Alternatively, a choice not to connect any battery pack may be made. Pins are provided to battery pack 130 and battery pack 132 at different positions. If the relation between the positions of the pins and the capacities is set beforehand, the capacity of a battery pack can be determined by observing ON/OFF of switch 122 and thereby recognizing a pin position by the control device on the vehicle side.

In the first embodiment, a shape provided to the battery-pack-side member of the connector for connecting a battery pack indicates information such as the capacity of the battery pack. Vehicle-side member 102A of the connector is provided with detection switch 122 serving as a detection unit for detecting the shape.

FIG. 10 shows an example of capacity increase and decrease in a case where there is one type of battery pack.

Referring to FIG. 10, a plurality of connectors 52-1 to 52-n connected to the inverters are provided on the vehicle side. Add-on unit battery packs 142-1, 142-2, . . . in a required number are connected to the connectors at a sales office or a service factory.

The control device on the vehicle side can detect the number of the connected battery packs by connection detection switches 122 provided to the connectors, and thereby can determine total battery capacity.

FIG. 11 is a flowchart for illustrating control associated with connection of an additional battery pack performed by control device 30. Processing in the flowchart is, for example, invoked from a main routine and performed when the vehicle's system is started.

Referring to FIG. 11, firstly, when the processing is started, control device 30 determines in step S1 whether or not an additional battery pack is connected. If detection

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switch **122** of connector **52** is in an ON state, it is determined that connection is established. If switches **122** are all in an OFF state, it is determined that no connection is established.

When it is determined in step **S1** that there is no additional battery, the processing proceeds to step **S4**, and the control is transferred to the main routine without special change in the control. In this case, a standard map among a plurality of maps stored in memory **32** of FIG. **1** is applied as is. On the other hand, when it is determined that there is an additional battery, the processing proceeds to step **S2**.

In step **S2**, battery capacity is detected. In the technique of changing the capacity of a battery pack as illustrated in FIG. **9**, the capacity can be detected by confirming into which port among pin insertion ports **122A** to **122C** of FIG. **6** a pin is inserted. In the technique of changing the number of battery packs as illustrated in FIG. **10**, the number of connected battery packs can be determined from the number of switches **122** respectively provided to connectors **52-1** to **52-n** that are in an ON state. Therefore, the battery capacity can be detected by multiplying the number by add-on unit battery capacity.

When the processing in step **S2** is terminated, the processing in step **S3** is then performed. In step **S3**, a control constant used by control device **30** for controlling a hybrid system is changed. The control constant is changed, for example, by switching the plurality of maps in memory **32** of FIG. **1** according to the battery capacity. Examples of the maps include an engine start map defining a threshold for starting the engine with respect to a required output power value, a map defining the maximum electric power *Wout* that can be output from the batteries or the maximum electric power *Win* that can be charged in the batteries, a boost control map for the boost converters, and a control map for a battery cooling device.

FIG. **12** is a view for illustrating switching of maps of engine start thresholds as an example of the control constant.

Referring to FIG. **12**, a map A is a map in a case where the battery capacity is increased, and a map B is a standard map used when the battery capacity is not increased. The more the battery capacity is, the more the battery can supply electric power to a motor. Therefore, even when an accelerator pedal is pressed down and the required output power value is increased, if there is an add-on battery, required power can be output to an axle only by the motor without starting the engine.

More specifically, in a case where battery SOC (State Of Charge) is 0 to 40%, if no battery is added, the engine is started when an output power of 5 kW is required, as shown in map B. On the other hand, if a battery is added, the engine is started when an output power of 10 kW is required, as shown in map A.

In a case where the battery SOC is 60%, if no battery is added, the engine is started when an output power of 10 kW is required, as shown in map B. On the other hand, if a battery is added, the engine is started when an output power of 20 kW is required, as shown in map A.

In a case where the battery SOC is 80%, if no battery is added, the engine is started when an output power of 15 kW is required, as shown in map B. On the other hand, if a battery is added, the engine is started when an output power of 30 kW is required, as shown in map A.

In a case where the battery SOC is 100%, if no battery is added, the engine is started when an output power of 20 kW is required, as shown in map B. On the other hand, if a battery is added, the engine is started when an output power of 40 kW is required, as shown in map A. In other words, if a battery is added and the SOC is 100%, the vehicle can

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travel only by the motor, with the engine stopped, until when the required output power value reaches 40 kW.

As described above, an increase in battery capacity causes an increase in outputtable power, expanding a range in which the engine need not be started.

Further, since the SOC for starting the engine is also changed, the travel distance that can be achieved with the engine stopped can be extended appropriately according to addition of a battery pack. Furthermore, in the hybrid vehicle, the engine is started by rotating motor generator **MG1** using electric power of the batteries, and when the number of battery packs is decreased, the SOC for starting the engine to start charging is also changed, preventing the battery from discharging excessively and disabling engine start.

It is to be noted that the maps shown in FIG. **12** are modeled and simplified, and they are actually adapted through vehicle travel experiments. Further, as to *Win* and *Wout*, maps defined for temperature or the SOC are switched according to the battery capacity.

Specifically, preferably, control device **30** performs processing related to main battery **BA** and sub battery **BB1** based on a prescribed control constant. Then, control device **30** changes the prescribed control constant based on information read from a pin position in the connector corresponding to a storage unit storing information.

Although the first embodiment illustrates an example in which control device **30** on the vehicle side automatically reads information of a battery pack and changes the control constant according to the information, there may be a case where control device **30** does not necessarily automatically perform reading the information. For example, control device **30** may be configured such that it is provided with a write terminal to allow the control constant to be rewritten, and when a battery pack is added, removed, or exchanged, the control constant on memory **32** of control device **30** is rewritten from the write terminal.

As has been described above, in the first embodiment, on-vehicle equipment is controlled under control conditions suitable for a mounted battery pack. For example, by appropriately controlling the inverters and boost converters serving as the on-vehicle equipment, charge and discharge of the batteries including the base battery and the optional battery can be satisfactorily performed.

Second Embodiment

FIG. **13** shows connection between a vehicle and a battery pack in a second embodiment.

Referring to FIG. **13**, a vehicle **150A** and a battery pack **39A** are connected by connector **52**. In addition to a connection unit for power cables **106** and **110** as shown in FIG. **4**, connector **52** is provided with a connection unit for a communication line for performing control communication such as CAN (Controller Area Network) communication. It is not always necessary to integrate a connector for the communication line with a connector for the power cables, and they may be provided as separate connectors.

Battery pack **39A** includes sub battery **BB1**, boost converter **12B** boosting the voltage of sub battery **BB1**, a battery pack control unit **156** controlling boost converter **12B**, and a memory **158** and a communication interface **154** connected to battery pack control unit **156**. Boost converter **12B** is connected to power supply line **PL2** and ground line **SL2** on the vehicle side via connector **52**.

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In addition to the configuration of vehicle 1 as shown in FIG. 1, vehicle 150A further includes a communication interface 152 for performing communication with battery pack 39A.

Memory 158 stores information related to battery pack 39A. The information includes, for example, the capacity of sub battery BB1. Memory 158 may store a type (a lithium ion battery, a nickel hydride battery, or the like), the date of manufacture, a manufacturer, and the like of the battery.

Battery pack control unit 156 reads information on the capacity of battery pack 39A from memory 158, and transmits the information to control device 30 via communication interfaces 154 and 152. Control device 30 switches the control constant, various maps, and the like for driving the vehicle, taking the capacity of battery pack 39A into consideration. Switching of the maps may be performed by selecting a suitable map among a plurality of maps held in control device 30, or performing rewrite processing by reflecting map data held in memory 158 in a map stored in control device 30.

FIG. 14 shows a modification of a configuration shown in FIG. 13.

While the power cables and the communication line are provided separately in FIG. 13, a PLC (Power Line Communications) interface superimposing communication information on a power cable is employed in FIG. 14, and thus an extra communication line is not required.

Battery pack 39B includes sub battery BB1, boost converter 12B boosting the voltage of sub battery BB1, a battery pack control unit 166 controlling boost converter 12B, and a memory 168 and a PLC communication interface 164 connected to battery pack control unit 166. Boost converter 12B is connected to power supply line PL2 and ground line SL2 on the vehicle side via connector 52.

In addition to the configuration of vehicle 1 as shown in FIG. 1, a vehicle 150B further includes a PLC communication interface 162 for performing communication with battery pack 39B.

Memory 168 stores information related to battery pack 39B. The information includes, for example, the capacity of sub battery BB1.

Battery pack control unit 166 reads information on the capacity of battery pack 39B from memory 168, and transmits the information to control device 30 via PLC communication interfaces 164 and 162 and the power cables. Control device 30 switches the control constant, various maps, and the like for driving the vehicle, taking the capacity of battery pack 39B into consideration.

FIG. 15 is a flowchart for illustrating control associated with connection of an additional battery pack performed by control device 30 in the second embodiment. Processing in the flowchart is, for example, invoked from a main routine and performed when the vehicle's system is started.

Referring to FIG. 15, firstly, when the processing is started, control device 30 determines in step S11 whether or not an additional battery pack is connected. If detection switch 122 of connector 52 is in an ON state, it is determined that connection is established. If switches 122 are in an OFF state, it is determined that no connection is established.

When it is determined in step S11 that there is no additional battery, the processing proceeds to step S15, and the control is transferred to the main routine without special change in the control. When it is determined that there is an additional battery, the processing proceeds to step S12.

In step S12, it is determined whether or not communication with the additional battery pack can be performed. When the communication can be performed, the communi-

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cation allows information such as the capacity of the sub battery to be read from the memory in the battery pack.

When the communication can be performed in step S12, the processing proceeds to step S13. In step S13, a control constant used by control device 30 for controlling a hybrid system is changed. The control constant can be changed, for example, by switching an engine start map defining a threshold for starting the engine with respect to a required output power value, a map defining the maximum electric power Wout that can be output from the batteries or the maximum electric power Win that can be charged in the batteries, and the like, according to the battery capacity.

On the other hand, when the communication is not established in step S12, the processing proceeds to step S14. Examples of cases where the communication is not established include a case where a non-standard battery pack that is not expected to be connected (for example, a battery pack that is not a genuine product, or a battery pack for which it is unknown whether it satisfies the standard) is connected. In that case, since it is unknown how to change the control constant appropriately, it is determined that a failure has occurred, and operation of the vehicle is prohibited to prevent abnormal discharge and the like.

Specifically, preferably, control device 30 determines whether or not battery pack 39A or 39B is an authorized product based on the information read from memory 158 or 168 serving as a storage unit.

When a battery pack that is not an authorized product is mounted, for example, the operation of the vehicle is prohibited. Thereby, a malfunction such as abnormal charge and discharge can be avoided. Alternatively, the vehicle may be operated by electrically disconnecting an unauthorized battery pack and using only an authorized battery pack. This can ensure the operation of the vehicle in a case where a user connects a battery pack to his/her purchased vehicle without recognizing that the battery pack is not an authorized product.

The configuration described above makes unauthorized modification difficult, when compared with a case where only the shape of the connector is used for determination. Specifically, although the connector can be easily copied, it is difficult to perform copying with the contents of the memory included. Therefore, the configuration described above prevents an unauthorized battery pack from being mounted and causing a malfunction.

When the processing in step S13 or S14 is terminated, the control is transferred to the main routine in step S15.

As has been described above, also in the second embodiment, on-vehicle equipment is controlled under control conditions suitable for a mounted battery pack, as in the first embodiment.

Third Embodiment

A battery generates heat when it charges or discharges a current. In addition, a battery may have a high temperature when it is left under the scorching sun for a long time in summer or the like. It is desirable to cool a battery for use in order not to decrease the battery's life.

However, when the amount of mounted batteries is changed, the amount of heat generated from the batteries is also changed. Therefore, it is necessary to change cooling capability according to the amount of mounted batteries.

FIG. 16 is a block diagram for illustrating a cooling device in a third embodiment.

In a configuration shown in FIG. 16, a cooling device 200 is added to the configuration shown in FIG. 13. Since the

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components other than cooling device 200 have been described in FIG. 13, the description thereof will not be repeated.

Cooling device 200 is provided on the vehicle side to cool battery pack 39A. Cooling device 200 may be the one also cooling battery BA serving as a base battery, in addition to battery pack 39A.

In a case where cooling device 200 is provided exclusively for battery pack 39A, when control device 30 of the vehicle detects that battery pack 39A has been mounted by the communication with battery pack control unit 156, control device 30 sets cooling device 200 to be operable. When control device 30 detects an increase in temperature of battery BB1 by a temperature sensor not shown or the like, control device 30 causes cooling device 200 to start cooling battery pack 39A by rotating a fan and circulating cooling water.

In a case where cooling device 200 is provided in common for the base battery and battery pack 39A, when control device 30 of the vehicle detects that battery pack 39A has been mounted by the communication with battery pack control unit 156, control device 30 increases cooling capability of cooling device 200. When battery pack 39A is mounted, control device 30 increases the rotation speed of the fan and increases the amount of circulated cooling water, when compared to a case where battery pack 39A is not mounted.

Herein, in a case where a battery cooling device and an ECU controlling the same are provided separately from a battery pack as shown in FIG. 16, battery cooling performance may vary, and vehicle performance such as the travel distance that can be achieved by batteries only may be degraded.

FIG. 17 shows a modification of the configuration of the battery pack used in the third embodiment.

Referring to FIG. 17, a plurality of battery packs 202-1 to 202-n are connected to power supply line PL2 and ground line SL2 via a system main relay SMR. Conductive/non-conductive states of system main relay SMR are controlled by the control device on the vehicle side.

Battery pack 202-1 includes connector 52, boost converter 12B, sub battery BB1, a temperature sensor 204, a fan control unit 206, and an air blowing fan 208.

Temperature sensor 204 measures a temperature of sub battery BB1. When a battery temperature detected by temperature sensor 204 is higher than a prescribed value, fan control unit 206 rotates fan 208 and adjusts the temperature to prevent an excessive increase in the battery temperature. Specifically, temperature sensor 204, fan control unit 206, and fan 208 correspond to a temperature adjustment device included in battery pack 202-1.

Other battery pack 202-n also has the same configuration as that of battery pack 202-1, and the description thereof will not be repeated.

In the third embodiment, a temperature adjustment device including a fan and the like is provided for each battery pack. Therefore, even when there is a change in the number or shape of battery packs, a sub battery incorporated into a battery pack can be kept at an appropriate temperature without the need for taking special consideration. In other words, since a cooling device and a control unit therefor are incorporated into a battery pack, and cooling control (from temperature measurement to fan control) is completed in the battery pack, degradation in battery cooling performance caused when a battery pack is added and resultant degradation in travel performance can be prevented.

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Finally, an on-vehicle equipment control system disclosed in the present embodiment will be summarized. Referring to FIGS. 1, 13, and 14, an on-vehicle equipment control system includes battery pack 39A, 39B configured to be attachable to and detachable from a vehicle and including a storage unit (memory 158, 168) storing information, and control device 30 controlling on-vehicle equipment based on the information stored in the storage unit when the battery pack is connected to the vehicle, and controlling the on-vehicle equipment based on information other than the information stored in the storage unit when the battery pack is not connected to the vehicle.

As shown in FIG. 16, preferably, the on-vehicle equipment control system further includes cooling device 200 cooling battery pack 39A. Control device 30 controls cooling device 200 based on the information stored in the storage unit (memory 158).

As shown in FIGS. 1 and 13, preferably, the on-vehicle equipment control system further includes first battery BA supplying electric power to the on-vehicle equipment. Battery pack 39 further includes second battery BB1 supplying electric power to the on-vehicle equipment. Control device 30 causes inverters 14, 22, boost converters 12A, 12B, and the like serving as the on-vehicle equipment to perform control related to the first battery BA and control related to the second battery BB1 based on the information stored in the storage unit (memory 158).

Preferably, the controls related to the first and second batteries include charge and discharge control, and control device 30 controls charge and discharge of the battery pack based on the information stored in the storage unit.

As shown in FIGS. 1 and 5, an on-vehicle equipment control system in accordance with another aspect of the present invention includes battery pack 39 having a connection unit (connector 52) for attachably and detachably connecting to a vehicle, a shape detection unit (switch 122) provided to the vehicle for detecting a shape of the connection unit, and control device 30 controlling on-vehicle equipment based on a detection result of the shape detection unit.

It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

The invention claimed is:

1. A vehicle, comprising:

a driving device driving said vehicle using electric power;
a control device controlling said driving device;
a first battery supplying electric power to said driving device; and

a battery pack, said battery pack including,

a second battery used in addition to said first battery for supplying electric power to said driving device,
a communication device performing communication with said control device;

said control device allowing said driving device to drive the vehicle in response to communication to said communication device being successfully established while said battery pack is connected to said vehicle, and prohibiting said driving device from driving the vehicle or restricting power from the second battery in response to communication to said communication device not being established while said battery pack is connected to said vehicle.

2. The vehicle according to claim 1, wherein
the control device makes a determination as to whether or
not the battery pack is authorized,
the control device allows said driving device to drive the
vehicle in response to the determination indicating the 5
battery pack is authorized, and
the control device prohibits said driving device from
driving the vehicle or restricts power from the second
battery in response to the determination indicating the
battery pack is unauthorized. 10

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