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(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI KAISHA** [JP/JP]; 1, Toyota-cho, Toyota-shi, Aichi-ken, 471-71 (JP).

(72) Inventors: **ONO, Tomoya**; c/o TOYOTA JIDOSHA KABUSHIKI KAISHA, of 1, Toyota-cho, Toyota-shi, Aichi-ken, 471-8571 (JP). **KINOMURA, Shigeki**; c/o TOYOTA JIDOSHA KABUSHIKI KAISHA, of 1, Toyota-cho, Toyota-shi, Aichi-ken, 471-8571 (JP). **TONEGAWA, Hiromi**; c/o Toyota Housing Corporation, of 22 go 23 ban 1 chone Izume, Higashi-ku Nagoya-shi, Aichi-ken 461-001 (JP).

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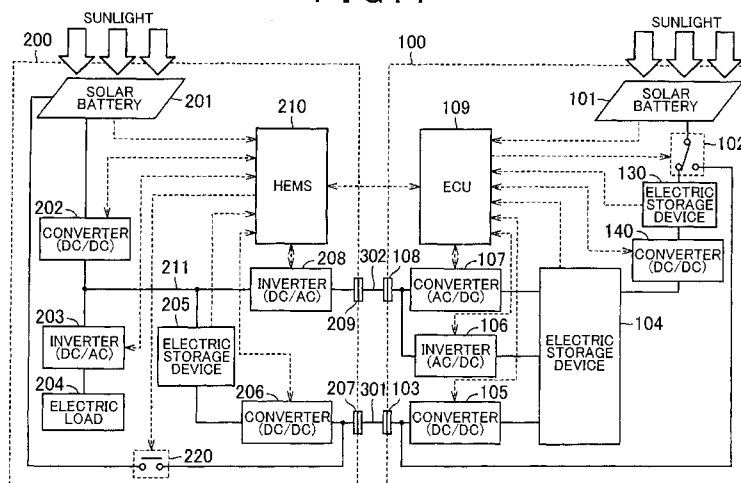
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FIG. 1



(57) Abstract: A vehicle supplies an electric power to an electric power system outside of the vehicle. The vehicle is equipped with an electric power generation device, an electric storage device, an output unit, and a switching device. The electric storage device stores an electric power generated by the electric power generation device. The output unit outputs an electric power to the electric power system. The switching device switches a first electric power transmission path to a second electric power transmission path. The first electric power transmission path transmits the generated electric power to the electric storage device. The second electric power transmission path transmits the generated electric power to the output unit without the intermediary of the electric storage device.

VEHICLE AND METHOD OF SUPPLYING ELECTRIC POWER TO ELECTRIC POWER SYSTEM OUTSIDE VEHICLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This invention relates to a vehicle, and more particularly, to a vehicle that supplies an electric power to an electric power system outside of the vehicle.

2. Description of Related Art

[0002] Japanese Patent Application Publication No. 2011-229220 (JP-2011-229220 A) discloses a vehicle that is mounted with a solar battery. The electric power generated by the solar battery fluctuates depending on the solar radiation intensity, the operating temperature of the solar battery, or the like. Thus, in the vehicle, the electric power generated by the solar battery is stored into an electric storage device via a transformer, and the electric power stored in the electric storage device is utilized (see Japanese Patent Application Publication No. 2011-229220 (JP-2011-229220 A)).

SUMMARY OF THE INVENTION

[0003] In the foregoing vehicle, it is conceivable to supply the electric power generated by the solar battery to the electric power system outside of the vehicle. In this case, the electric storage device is temporarily charged with the electric power generated by the solar battery. Thus, the electric power is lost as a result of charge/discharge of the electric storage device.

[0004] Therefore, this invention provides a vehicle that suppresses the loss of an electric power when the electric power is supplied from the vehicle to an electric power system outside of the vehicle.

[0005] According to a first aspect of this invention, a vehicle supplies an electric power to an electric power system outside of the vehicle. The vehicle is equipped with an electric power generation device, an electric storage device, an output unit, and a switching device. The electric storage device stores an electric power generated by the electric

power generation device. The output unit outputs an electric power to the electric power system. The switching device switches a first electric power transmission path to a second electric power transmission path. The first electric power transmission path transmits the generated electric power to the electric storage device. The second electric power transmission path transmits the generated electric power to the output unit without an intermediary of the electric storage device.

[0006] In the foregoing aspect of the invention, the switching device may switch the first electric power transmission path to the second electric power transmission path when a state quantity of the electric storage device becomes larger than a predetermined charge amount. The state quantity indicates a state of charge of the electric storage device.

[0007] In the foregoing aspect of the invention, the switching device may switch the first electric power transmission path to the second electric power transmission path when an amount of the electric power generated by the electric power generation device becomes larger than a predetermined electric power generation amount.

[0008] In the foregoing aspect of the invention, the vehicle may be further equipped with a converter. The converter may be provided in the first electric power transmission path, and may be electrically connected to the electric storage device.

[0009] In the foregoing aspect of the invention, the electric power generation device may include a first solar battery. Besides, the electric power system may include a second solar battery. The switching device may switch the first electric power transmission path to the second electric power transmission path when an amount of an electric power generated by the second solar battery becomes larger than a predetermined amount.

[0010] In the foregoing aspect of the invention, the vehicle supplies an electric power to the electric power system for a household electric storage device and a household electric load.

[0011] Besides, in the foregoing aspect of the invention, the vehicle may have a method of supplying an electric power to an electric power system outside of the vehicle.

The method is a method of switching the first electric power transmission path to the second electric power transmission path.

[0012] In the foregoing aspect of the invention, the switching device is configured to switch first electric power transmission path to the second electric power transmission path. The first electric power transmission path transmits the electric power generated by the electric power generation device to the electric storage device. The second electric power transmission path transmits the electric power generated by the electric power generation device to the output unit without the intermediary of the electric storage device. In consequence, the electric power generated by the electric power generation device is supplied to the electric power system outside or the vehicle via the second electric power transmission path. Thus, the electric power can be prevented from being lost as a result of charge/discharge of the electric storage device. Accordingly, the foregoing aspect of the invention makes it possible to suppress the loss of the electric power when the electric power is supplied from the vehicle to the electric power system outside of the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a general block diagram of a vehicle and a house according to the first embodiment of the invention;

FIG. 2 is a view showing an electric power transmission path of an electric power generated by a solar battery of the vehicle shown in FIG. 1;

FIG. 3 is a view showing an electric power transmission path of the electric power generated by the solar battery of the vehicle shown in FIG. 1;

FIG. 4 is a flowchart for explaining a processing that is performed in the vehicle and the house shown in FIG. 1; and

FIG. 5 is a flowchart for explaining a processing that is performed in a vehicle and a house according to the second embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0014] The embodiments of the invention will be described in detail hereinafter with reference to the drawings. Like or equivalent components in the drawings are denoted by the same reference symbols respectively, and the description thereof will not be repeated. Incidentally, the "DC" and "AC" in the description mean "direct current" and "alternating current" respectively.

[0015] FIG. 1 is a general block diagram of a vehicle and a house according to the first embodiment of the invention. First of all, the vehicle will be described.

[0016] Referring to FIG. 1, a vehicle 100 is equipped with a solar battery 101, a relay 102, electric storage devices 104 and 130, a converter 140, and a control device (hereinafter referred to also as an electronic control unit (an ECU)) 109.

[0017] The solar battery 101 generates a DC electric power through sunlight. An output terminal of the solar battery 101 is connected to a first terminal of the relay 102. The solar battery 101 includes a wattmeter to detect an amount of an electric power generated by the solar battery 101. The solar battery 101 outputs a signal indicating the detected amount of the generated electric power to the ECU 109.

[0018] The electric storage devices 104 and 130 are electric power storage elements that are configured in a chargeable/dischargeable manner. The electric storage devices 104 and 130 are configured to include cells of electric storage elements. The cells of the electric storage cells are, for example, secondary batteries such as lithium-ion batteries, nickel hydrate batteries, lead storage batteries or the like, or electric double-layer capacitors or the like. The electric storage device 130 is connected to a second terminal of the relay 102. The electric storage device 130 is configured to output a voltage lower than a voltage generated by the solar battery 101. Owing to this configuration, the electric power generated by the solar battery 101 can be stored into the electric storage device 130 without carrying out electric power conversion. On the other hand, the electric storage device 104 is configured to output a voltage higher than an output voltage of the electric storage device 130. The electric storage device 104 thus configured

supplies an electric power to electrical machines that are mounted on the vehicle 100.

[0019] The electric storage devices 104 and 130 include protection circuits respectively. The protection circuits are endowed with functions of monitoring states of charge (SOC's) of the electric storage devices 104 and 130 to prevent overcharge or overdischarge thereof respectively. Besides, the SOC's of the electric storage devices 104 and 130 and collateral information thereon, are obtained by monitoring the protection circuits respectively. The electric storage devices 104 and 103 are configured to be able to transmit the foregoing collateral information to the ECU 109. The collateral information is information or the like indicating, for example, the possibility of being charged or the impossibility of being charged.

[0020] The converter 140 is provided between the electric storage device 130 and the electric storage device 104. The converter 140 boosts an output voltage of the electric storage device 130 and outputs the boosted output voltage to the electric storage device 104, on the basis of a control signal from the ECU 109. Thus, the electric storage device 104 can be charged using the electric power stored in the electric storage device 130.

[0021] When the SOC of the electric storage device 130 rises due to an electric power generated by the solar battery 101, the ECU 109 operates the converter 140. Besides, when the SOC of the electric storage device 130 falls as a result of charge of the electric storage device 104, the ECU 109 stops the converter 140. The converter 140 can be intermittently operated through this operation and stoppage of the converter 140. By intermittently operating the converter 140 in this manner, the electric storage device 104 can be charged at a higher voltage in a short time. Accordingly, the electric power consumption for operating the converter 140 is suppressed, so that the charge efficiency can be enhanced.

[0022] The vehicle 100 is further equipped with a connection terminal 108, an inverter 106, and a converter 107. This is a configuration for giving and receiving an AC electric power between the vehicle 100 and a house 200.

[0023] The connection terminal 108 is a connection terminal for inputting/outputting an AC electric power thereinto/therefrom. One connector of an

electric power cable 302 is connected to the connection terminal 108. The other connector of the electric power cable 302 is connected to a connection terminal 209 of the house 200.

[0024] The inverter 106 is a bidirectional inverter that is provided between the electric storage device 104 and the connection terminal 108. The inverter 106 converts a DC electric power from the electric storage device 104 into an AC electric power on the basis of a control signal from the ECU 109. The AC electric power obtained through conversion is output to the connection terminal 108. The inverter 106 functions as a discharger that discharges the electric power stored in the electric storage device 104 to the outside of the vehicle.

[0025] The converter 107 is a bidirectional converter that is provided between the electric storage device 104 and the connection terminal 108. The converter 107 converts an AC electric power into a DC electric power on the basis of a control signal from the ECU 109. The AC electric power is input from the house 200 via the connection terminal 108. The DC electric power obtained through conversion of the AC electric power is output to the electric storage device 104. The converter 107 functions as a charger that charges the electric storage device 104 through an electric power input from outside the vehicle.

[0026] Incidentally, in this first embodiment of the invention, the inverter 106 and the converter 107 are provided in parallel between the connection terminal 108 and the electric storage device 104. However, it is also acceptable to adopt a configuration in which a bidirectional inverter is provided between the connection terminal 108 and the electric storage device 104 instead of the inverter 106 and the converter 107.

[0027] The vehicle 100 is further equipped with a connection terminal 103 and a converter 105. This is a configuration for giving and receiving a DC electric power between the vehicle 100 and the house 200.

[0028] The connection terminal 103 is a connection terminal for inputting/outputting a DC electric power thereinto/therefrom. One connector of the electric power cable 301 is connected to the connection terminal 103. The other

connector of the electric power cable 301 is connected to a connection terminal 207 of the house 200. The connection terminal 103 is also connected to a third terminal of the relay 102.

[0029] The converter 105 is provided between the connection terminal 103 and the electric storage device 104. The converter 105 is a bidirectional converter that converts a DC voltage between the connection terminal 103 and the electric storage device 104. Owing to this configuration, the converter 105 can discharge the electric power stored in the electric storage device 104 to the outside of the vehicle. Alternatively, the converter 105 can charge the electric storage device 104 through the electric power input from outside of the vehicle.

[0030] The relay 102 switches a conductive state and a non-conductive state of the connection between the first terminal and the second terminal and of the connection between the first terminal and the third terminal. The conductive state and the non-conductive state are switched on the basis of a control signal from the ECU 109. The relay 102 brings one of the connection between the first terminal and the second terminal and the connection between the first terminal and the third terminal, to the conductive state, and the other of them to the non-conductive state.

[0031] The ECU 109 controls electrical machines and the like included in the vehicle 100. Furthermore, the ECU 109 is configured to be able to communicate with a home energy management system (an HEMS) 210 of the house 200, which will be described later. Together with the HEMS 210, the ECU 109 performs electric power control between the vehicle 100 and the house 200.

[0032] Next, the house 200 that is connected to the vehicle 100 will be described. The house 200 is equipped with a solar battery 201, a converter 202, an inverter 203, an electric load 204, an electric storage device 205, and the HEMS 210.

[0033] The solar battery 201 generates a DC electric power through sunlight. An output terminal of the solar battery 201 is connected to the converter 202. The solar battery 201 includes a wattmeter to detect an amount of an electric power generated by the solar battery 201. The solar battery 201 outputs a signal indicating the detected amount

of the generated electric power to the HEMS 210.

[0034] The converter 202 is a unidirectional converter that operates on the basis of a control signal from the HEMS 210. The converter 202 fetches the DC electric power generated by the solar battery 201, from an input terminal (on an upper side of FIG. 1). The fetched DC electric power is converted into a DC electric power with an appropriate DC voltage. The DC electric power obtained through conversion is output from an output terminal (on a lower side of FIG. 1). In order to efficiently take out the DC electric power from the solar battery 201, the converter 202 may utilize a maximum power point tracking (MPPT) method.

[0035] The output terminal of the converter 202 is connected to electrical machines such as the inverter 203, the electric storage device 205, the inverter 208 and the like. For the sake of simplicity, that location to which those electrical machines are connected and which are at the same potential is referred to as a DC bus line 211. The respective electrical machines can give and receive a DC electric power through the DC bus line 211.

[0036] The inverter 203 is a bidirectional inverter that converts a DC electric power into an AC electric power on the basis of a control signal from the HEMS 210. A DC-side terminal (on the upper side of FIG. 1) of the inverter 203 is connected to the DC bus line 211. An AC-side terminal (on the lower side of FIG. 1) of the inverter 203 is connected to the electric load 204. Thus, the DC electric power of the DC bus line 211 is converted into an AC electric power by the inverter 203. The AC electric power obtained through conversion of the DC electric power is supplied to the electric load 204.

[0037] The electric load 204 is an electrical appliance or the like that is used in the house 200. Such an electrical appliance can be used by being supplied with an AC electric power.

[0038] The electric storage device 205 is connected to the DC bus line 211. The electric storage device 205 is an electric power storage element that is configured in a chargeable/dischargeable manner. The electric storage device 205 is configured to include a cell of an electric storage element. The cell of the electric storage cell is, for

example, a secondary battery such as a lithium-ion battery, a nickel hydrate battery, a lead storage battery or the like, or an electric double-layer capacitor or the like. The electric storage device 205 may be different in electric characteristics such as capacity, voltage and the like from the electric storage devices 104 and 130. The electric storage device 205 can fetch a DC electric power (be charged) from the DC bus line 211. Furthermore, the electric storage device 205 can also output (discharge) the DC electric power to the DC bus line 211.

[0039] The house 200 is further equipped with a connection terminal 209 and an inverter 208. This is a configuration for giving and receiving an AC electric power between the house 200 and the vehicle 100.

[0040] The connection terminal 209 is a connection terminal for inputting/outputting an AC electric power thereinto/therefrom. The other connector of the electric power cable 302 is connected to the connection terminal 209.

[0041] The inverter 208 is a bidirectional inverter that is provided between the connection terminal 209 and the DC bus line 211. A DC-side terminal of the inverter 208 is connected to the DC bus line 211. An AC-side terminal of the inverter 208 is connected to the connection terminal 209.

[0042] The inverter 208 converts a DC electric power of the DC bus line 211 into an AC electric power on the basis of a control signal from the HEMS 210. The AC electric power obtained through conversion of the DC electric power is output to the connection terminal 209. Besides, the inverter 208 converts an AC electric power into a DC electric power on the basis of a control signal from the HEMS 210. The AC electric power is supplied to the connection terminal 209 from outside of the house 200. The DC electric power obtained through conversion of the AC electric power can also be supplied to the DC bus line 211.

[0043] The house 200 is further equipped with a connection terminal 207, a converter 206, and a relay 220. These are configurations for giving and receiving a DC electric power between the house 200 and the vehicle 100.

[0044] The connection terminal 207 is a connection terminal for

inputting/outputting a DC electric power thereinto/therefrom. The other connector of the electric power cable 301 is connected to the connection terminal 209.

[0045] The converter 206 is a bidirectional converter that is provided between the connection terminal 207 and the electric storage device 205. The converter 206 fetches a DC electric power on the basis of a control signal from the HEMS 210. The DC electric power is supplied to the connection terminal 207 from outside the house 200. The fetched DC electric power is converted into a DC electric power with a DC voltage suited to charge the electric storage device 205. The DC electric power obtained through conversion is output to the electric storage device 205. Besides, the converter 206 can also output the electric power stored in the electric storage device 205 to the connection terminal 207. The output electric power is stored into the electric storage device 205 on the basis of a control signal from the HEMS 210. Incidentally, the converter 206 may utilize the MPPT method.

[0046] The relay 220 is provided between the connection terminal 207 and the solar battery 201. The relay 220 switches a conductive state (ON) and a non-conductive state (OFF) of the connection between the connection terminal 207 and the solar battery 201. ON and OFF of the connection between the connection terminal 207 and the solar battery 201 is switched on the basis of a control signal from the HEMS 210.

[0047] The HEMS 210 performs management and the like of the electric power in the house 200. The HEMS 210 also performs the control of the electrical machines and the like included in the house 200. As described above, the HEMS 210 is configured to be able to communicate with the ECU 109. Then, together with the ECU 109, the HEMS 210 performs electric power control between the vehicle 100 and the house 200.

[0048] In the foregoing configuration, it is conceivable to supply the electric power generated by the solar battery 101 to the house 200. when the electric power generated by the solar battery 101 is supplied to the house 200 via the electric storage device 104, the electric power is lost due to charge/discharge of the electric storage device 104.

[0049] Besides, in order to store the electric power generated by the solar battery

101 into the electric storage device 104, the electric storage device 130 needs to be charged with the generated electric power, and electric power conversion needs to be carried out by the converter 140. In consequence, the electric power is lost as a result of charge/discharge of the electric storage device 130 and the electric power conversion by the converter 140 as well.

[0050] Thus, in this embodiment of the invention, the control of switching of an electric power transmission path of the electric power generated by the solar battery 101 is performed. The contents of this control will be described hereinafter in detail.

[0051] FIG. 2 and FIG. 3 are views showing the electric power transmission path of the electric power generated by the solar battery of the vehicle shown in FIG. 1. Referring to FIG. 2 and FIG. 3, a first electric power transmission path LN1 is an electric power transmission path that is formed in the case where the electric power generated by the solar battery 101 is stored into the electric storage device 104. A second electric power transmission path LN2 is an electric power transmission path that is formed in the case where the electric power generated by the solar battery 101 is supplied to the house 200. The relay 102 can switch the first electric power transmission path LN1 to the second electric power transmission path LN2. Then, in the vehicle 100, the control of supplying the electric power generated by the solar battery 101 to the house 200 via the second electric power transmission path LN2 is performed. Besides, at this time, the relay 220 is controlled to be in a conductive state in the house 200. Thus, the solar battery 101 and the solar battery 201 are connected in series to each other.

[0052] Owing to the control as described above, the electric power can be prevented from being lost as a result of charge/discharge of the electric storage device. In consequence, the occurrence of electric power loss can be suppressed when the electric power is supplied from the vehicle to the electric power system outside the vehicle.

[0053] FIG. 4 is a flowchart for explaining a processing that is performed in the vehicle 100 and the house 200, which are shown in FIG. 1. The flowchart shown in FIG. 4 is realized by executing, on a predetermined cycle, programs that are stored in advance in the HEMS 210 of the house 200 and the ECU 109 of the vehicle 100. Alternatively, the

processing can also be realized by structuring a dedicated piece of hardware (an electronic circuit) as to one or some steps (the same holds true for a flowchart shown in FIG. 5, which will be described later). Incidentally, all the following conditions (1) to (3) are fulfilled in an initial state where the processing is started. The condition (1) is that the house 200 and the vehicle 100 be connected to each other via the electric power cable 301. The condition (2) is that the relay 220 be OFF. The condition (3) is that the relay 102 be changed over to the first electric power transmission path LN1.

[0054] Referring to FIG. 1 and FIG. 4, in step (step will be abbreviated hereinafter as S) 200, the HEMS 210 of the house 200 inquires the ECU 109 of the vehicle 100 about an amount PV of an electric power generated by the solar battery 101 of the vehicle 100. In S100, the ECU 109 determines whether or not an inquiry about the electric power generation amount PV has been received from the HEMS 210. when it is determined that no inquiry about the electric power generation amount PV has been received from the HEMS 210 (NO in S100), the processing is advanced to S104. when it is determined that an inquiry about the electric power generation amount PV has been received from the HEMS 210 (YES in S100), the ECU 109 transmits the electric power generation amount PV to the HEMS 210 (S102).

[0055] Subsequently in S202, the HEMS 210 determines whether or not the electric power generation amount PV received from the ECU 109 is larger than a predetermined electric power generation amount P1. Incidentally, the predetermined electric power generation amount P1 is a threshold indicating that an electric power can be supplied from the solar battery 101 to the house 200. For example, the predetermined electric power generation amount P1 is set to a value indicating the sum of an electric power transmission loss and an electric power conversion loss during the transmission of the electric power from the solar battery 101 to the electric storage device 205 of the house 200.

[0056] When it is determined that the electric power generation amount PV is equal to or smaller than the predetermined electric power generation amount P1 (NO in S202), the following processes are skipped to return the processing to a main routine.

When it is determined that the electric power generation amount PV is larger than the predetermined electric power generation amount P1 (YES in S202), the HEMS 210 inquires the ECU 109 about the SOC of the electric storage device 104 of the vehicle 100 (S204). The ECU 109 determines in S104 whether or not an inquiry about the SOC has been received from the HEMS 210. When it is determined that no inquiry about the SOC has been received from the HEMS 210 (NO in S104), the processing is advanced to S108. When it is determined that an inquiry about the SOC has been received from the HEMS 210 (YES in S104), the ECU 109 transmits the SOC to the HEMS 210 (S106).

[0057] Subsequently in S206, the HEMS 210 determines whether or not the SOC received from the ECU 109 is equal to or larger than a predetermined charge amount S1. Incidentally, the predetermined charge amount S1 is a value for determining whether or not the electric storage device 104 can be charged. Concretely, the predetermined charge amount S1 is a value indicating that the electric storage device 104 is fully charged.

[0058] When it is determined that the SOC of the electric storage device 104 of the vehicle 100 is smaller than the predetermined charge amount S1 (NO in S206), the HEMS 210 outputs a charge command to charge the electric storage device 104 with the electric power generated by the solar battery 101, to the ECU 109 (S208).

[0059] The ECU 109 determines in S108 whether or not a charge command has been received from the HEMS 210. When it is determined that no charge command has been received from the HEMS 210 (NO in S108), the processing is advanced to S112. When it is determined that a charge command has been received from the HEMS 210 (YES in S108), the ECU 109 performs the charge control of charging the electric storage device 104 with the electric power generated by the solar battery 101 (S110). Concretely, the ECU 109 controls the converter 140 so as to charge the electric storage device 104 with the electric power generated by the solar battery 101 and stored in the electric storage device 130.

[0060] Subsequently in S210, the HEMS 210 inquires the ECU 109 about the SOC of the electric storage device 104 of the vehicle 100. Subsequently in S212, the HEMS 210 determines whether or not the SOC of the electric storage device 104 of the

vehicle 100 received from the ECU 109 is equal to or larger than the predetermined charge amount S1. When it is determined that the SOC of the electric storage device 104 is smaller than the predetermined charge amount S1 (NO in S212), the HEMS 210 inquires the ECU 109 of the vehicle 100 about the amount PV of the electric power generated by the solar battery 101 of the vehicle 100 (S214). Subsequently in S216, the HEMS 210 determines whether or not the electric power generation amount PV received from the ECU 109 is larger than the predetermined electric power generation amount P1. When it is determined that the electric power generation amount PV is equal to or smaller than the predetermined electric power generation amount P1 (NO in S216), the following processes are skipped to return the processing to the main routine.

[0061] When it is determined that the electric power generation amount PV is larger than the predetermined electric power generation amount P1 (YES in S216), the processing is returned to S208, and the electric storage device 104 continues to be charged with the electric power generated by the solar battery 101.

[0062] On the other hand, When it is determined in S212 that the SOC of the electric storage device 104 of the vehicle 100 is equal to or larger than the predetermined charge amount S1 (YES in S212), the HEMS 210 turns the relay 220 ON, and outputs a signal indicating that the relay 220 is ON, to the ECU 109 (S218). Besides, When it is determined in S206 that the SOC of the electric storage device 104 of the vehicle 100 is equal to or larger than the predetermined charge amount S1 as well (YES in S206), the processing is advanced to S218.

[0063] In S112, the ECU 109 determines, on the basis of a signal from the HEMS 210, whether or not the relay 220 is ON. When it is determined that the relay 220 is OFF (NO in S112), the processing is advanced to S116. When it is determined that the relay 220 is ON (YES in S112), the ECU 109 changes over the relay 102 to the second electric power transmission path LN2. Thus, the electric power generated by the solar battery 101 is supplied to the house 200.

[0064] Subsequently in S220, the HEMS 210 inquires the ECU 109 of the vehicle 100 about the amount PV of the electric power generated by the solar battery 101 of the

vehicle 100. Subsequently in S222, the HEMS 210 determines whether or not the electric power generation amount PV received from the ECU 109 is larger than the predetermined electric power generation amount P1. When it is determined that the electric power generation amount PV is larger than the predetermined electric power generation amount P1 (YES in S222), the HEMS 210 continues to supply the electric power from the solar battery 101 to the house 200. When it is determined that the amount of the electric power generated by the solar battery 101 of the vehicle 100 is equal to or smaller than the predetermined electric power generation amount P1 (NO in S222), the HEMS 210 turns the relay 220 OFF, and outputs a signal indicating that the relay 220 is OFF, to the ECU 109 (S224).

[0065] In S116, the ECU 109 determines, on the basis of a signal from the HEMS 210, whether or not the relay 220 is OFF. When it is determined that the relay 220 is ON (NO in S116), the processing is returned to the main routine. When it is determined that the relay 220 is OFF (YES in S116), the ECU 109 changes over the relay 102 to the first electric power transmission path LN1 (S118). Thus, the electric power is stopped from being supplied from the solar battery 101 to the house 200.

[0066] As described above, this first embodiment of the invention adopts a configuration in which a changeover can be made from the first electric power transmission path LN1 to the second electric power transmission path LN2. The first electric power transmission path LN1 transmits the electric power generated by the solar battery 101 to the electric storage device 104. The second electric power transmission path LN2 transmits the electric power generated by the solar battery 101 to the electric storage device 104 without the intermediary of the electric storage device 104. In consequence, by supplying the electric power generated by the solar battery 101 to the house 200 via the second electric power transmission path LN2, the electric power can be prevented from being lost as a result of charge/discharge of the electric storage device 104. Accordingly, this first embodiment of the invention makes it possible to restrain the electric power from being lost when the electric power is supplied from the vehicle 100 to the house 200.

[0067] Besides, in this first embodiment of the invention, the converter 202 may operate and the converter 206 may stop when the relay 220 is ON. In this case, the electric power generated by the solar battery 101 is converted by the converter 202 and output to the DC bus line 211. In consequence, the electric power consumed to operate the converter 206 can be reduced.

[0068] In the first embodiment of the invention, the amount of the electric power generated by the solar battery is acquired as follows. The ECU of the vehicle detects the amount of the electric power generated by the solar battery of the vehicle. The ECU of the vehicle outputs a signal indicating the detected amount of the generated electric power, to the HEMS through communication. By receiving the signal from the ECU, the HEMS acquires the amount of the electric power generated by the solar battery. Thus, the ECU of the vehicle needs to detect the amount of the electric power generated by the solar battery of the vehicle.

[0069] It should be noted herein that the amount of the electric power generated by the solar battery greatly depends on the solar radiation intensity. Thus, the HEMS can estimate the amount of the electric power generated by the solar battery of the vehicle from the amount of the electric power generated by the solar battery of the house. Thus, in the second embodiment of the invention, a configuration in which the HEMS determines whether or not the amount of the electric power generated by the solar battery of the vehicle is large will be described. It is determined, on the basis of the amount of the electric power generated by the solar battery of the house, whether or not the amount of the electric power generated by the solar battery of the vehicle is large. In this case, there is no need to detect the amount of the electric power generated by the solar battery of the vehicle. Thus, the number of opportunities in which a component for detecting the amount of the electric power generated by the solar battery of the vehicle operates can be reduced. In consequence, the foregoing configuration can prolong the life span of the component. Besides, there is no need either to transmit a signal indicating the amount of the electric power generated by the solar battery of the vehicle, from the ECU to the HEMS. Therefore, the processing that is performed between the ECU and the HEMS can

be simplified.

[0070] The vehicle according to the second embodiment of the invention is identical in configuration to the vehicle according to the first embodiment of the invention shown in FIG. 1.

[0071] FIG. 5 is a flowchart for explaining a processing that is performed in the vehicle 100 and the house 200 according to the second embodiment of the invention.

[0072] Referring to FIG. 5, S104 to S118, S204 to S212, S218, and S224 are identical to those of the first embodiment of the invention respectively, and hence the description thereof will not be repeated.

[0073] In S201, the HEMS 210A detects an amount PH of an electric power generated by the solar battery 201 of the house 200. Subsequently in S203, the HEMS 210A determines whether or not the electric power generation amount PH is larger than a predetermined electric power generation amount P2. It should be noted herein that the predetermined electric power generation amount P2 is a value for determining whether or not an electric power should be transmitted from the solar battery 101 to the house 200. Concretely, the predetermined electric power generation amount P2 is set to an amount of an electric power generated by the solar battery 201 at the time when the amount of the electric power generated by the solar battery 101 of the vehicle 100 is the predetermined electric power generation amount P1. Thus, the HEMS 210A can estimate the amount of the electric power generated by the solar battery 101 from the amount of the electric power generated by the solar battery 201.

[0074] When it is determined that the amount of the electric power generated by the solar battery 201 of the house 200 is equal to or smaller than the predetermined electric power generation amount P2 (NO in S203), the following processes are skipped to return the processing to the main routine. When it is determined that the amount of the electric power generated by the solar battery 201 of the house 200 is larger than the predetermined electric power generation amount P2 (YES in S203), the HEMS 210A inquires an ECU 109A about the SOC of the electric storage device 104 of the vehicle 100 (S204).

[0075] Besides, when it is determined in S212 that the SOC of the electric storage

device 104 is smaller than the predetermined charge amount S1 (NO in S212), the HEMS 210A detects the amount PH of the electric power generated by the solar battery 201 of the house 200 (S215). Subsequently in S217, the HEMS 210A determines whether or not the electric power generation amount PH is larger than the predetermined electric power generation amount P2. When it is determined that the electric power generation amount PH is equal to or smaller than the predetermined electric power generation amount P2 (NO in S217), the following processes are skipped to return the processing to the main routine.

[0076] When it is determined that the electric power generation amount PH is larger than the predetermined electric power generation amount P2 (YES in S217), the processing is returned to S208, and the electric storage device 104 continues to be charged with the electric power generated by the solar battery 101.

[0077] Besides, when the relay 220 is turned ON in S218, the HEMS 210A detects the amount PH of the electric power generated by the solar battery 201 of the house 200 (S221). Subsequently in S223, the HEMS 210A determines whether or not the electric power generation amount PH is larger than the predetermined electric power generation amount P2. When it is determined that the electric power generation amount PH is larger than the predetermined electric power generation amount P2 (YES in S223), the HEMS 210A continues to supply the electric power from the solar battery 101 to the house 200. When it is determined that the electric power generation amount PH is equal to or smaller than the predetermined electric power generation amount P2 (NO in S223), the HEMS 210A turns the relay 220 OFF, and outputs a signal indicating that the relay 220 is OFF, to the ECU 109A (S224).

[0078] As described above, in this second embodiment of the invention, the relay 220 switches the first electric power transmission path LN1 to the second electric power transmission path LN2 when the amount of the electric power generated by the solar battery 201 becomes larger than the predetermined electric power generation amount P2. In consequence, there is no need to detect the amount of the electric power generated by the solar battery 101 of the vehicle 100. Thus, the number of opportunities in which a component for detecting the amount of the electric power generated by the solar battery

101 of the vehicle 100 operates can be reduced. In consequence, the foregoing configuration makes it possible to prolong the life span of the component. Besides, there is no need either to transmit a signal indicating the amount of the electric power generated by the solar battery 101 of the vehicle 100 from the ECU 109A to the HEMS 210A. Therefore, the processing can be simplified.

[0079] In the foregoing, the electric power is transmitted from the solar battery 101 to the electric storage device 205 in the case where the amount of the electric power generated by the solar battery 101 is larger than the sum of an electric power transmission loss and an electric power conversion loss at the time when the electric power is transmitted from the solar battery 101 to the electric storage device 205. On the other hand, the HEMS 210 or 210A may determine, on the basis of electric power rates, whether or not the electric power should be transmitted from the solar battery 101 to the electric storage device 205. Concretely, the HEMS 210 or 210A may transmit the electric power from the solar battery 101 to the electric storage device 205 when the following expression is established.

[0080] Amount of Electric Power Generated by Solar Battery of Vehicle per Arbitrary Time $\times$ Present Electric Power Rate $>$ (Electric Power Rate during Time in which Use of Electric Power is Envisioned after Storage of Electric Power $-$ Present Electric Power Rate) $\times$ Amount of Electric Power with which Solar Battery Can Be Charged in Arbitrary Time ... (1)

In the foregoing, the case where the vehicle 100 is equipped with the solar battery has been described. On the other hand, the vehicle 100 may be equipped with a different type of electric power generation device instead of the solar battery. This different type of electric power generation device may generate an electric power through, for example, fuel cell electric power generation, thermoelectric power generation or the like.

[0081] In the foregoing, the configuration in which each of the solar batteries 101 and 201 includes a wattmeter has been described. On the other hand, it is also acceptable to adopt a configuration in which the converter 140 includes a wattmeter that measures an electric power generated by the solar battery 101, and the converter 202 includes a

wattmeter that measures an electric power generated by the solar battery 201.

[0082] In the foregoing, the house 200 corresponds to one embodiment of "the electric power system" in this invention. The solar battery 101 corresponds to one embodiment of "the electric power generation device" in this invention. The connection terminal 103 corresponds to one embodiment of "the output unit" in this invention. The relay 220 corresponds to one embodiment of "the switching device" in this invention.

[0083] The embodiments of the invention disclosed this time should be considered to be exemplary and non-limitative in all respects. The scope of the invention is defined not by the foregoing description but by the claims. That is, the scope of the invention is intended to cover all the modifications that are equivalent in significance and scope to the claims.

CLAIMS

1. A vehicle for supplying an electric power to an electric power system outside of the vehicle, the vehicle comprising:

an electric power generation device;

an electric storage device that stores an electric power generated by the electric power generation device;

an output unit that outputs an electric power to the electric power system; and

a switching device configured to switch a first electric power transmission path to a second electric power transmission path, the first electric power transmission path transmitting the generated electric power to the electric storage device, and the second electric power transmission path transmitting the generated electric power to the output unit without an intermediary of the electric storage device.

2. The vehicle according to claim 1, wherein

the switching device switches the first electric power transmission path to the second electric power transmission path when a state quantity of the electric storage device becomes larger than a predetermined charge amount,

the state quantity indicates a state of charge of the electric storage device.

3. The vehicle according to claim 1, wherein

the switching device switches the first electric power transmission path to the second electric power transmission path when an amount of the electric power generated by the electric power generation device becomes larger than a predetermined electric power generation amount.

4. The vehicle according to claim 1 further comprising:

a converter that is provided in the first electric power transmission path, and the converter being electrically connected to the electric storage device.

5. The vehicle according to claim 1, wherein
the electric power generation device includes a first solar battery.
6. The vehicle according to claim 5, wherein
the electric power system includes a second solar battery, and
the switching device switches the first electric power transmission path to the second electric power transmission path when an amount of an electric power generated by the second solar battery becomes larger than a predetermined electric power generation amount.
7. The vehicle according to claim 1, wherein
the vehicle supplies an electric power to the electric power system for a household electric storage device and a household electric load.
8. A method of supplying an electric power to an electric power system outside of a vehicle, the vehicle including:
an electric power generation device;
an electric storage device that stores an electric power generated by the electric power generation device; and
an output unit that outputs an electric power to the electric power system,
the method comprising:
switching a first electric power transmission path to a second electric power transmission path, the first electric power transmission path transmitting the generated electric power to the electric storage device, and the second electric power transmission path transmitting the generated electric power to the output unit without an intermediary of the electric storage device.

FIG. 1

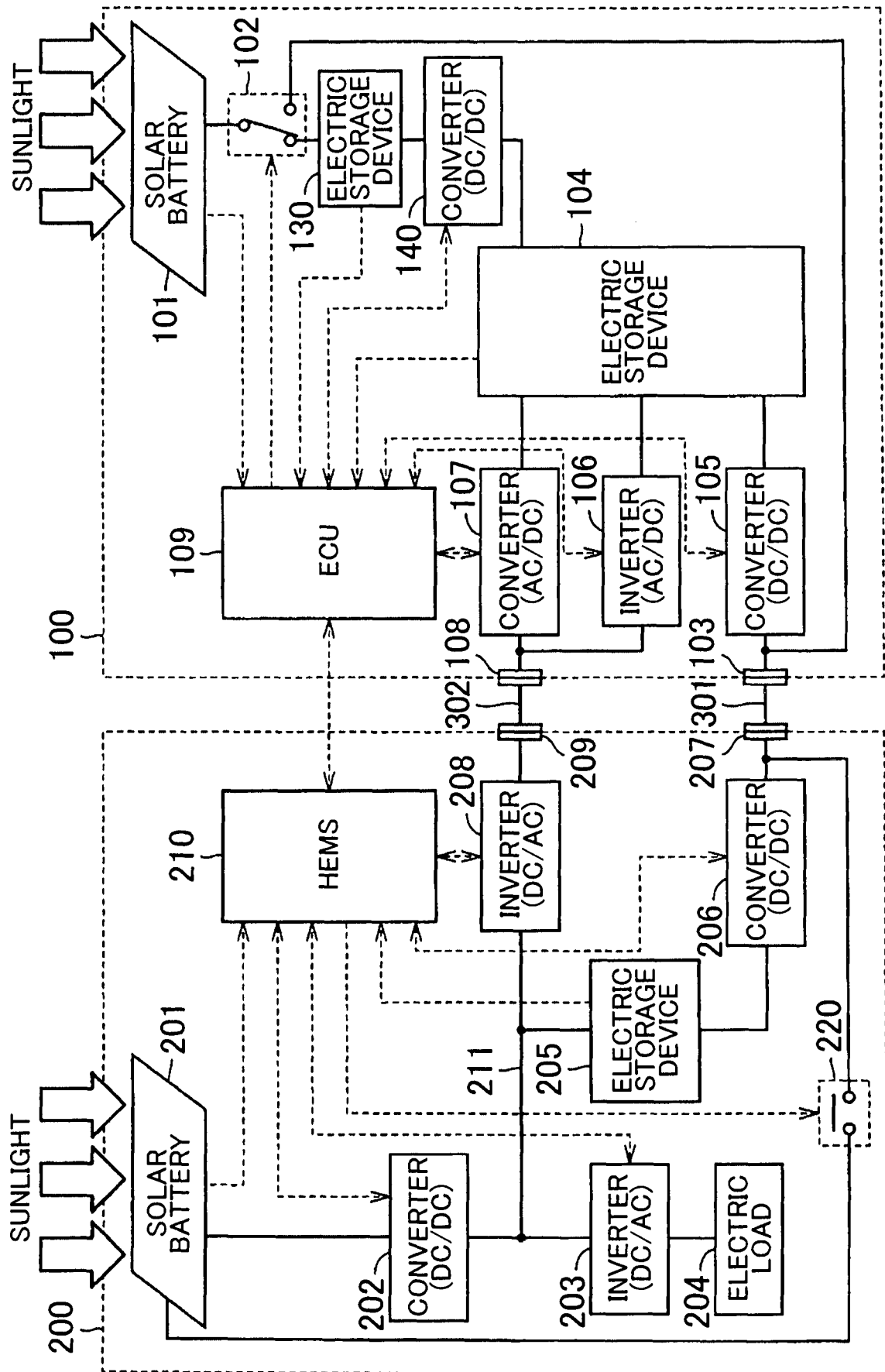


FIG. 2

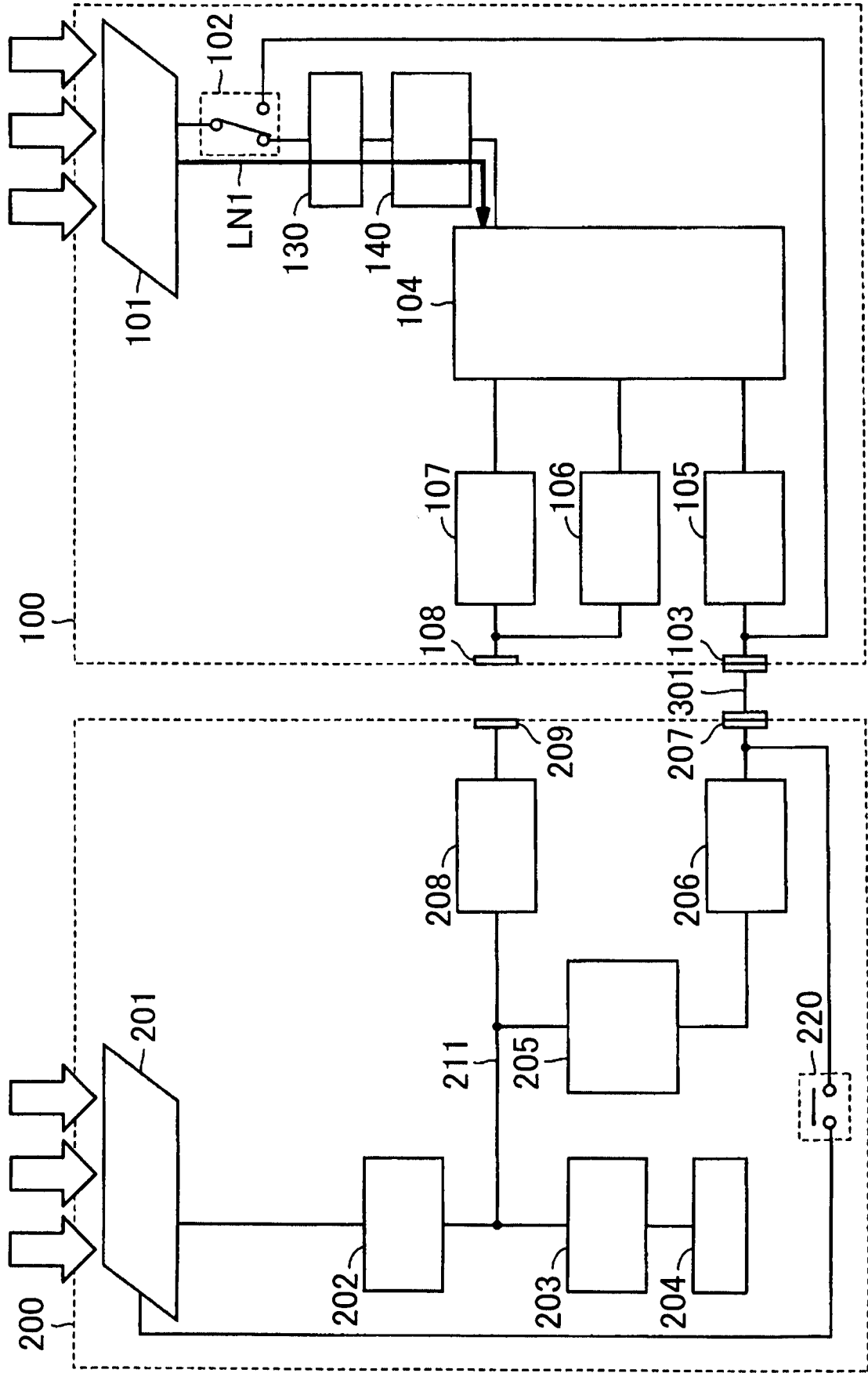


FIG. 3

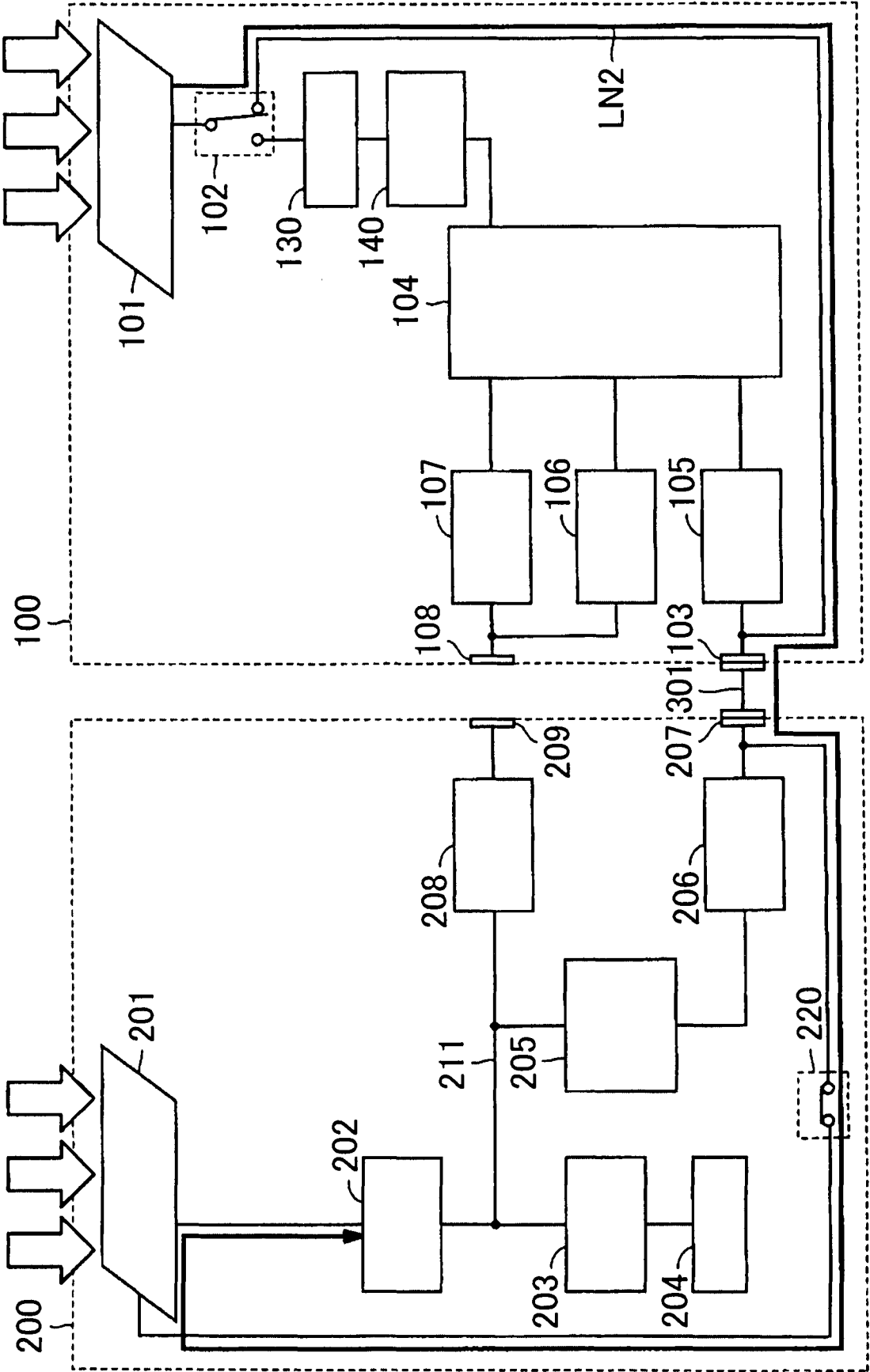


FIG. 4A

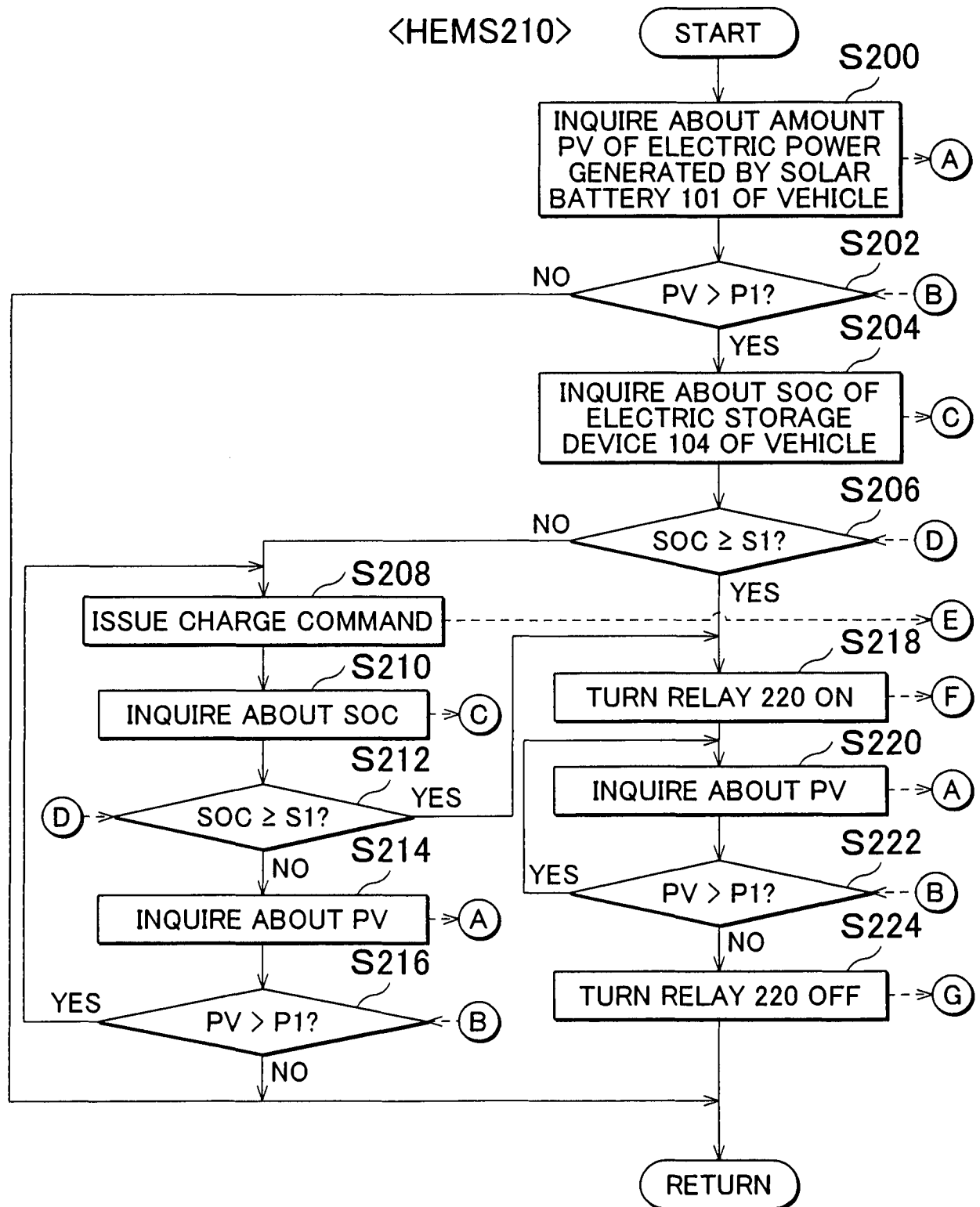


FIG. 4B

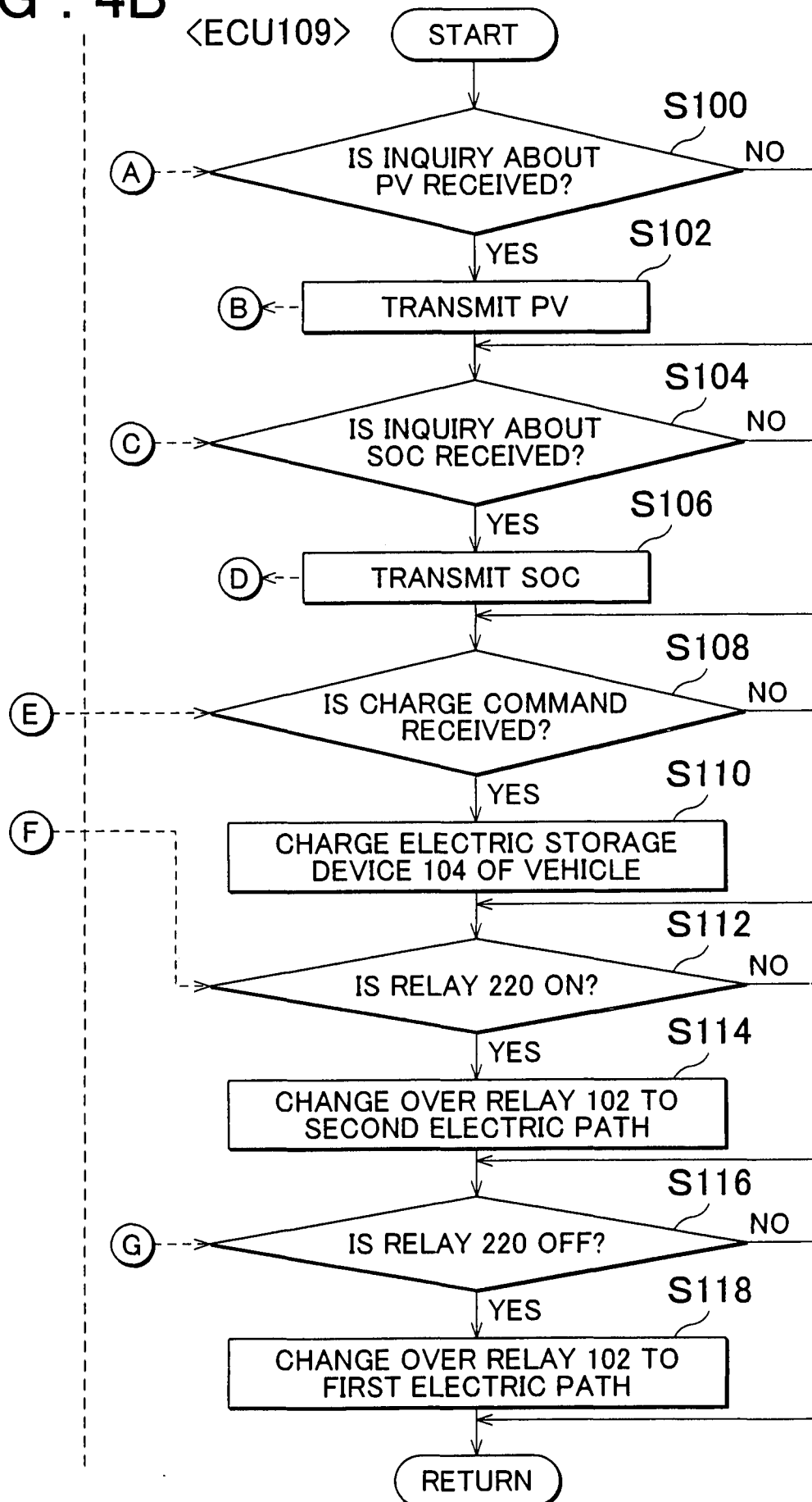


FIG. 5A

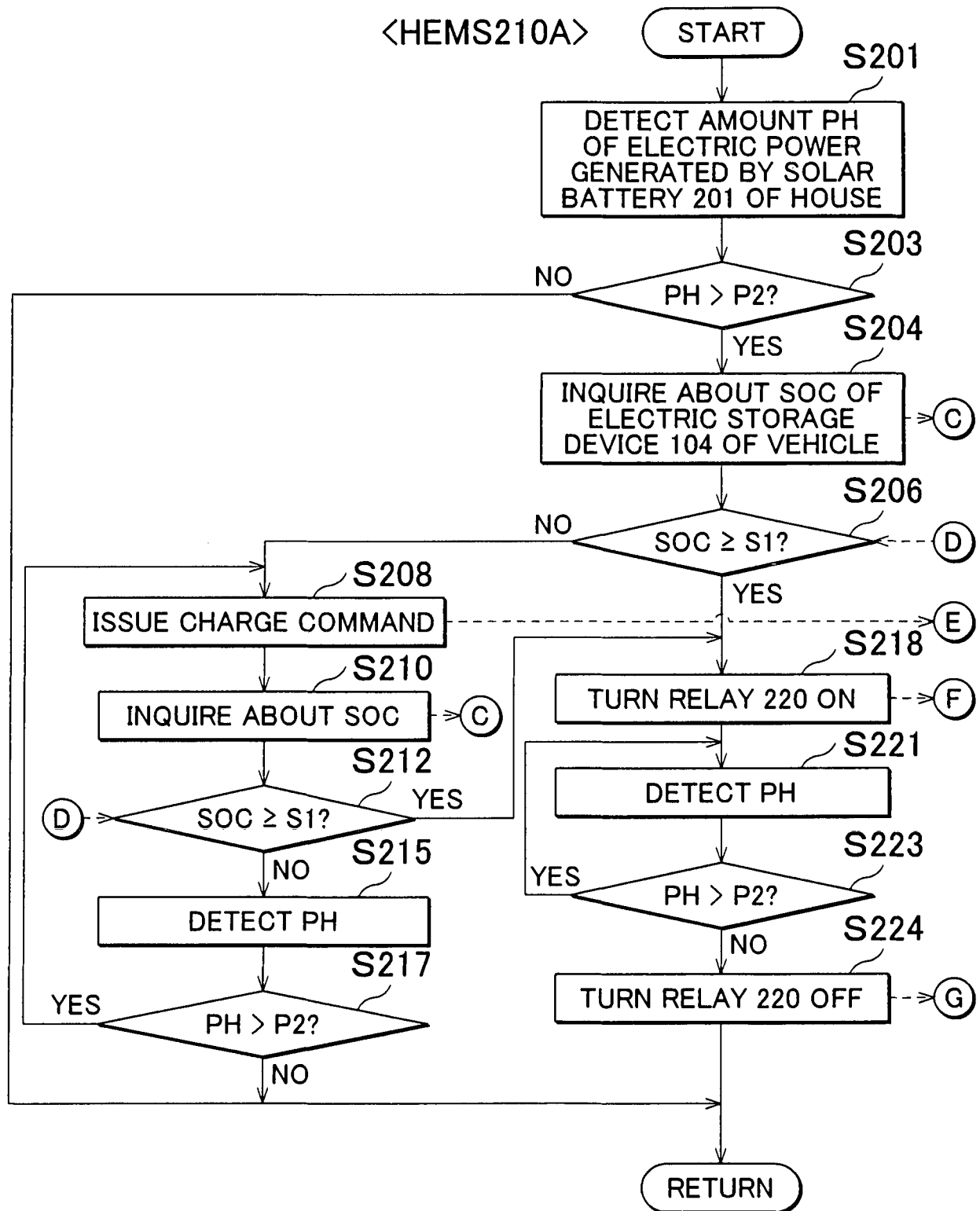
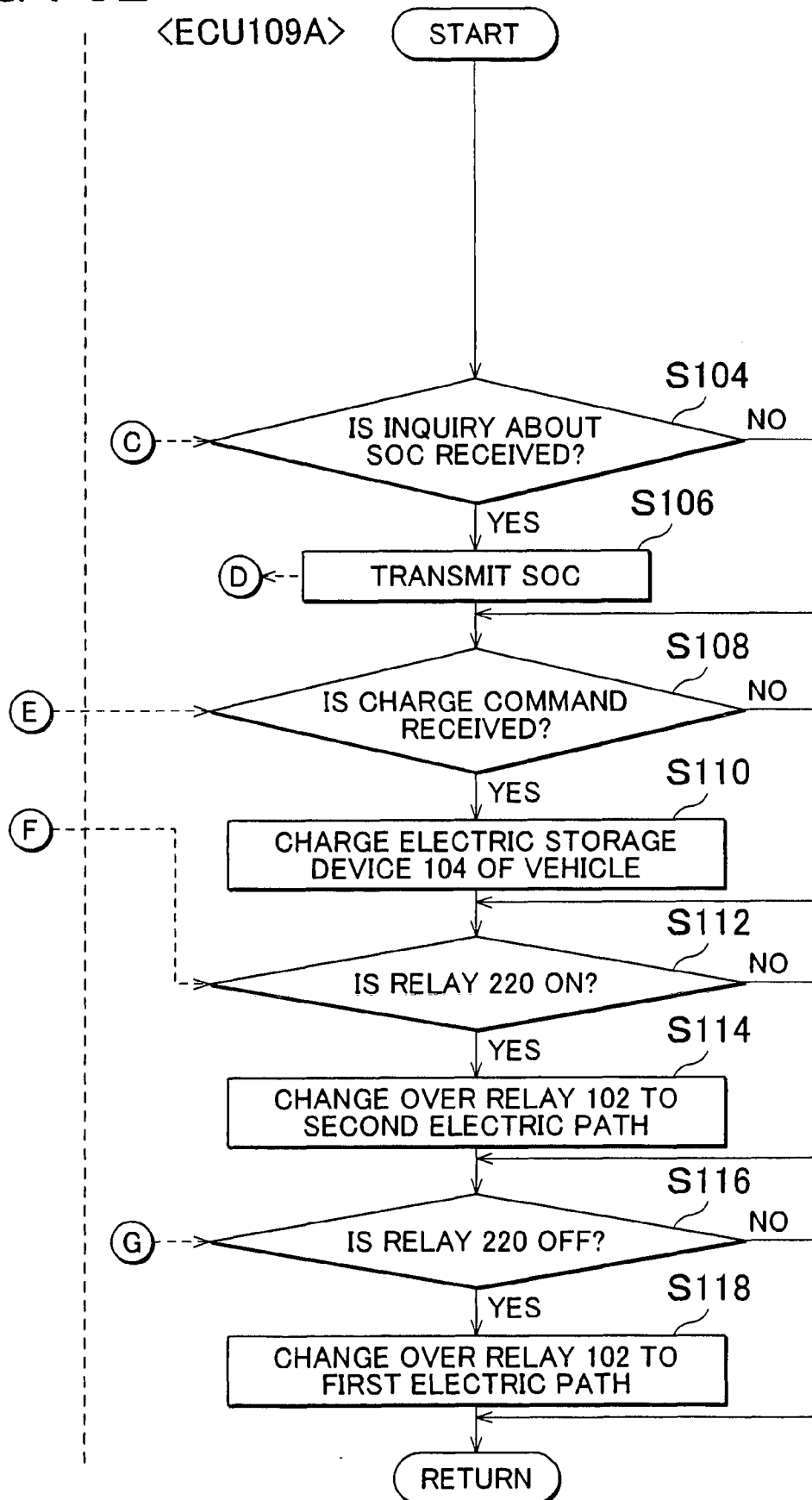


FIG. 5B



INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2014/000899

A. CLASSIFICATION OF SUBJECT MATTER

INV. B60L11/18 B60L8/00 H02J7/35 B60W10/26
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60L H02J B60W

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 2008/107767 A2 (PLISHNER PAUL J [US]) 12 September 2008 (2008-09-12) abstract; claims 1-18; figures 1,4A,4B page 8 - page 11 page 15 page 20 - page 23	1-8
X	DE 10 2008 043205 A1 (BOSCH GMBH ROBERT [DE]) 29 April 2010 (2010-04-29) abstract; claim 4; figure 4 page 3 - page 5	1,4,5,8
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

17 November 2014

Date of mailing of the international search report

27/11/2014

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Koutsorodis, Dafni

INTERNATIONAL SEARCH REPORT

International application No

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