



- (51) International Patent Classification:
B60L 11/18 (2006.01)
- (21) International Application Number:
PCT/IB2014/000868
- (22) International Filing Date:
27 May 2014 (27.05.2014)
- (25) Filing Language:
English
- (26) Publication Language:
English
- (30) Priority Data:
2013-121636 10 June 2013 (10.06.2013) JP
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- (81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

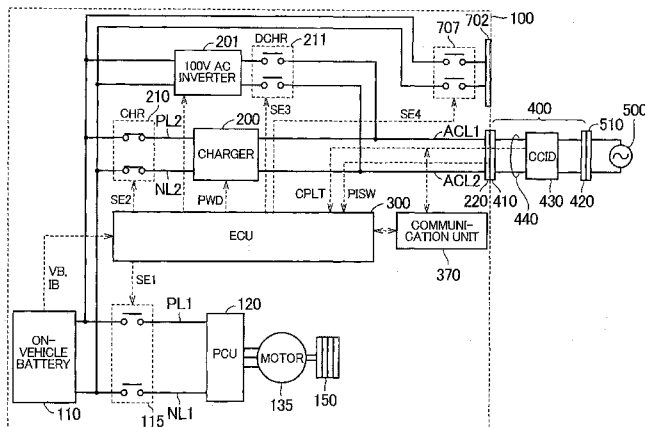
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: POWER SUPPLY DEVICE FOR VEHICLE

FIG. 1



(57) Abstract: The power supply device for a vehicle includes a power supply (110) an alternating current coupling unit (220), a direct current coupling unit (702), a communication unit (370), and an electronic control unit (300). The alternating current coupling unit (220) is configured to transmit and receive alternating current power between the power supply (110) and an external device for the vehicle. The direct current coupling unit (702) is configured to transmit and receive direct current power between the power supply (110) and the external device. The communication unit (370) is configured to obtain information on the external device from the external device through communications. The electronic control unit (300) is configured to determine: whether to discharge electric power from the power supply (110) to the external device via the alternating current coupling unit (220); and whether to discharge electric power from the power supply (110) to the external device via the direct current coupling unit (702), based on the information obtained from the communication unit (370).

WO 2014/199203 A2

POWER SUPPLY DEVICE FOR VEHICLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This invention relates to a power supply device for a vehicle.

2. Description of Related Art

[0002] Recently, various electricity supply systems that supply electric power in an electric storage device mounted in a vehicle to a household side and that charge the electric storage device mounted in the vehicle with electric power at the household side have been proposed. Japanese Patent Application Publication No. 2012-228034 (JP 2012-228034 A) discloses that an electric vehicle with an AC power cable for normal charge and a plug for DC fast charge supplies a house with electric power.

[0003] It is considered that the vehicle disclosed in JP 2012-228034 A discharges to the outside in both alternating current and direct current. However, which of discharge in alternating current or direct current is appropriate is unclear.

[0004] In an electric vehicle with an alternating current charging inlet and a direct current charging inlet, both charging inlets can be simultaneously coupled from the house and charge and discharge facility. In this case, to feed power from the vehicle to the house and the facility, it is necessary to appropriately determine that from which of the alternating current charging inlet and the direct current charging inlet power should be fed.

SUMMARY OF THE INVENTION

[0005] In view of the above-described problems, this invention provides a power supply device for a vehicle that allows power feeding from a vehicle to an external device in an aspect of output appropriate for the external device to which power is fed from the vehicle.

[0006] Therefore, according to one aspect of the invention, a power supply

device for a vehicle that includes a power supply, an alternating current coupling unit, a direct current coupling unit, a communication unit, and an electronic control unit is provided. Here, the alternating current coupling unit is configured to transmit and receive alternating current power between the power supply and an external device for a vehicle. The direct current coupling unit is configured to transmit and receive direct current power between the power supply and the external device. The communication unit is configured to obtain information on the external device from the external device through communications. The electronic control unit is configured to determine whether or not to discharge electric power from the power supply to the external device via the alternating current coupling unit based on the information obtained from the communication unit and whether or not to discharge electric power from the power supply to the external device via the direct current coupling unit based on the information obtained from the communication unit.

[0007] With the power supply device for the vehicle, the external device may include a first power conversion unit, a second power conversion unit, and an external control unit. The first power conversion unit is coupled to the alternating current coupling unit. The first power conversion unit is configured to convert electric power. The second power conversion unit is coupled to the direct current coupling unit. The second power conversion unit is configured to convert electric power. The external control unit is configured to monitor states of the first power conversion unit and the second power conversion unit. The external control unit is configured to transmit a monitoring result to the communication unit. The electronic control unit may be configured to obtain the monitoring result from the external control unit as the information.

[0008] With the power supply device for the vehicle, when both the first power conversion unit and the second power conversion unit normally operate, the electronic control unit may be configured to perform a control to discharge electric power from the power supply to the external device via the direct current coupling unit without use of the alternating current coupling unit.

[0009] With the power supply device for the vehicle, when the monitoring result shows that the first power conversion unit normally operates and the second power conversion unit does not normally operate, the electronic control unit may be configured to perform a control to discharge electric power from the power supply to the external device via the alternating current coupling unit without use of the direct current coupling unit.

[0010] With the power supply device for the vehicle, when the monitoring result shows that both the first power conversion unit and the second power conversion unit are not able to normally operate, the electronic control unit may be configured to inhibit discharge from the power supply to the external device.

[0011] With the power supply device for the vehicle, when the electronic control unit does not obtain the information from the communication unit, when an operator inputs an emergency power feeding command, the electronic control unit may be configured to perform a control to discharge electric power from the power supply to the external device using both of a path via the alternating current coupling unit and a path via the direct current coupling unit.

[0012] With the power supply device for the vehicle, when the electronic control unit does not obtain the information from the communication unit, when an operator does not input an emergency power feeding command, the electronic control unit may be configured to inhibit discharge of electric power from the power supply to the external device.

[0013] With the power supply device for a vehicle of the present invention as described above, power feeding from a vehicle to an external device is possible in an aspect of output appropriate for the external device coupled to the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] 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 an overall block diagram of a vehicle 100;

FIG. 2 is a view for describing charge and discharge of alternating current power from the vehicle;

FIG. 3 is a view for describing an outline of a direct current charge mode and a direct current discharge mode from the vehicle;

FIG. 4 illustrates a state where charging and discharging cables are coupled simultaneously to an AC inlet and a DC inlet illustrated in FIG. 2 and FIG. 3;

FIG. 5 is a block diagram illustrating a schematic constitution of the vehicle and a house when a direct current path and an alternating current path are coupled simultaneously;

FIG. 6 is a block diagram illustrating a schematic constitution of when an emergency outlet is provided to a house side with the constitution illustrated in FIG. 5;

FIG. 7 is a flowchart for describing a process of selecting a charge control and a discharge control performed by an ECU 300 in Embodiment 1 of the present invention;

FIG. 8 is a flowchart for describing a first process of selecting AC discharge and DC discharge in the discharge control performed by the ECU 300 in Embodiment 1 of the present invention;

FIG. 9 is a flowchart for describing a second process of selecting AC discharge and DC discharge in the discharge control performed by the ECU 300 in Embodiment 2 of the present invention; and

FIG. 10 is a flowchart for describing a process of determining whether the AC discharge and the DC discharge are simultaneously performed or not in the discharge control performed by the ECU 300 in Embodiment 3 of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0015] The following describes embodiments of the present invention in detail with reference to the drawings. Like reference numerals designate corresponding or identical elements throughout the drawings, and therefore such elements will not be further elaborated here.

[0016] First, the following describes a vehicle and an alternating current charging cable. FIG. 1 is an overall block diagram of a vehicle 100. Now referring to FIG. 1, the vehicle 100 includes an on-vehicle battery 110, a System Main Relay (SMR) 115, a Power Control Unit (PCU) 120, a motor 135, a driving wheel 150, and an Electronic Control Unit (ECU) 300. The on-vehicle battery 110 is an electric storage device as well as a power supply. The ECU 300 is a control unit. The PCU 120 (not illustrated) includes a converter, an inverter, and a capacitor.

[0017] The on-vehicle battery 110 is an electric power storage element constituted to be chargeable and dischargeable. The on-vehicle battery 110 is, for example, constituted including a secondary battery such as a lithium ion battery, a nickel-metal hydride battery, or a lead-acid battery; or a power storage element such as an electric double layer capacitor.

[0018] The on-vehicle battery 110 is coupled to the PCU 120 via a positive power line PL1 and a negative power line NL1. Then, the on-vehicle battery 110 supplies electric power for generating driving power of the vehicle 100 to the PCU 120. The on-vehicle battery 110 stores electric power regenerated by the motor 135. An output from the on-vehicle battery 110 is, for example, approximately 200 V.

[0019] The on-vehicle battery 110 includes a voltage sensor and a current sensor (both are not illustrated). The on-vehicle battery 110 outputs a voltage VB and a current IB of the on-vehicle battery 110 detected by the voltage sensor and the current sensor to the ECU 300.

[0020] One side of relays included in an SMR 115 is coupled between a positive electrode of the on-vehicle battery 110 and the positive power line PL1 coupled to the PCU 120. The other side of relays included in the SMR 115 is coupled between the negative electrode of the on-vehicle battery 110 and the negative power line NL1. Then, based on a control signal SE1 from the ECU 300, the SMR 115 switches supply and cutoff of electric power between the on-vehicle battery 110 and the PCU 120.

[0021] The PCU internally includes an inverter. The inverter converts direct current power into alternating current power based on the control signal from the ECU

300, and drives each motor 135.

[0022] The motor 135 is an alternating current rotary electric machine. For example, the motor 135 is a permanent-magnet synchronous motor including a rotor where a permanent magnet is embedded.

[0023] Driving power of the motor 135 is transmitted to the driving wheel 150 to cause the vehicle 100 to run. When the vehicle 100 is in regenerative braking operation, the motor 135 can generate electric power by rotational force of the driving wheel 150. The PCU 120 converts the generated electric power into charging power of the on-vehicle battery 110.

[0024] The vehicle 100 may be a hybrid vehicle. In this case, the vehicle 100 further includes an engine and an electric generator. The electric generator can generate electric power by rotation of the engine. The use of the generated electric power allows charging the on-vehicle battery 110.

[0025] The vehicle 100 may be an electric vehicle without an engine and may be a fuel cell vehicle.

[0026] As a constitution for charging the on-vehicle battery 110 by electric power from an external alternating current power supply 500, the vehicle 100 includes a charger 200, a charge relay (CHR) 210 an AC inlet (hereinafter also referred to as an alternating current charging inlet or an alternating current coupling unit) 220, a charge and discharge relay 707, and a DC inlet (hereinafter also referred to as a direct current charging inlet or a direct current coupling unit) 702. To the DC inlet 702, a connector for performing direct current charge and discharge, which will be described later with FIG. 3 to FIG. 6, is coupled.

[0027] To the AC inlet 220, an AC connector 410 of a charging cable 400 is coupled. Then, electric power from the external alternating current power supply 500 is transmitted to the vehicle 100 via the charging cable 400.

[0028] The charging cable 400 includes a plug 420 and a power line 440 in addition to the AC connector 410. The plug 420 is to be coupled to an outlet 510 of the external alternating current power supply 500. The power line 440 couples the AC

connector 410 and the plug 420. To the power line 440, a Charging Circuit Interrupt Device (hereinafter also referred to as a CCID) 430 to switch supply and cutoff of electric power from the external alternating current power supply 500 is interposed.

[0029] The charger 200 is coupled to the AC inlet 220 via the power lines ACL1 and ACL2. The charger 200 is coupled to the on-vehicle battery 110 via the CHR 210.

[0030] The charger 200 converts alternating current power supplied from the AC inlet 220 into charging power of the on-vehicle battery 110 by being controlled by a control signal PWD from the ECU 300.

[0031] As a constitution for supplying electric power to the outside, the vehicle 100 further includes a 100 V AC inverter 201 and a discharging relay (DCHR) 211. The AC inlet 220 is also used as a coupling unit for outputting alternating current power.

[0032] The 100 V AC inverter 201 also can convert direct current power from the on-vehicle battery 110 or direct current power generated by the motor 135 and converted by the PCU 120 into alternating current power and can feed power to the outside of the vehicle. Instead of the 100 V AC inverter 201, a device for outputting other alternating current voltages may be disposed. The charger 200 and the 100 V AC inverter 201 may be one device where bidirectional power conversion of charge and power feeding is possible.

[0033] The CHR 210 is controlled by a control signal SE2 from the ECU 300 and switches supply and cutoff of electric power between the charger 200 and the on-vehicle battery 110. The discharging relay (DCHR) 211 is controlled by a control signal SE3 from the ECU 300 and switches coupling and cutoff of an electric power path between the AC inlet 220 and the 100 V AC inverter 201. When charged as illustrated in FIG. 1, the CHR 210 is controlled to be in a coupling state while the DCHR 211 is controlled to be in a cutoff state.

[0034] The ECU 300 includes a Central Processing Unit (CPU), a storage device, and an input/output buffer (all of them are not illustrated in FIG. 1). The ECU 300 inputs a signal from each sensor or a similar component, outputs a control signal to each device, and controls each device of the on-vehicle battery 110 and the vehicle 100.

These controls are not limited to be processed by software, but can be processed by dedicated hardware (an electronic circuit).

[0035] The ECU 300 operates a State Of Charge (SOC) of the on-vehicle battery 110 based on detected values of the voltage VB and the current IB from the on-vehicle battery 110.

[0036] The ECU 300 receives a proximate detection signal PISW (hereinafter referred to as a detection signal PISW) indicating a coupling state of the charging cable 400 from the AC connector 410. The ECU 300 receives a control pilot signal CPLT (hereinafter referred to as a pilot signal CPLT) from the CCID 430 of the charging cable 400. The ECU 300 performs a charge operation based on these signals.

[0037] The constitution of FIG. 1 includes one control unit as the ECU 300. However, for example, like a control unit for the PCU 120 and a control unit for the on-vehicle battery 110, individual control units may be disposed for each function and each controlled equipment.

[0038] Next, the following describes an alternating current charge mode. Society of Automotive Engineers (SAE) of the United States of America, International Electrotechnical Commission (IEC), and a similar organization standardize the pilot signal CPLT and the detection signal PISW, the shape of the AC inlet 220 and the AC connector 410, a terminal layout, and similar constitutions.

[0039] The CCID 430 includes a CPU, a storage device, and an input/output buffer (all of them are not illustrated). The CCID 430 inputs/outputs each sensor and a control pilot signal and controls a charging operation of the charging cable 400.

[0040] The ECU 300 operates the electric potential of the pilot signal CPLT. A duty cycle is set based on a rated current that can be supplied from the external alternating current power supply 500 to the vehicle 100 via the charging cable 400.

[0041] When the electric potential of the pilot signal CPLT decreases from a specified electric potential, the pilot signal CPLT oscillates at a specified cycle. Here, based on the rated current that can be supplied from the external alternating current power supply 500 to the vehicle 100 via the charging cable 400, a pulse width of the pilot

signal CPLT is set. That is, according to a duty indicated by a pulse width ratio with respect to the oscillating cycle, the use of the pilot signal CPLT notifies the rated current from a control pilot circuit in the CCID 430 to the ECU 300 in the vehicle 100.

[0042] A rated current is defined to each charging cable. The charging cable 400 of different type has a different rated current. Accordingly, the duty of the pilot signal CPLT differs depending on each charging cable 400.

[0043] The ECU 300 can sense a rated current that can be supplied to the vehicle 100 via the charging cable 400 based on the duty of the received pilot signal CPLT.

[0044] When a contact of internal relay of the CCID 430 is closed, alternating current power from the external alternating current power supply 500 is provided to the charger 200, thus preparation of charge from the external alternating current power supply 500 to the on-vehicle battery 110 is completed. The ECU 300 outputs the control signal PWD to the charger 200 to convert alternating current power from the external alternating current power supply 500 into a direct current power chargeable into the on-vehicle battery 110. Then, the ECU 300 outputs the control signal SE2 and closes the contact of the CHR 210, thus the on-vehicle battery 110 is charged.

[0045] FIG. 2 is a view for describing charge and discharge of alternating current power from the vehicle. As illustrated in the upper side of the view in FIG. 2, the vehicle 100 allowing external charging can store electric power from a power supply outside of the vehicle, such as the external alternating current power supply 500, into the on-vehicle battery 110 in the vehicle via an external Power Conditioning System (PCS) 900, the AC connector 410, and the charger 200.

[0046] Next, the following describes an alternating current discharge mode. Meanwhile, like what is called a smart grid, the following has been examined. A vehicle is considered as electric power supply source, and electric power stored in the vehicle is supplied to an electrical device outside of the vehicle. As a power supply in the case where an electrical device is used in a camp, outdoor work or a similar purpose, a vehicle is employed in some cases.

[0047] In this case, as illustrated at the lower drawing in FIG. 2, the vehicle operates in the alternating current discharge mode. Insofar as the alternating current discharge mode can supply electric power from the vehicle via the AC inlet 220, an outlet for coupling an electrical device needs not to be disposed separately. Therefore, modification at the vehicle side is not necessarily or can be reduced, thus the alternating current discharge mode is preferable.

[0048] The 100 V AC inverter 201 in the vehicle 100 converts direct current power stored in the on-vehicle battery 110, which is a power-generating device, into alternating current power (for example, 100 V AC and 200 V AC). The 100 V AC inverter 201 supplies the electric power to an electrical product 810 or a household battery 820 via an external PCS 900.

[0049] As an electric power generating device for the vehicle 100 in addition to the above-described on-vehicle battery 110, in the case of a hybrid vehicle with an engine, an engine and an electric generator are included. Further, electric power from an auxiliary battery (not illustrated in FIG. 1) to supply an auxiliary device included in the vehicle 100 with power supply voltage can also be used. Alternatively, in the case where the vehicle 100 is a fuel cell vehicle, electric power generated by fuel cell can also be supplied.

[0050] Next, the following describes the direct current charge mode and the direct current discharge mode. FIG. 3 is a view for describing an outline of a direct current charge mode and a direct current discharge mode. Now referring to FIG. 3, the direct current charge mode is a mode for charging an electric storage device of a vehicle using electric power from an external direct current power supply. The direct current charge mode allows high-speed charge compared with the alternating current charge mode in many cases.

[0051] Usually, the direct current charge mode converts alternating current power from the external alternating current power supply 500 into direct current power at the external PCS 900. The direct current power is supplied to the on-vehicle battery 110 via a DC connector 901 and the DC inlet 702. In this case, usually none is coupled to

the AC inlet 220.

[0052] On the other hand, supplying electric power from the vehicle 100 to the electrical product 810 and the household battery 820 via the external PCS 900 is also considered. Since a direct current charging path can handle large electric power compared with an alternating current charging path in many cases, the direct current charging path is preferable to feed comparatively large electric power from the vehicle to the outside.

[0053] Next, the following describes when the direct current path and the alternating current path are coupled simultaneously. FIG. 4 illustrates a state where charging and discharging cables are coupled simultaneously to an AC inlet and a DC inlet. Now referring to FIG. 4, the AC connector 410 is coupled to the AC inlet 220, and the DC connector 901 is coupled to the DC inlet 702. Thus, the external PCS 900 is coupled to the vehicle 100 with two paths (cables).

[0054] In the case where the coupling with two paths is available, the following cases are possible. Discharge from the on-vehicle battery 110 to the external PCS 900 is performed by only the use of the AC path. Discharge from the on-vehicle battery 110 to the external PCS 900 is performed by only the use of the DC path. Discharge from the on-vehicle battery 110 to the external PCS 900 is performed by the use of both paths.

[0055] Thus, when a plurality of paths are coupled, it is preferred to determine which path is the most appropriate and use the most appropriate path.

[0056] FIG. 5 is a block diagram illustrating a schematic constitution of the vehicle and a house when a direct current path and an alternating current path are coupled simultaneously. Now referring to FIG. 5, the vehicle 100 includes a DC charging inlet 702, an AC charging inlet 220, an AC/DC inverter 201', the on-vehicle battery 110, the communication unit 370, and the ECU 300. The AC/DC inverter 201' performs DC-AC conversion.

[0057] Direct current power from the on-vehicle battery 110 can be output from the AC charging inlet 220 to the outside after being converted into alternating current power by the AC/DC inverter 201'. Direct current power from the on-vehicle battery

110 can be output from the DC charging inlet 702 to the outside remaining as direct current power.

[0058] A house 1000 includes the electrical product (a load) 810, the household battery 820, the PCS 900, a communication unit 870, and an external control unit 800. The PCS 900 includes an AC/DC inverter 906, a DC/DC converter 902, and a DC/AC converter 904. The AC/DC inverter 906 performs DC-AC conversion. The DC/DC converter 902 performs DC-DC conversion. The DC/AC converter 904 performs AC-DC conversion.

[0059] The DC connector 901 and a power cable for direct current can couple the DC/DC converter 902 and the DC charging inlet 702. The AC connector 410 and a power cable for alternating current can couple the DC/AC converter 904 and the AC charging inlet 220. The power cable for alternating current includes a communications line for transmitting the control pilot signal CPLT as well as the power line. The AC connector 410 and the AC charging inlet 220 include connecting terminals for the communications line as well as terminals for the power line.

[0060] The AC connector 410 and the DC connector 901 may be like an integrated combo connector of SAE J1772 standard. The AC charging inlet 220 and the DC charging inlet 702 may be like an integrated port for combo connector of SAE J1772 standard.

[0061] The communication unit 370 is constituted so as to cause a control pilot signal CPLTC to superimpose information JC to produce a control pilot signal CPLT. The communication unit 370 is also constituted so as to separate the information JC from the control pilot signal CPLT with the information JC superimposed and produce a control pilot signal CPLTC or CPLTH. The information JC is transmitted/received between the communication unit 370 and the ECU 300 over, for example, an in-vehicle communications network.

[0062] The communication unit 870 is constituted so as to cause the control pilot signal CPLTH to superimpose information JH to produce the control pilot signal CPLT. The communication unit 870 is also constituted so as to separate the information

JH from the control pilot signal CPLT with the information JH superimposed and produce the control pilot signal CPLTH. The separated information JH is transmitted/received between the communication unit 870 and the external control unit 800 over, for example, a domestic communications network.

[0063] FIG. 6 is a block diagram illustrating a schematic constitution of when an emergency outlet is provided to a house side with the constitution illustrated in FIG. 5. Now referring to FIG. 6, an emergency AC outlet 920 is installed to the house 1000. The emergency AC outlet 920 can be coupled to the AC connector 410 via a switch 922. For example, when power is fed from the vehicle 100 in case of emergency, coupling of the switch 922 is switched from the DC/AC converter 904 to the emergency AC outlet 920. A user may switch the switch 922, or the switch 922 may be constituted so as to automatically switch upon detection of a power failure.

[0064] Now, the following describes Embodiment 1 in charge and discharge controls of the present invention. FIG. 7 is a flowchart for describing a process of selecting a charge control and a discharge control performed by the ECU 300.

[0065] Now referring to FIG. 5 and FIG. 7, when a process is started, the ECU 300 detects whether a discharge request is made or not in Step S1. For example, when the discharge request is input from the external control unit 800 in the house 1000 to the ECU 300 via the communication units 870 and 370 or when the user inputs a discharge command to an operating unit (not illustrated) in case of a power failure or a similar failure and then the operating unit inputs a discharge request to the ECU 300, the discharge request is determined to be made in Step S1.

[0066] More specifically, the following is considered. The external control unit 800 charges electric power of cheap unit price during nighttime in the on-vehicle battery 110. For consuming electric power charged in the electrical product 810 during daytime, the external control unit 800 transmits a discharge request to the vehicle 100. In case of a power failure or a similar failure, the following is considered. The user operates the operating unit to input the discharge request to the vehicle 100, and the electric power from the on-vehicle battery 110 can be used for the electrical product 810

in the house.

[0067] When the discharge request is made in Step S1, the process proceeds to Step S2, the ECU 300 performs discharge control of the on-vehicle battery 110. Meanwhile, when the discharge request is not made in Step S1, the process proceeds to Step S3.

[0068] In Step S3, the ECU 300 detects whether the charge request is made or not. For example, when the discharge request is input from the external control unit 800 in the house 1000 to the ECU 300 via the communication units 870 and 370 or when the user inputs the discharge command to the operating unit (not illustrated) when the vehicle 100 that has been out returns or a similar situation, and the operating unit inputs the discharge request to the ECU 300, the discharge request is determined to be made in Step S3.

[0069] When the discharge request is made in Step S3, the process proceeds to Step S4, the ECU 300 performs discharge control of the on-vehicle battery 110. Meanwhile, when the discharge request is not made in Step S3, the process proceeds to Step S5, and the process is returned to the main routine.

[0070] FIG. 8 is a flowchart for describing a first process of selecting AC discharge and DC discharge in the discharge control performed by the ECU 300. Now referring to FIG. 5 and FIG. 8, when the process in the flowchart is started, the ECU 300 obtains information on the house 1000 side from the external control unit 800 via the communication units 870 and 370 in Step S11. The obtained information includes information on: 1) whether PCS 900 is present in the house 1000 or not; 2) whether the PCS 900 can receive DC discharge or not (whether the DC power path is dedicated for charge of an on-vehicle battery or not); 3) whether the PCS 900 can receive AC discharge or not (whether the AC power path is dedicated for charge of the on-vehicle battery or not); 4) whether an emergency outlet is present in the house or not, or similar information.

[0071] In Step S12, the ECU 300 determines whether the PCS 900 is present at the house side or not, based on the obtained information. For example, the house with

the constitution illustrated in FIG. 5 is determined that the PCS 900 is present in Step S12, and the process proceeds to Step S13.

[0072] In Step S13, the ECU 300 determines whether the PCS 900 can receive DC discharge or not, based on the obtained information. Even if the PCS 900 includes the DC connector 901, the PCS 900 may have a specification chargeable only to the on-vehicle battery 110.

[0073] In Step S13, when it is determined that the PCS 900 can receive the DC discharge, the process proceeds to Step S14. To perform discharge using the DC path, the ECU 300 conducts the relay 707 in FIG. 1, stops the inverter 201, separates the relay 211, or performs similar control.

[0074] In Step S13, if it is determined that the PCS 900 cannot receive the DC discharge, the process proceeds to Step S16.

[0075] In Step S16, the ECU 300 determines whether the PCS 900 can receive AC discharge or not, based on the obtained information. Even if the PCS 900 includes the AC connector 410, the PCS 900 may have a specification chargeable only to the on-vehicle battery 110. In Step S16, when it is determined that the PCS 900 can receive the AC discharge, the process proceeds to Step S17. In Step S16, when it is determined that the PCS 900 cannot receive the AC discharge, the process proceeds to Step S18.

[0076] When the process proceeds from Step S12 to Step S15, the ECU 300 determines whether an emergency outlet is present at the house side or not, based on the information obtained in Step S11. For example, the house with the constitution illustrated in FIG. 5 is determined that the emergency outlet is absent in Step S15, and the process proceeds to Step S18. The house with the constitution illustrated in FIG. 6 is determined that the emergency outlet is present in Step S15, and the process proceeds to Step S17.

[0077] In Step S17, to perform discharge using the AC path, the ECU 300 separates the relay 707 in FIG. 1, operates the inverter 201, couples the relay 211, or performs similar control.

[0078] When the process proceeds to Step S18, discharge from the on-vehicle

battery 110 is not performed.

[0079] As described above, the power supply device for a vehicle of Embodiment 1 can obtain information regarding specifications of an external device coupled over communications and can discharge the external device with optimum aspect.

[0080] In Embodiment 1, in the case where the house and the vehicle are coupled with both the DC power path and the AC power path, in particular, like the case where a combo connector of SAE J1772 standard is used, which path should be selected for discharge is clarified.

[0081] Next, the following describes Embodiment 2. FIG. 9 is a flowchart for describing a second process of selecting AC discharge and DC discharge in the discharge control performed by the ECU 300. Now referring to FIG. 5 and FIG. 9, when the process in the flowchart is started, the ECU 300 first obtains a failure situation of the PCS 900 at the house 1000 side from the external control unit 800 via the communication units 870 and 370 in Step S31. The obtained information includes information on presence/absence of a failure in the DC/DC converter 902, presence/absence of a failure in the DC/AC converter 904, or similar information.

[0082] In Step S32, the ECU 300 determines whether the DC/DC converter 902 is faulty or not based on the obtained information. When it is determined that the DC/DC converter 902 is not faulty in Step S32, the process proceeds to Step S36 and DC discharge is performed. Since DC discharge can output electric power of the on-vehicle battery 110 without conversion into alternating current, the number of conversions is small. Therefore, DC discharge is efficient and is preferentially selected. On the other hand, when it is determined that the DC/DC converter 902 has a fault in Step S32, the process proceeds to Step S33.

[0083] In Step S33, the ECU 300 determines whether the DC/AC converter 904 is faulty or not, based on the obtained information. When it is determined that the DC/AC converter 904 is not faulty in Step S33, the process proceeds to Step S35 and AC discharge is performed. AC discharge is less efficient than DC discharge; however, the

AC discharge is selected because electric power of the on-vehicle battery 110 can be supplied to the PCS 900. On the other hand, when it is determined that the DC/AC converter 904 has a fault in Step S33, the process proceeds to Step S34. The ECU 300 does not perform discharge from the on-vehicle battery 110.

[0084] With the power supply device for a vehicle of Embodiment 2, as long as the PCS 900 at the house side normally operates, the number of conversions is small. Therefore, efficient DC discharge is performed. Even if DC discharge cannot be performed due to a failure, AC discharge is performed and power can be fed from the vehicle to the PCS 900 in the house.

[0085] In Embodiment 2 as well, in the case where the house and the vehicle are coupled with both the DC power path and the AC power path, in particular, like the case where the combo connector of SAE J1772 standard is used, which path should be selected for discharge is clarified.

[0086] [Embodiment 3] Embodiment 3 simultaneously performs AC discharge and DC discharge in case of a power failure. During a power failure, a commercial power supply is not supplied to the house side. This tends to cause shortage of electric power; therefore, it is designed that the maximum electric power can be supplied from the vehicle.

[0087] FIG. 10 is a flowchart for describing a process of determining whether the AC discharge and the DC discharge are simultaneously performed or not in the discharge control performed by the ECU 300. Now referring to FIG. 5 and FIG. 10, after starting the process of this flowchart, first, communications are attempted to the communication unit 870 at the house 1000 side, and it is determined whether the communication unit 870 responds to it or not in Step S51.

[0088] When the communication unit 870 responds in Step S51, the process proceeds to Step S54 and control is returned to the main routine. On the other hand, when there is no response in Step S51, it is determined that a power failure occurs in the house 1000, and the process proceeds to Step S52. For example, if the communication unit 870 obtains its power supply from the commercial power supply, a power failure

causes the communication unit 870 to stop responding.

[0089] In Step S52, the ECU 300 determines whether an emergency power feeding command is input or not. The user inputs the emergency power feeding command from the operating unit (not illustrated). This operating unit may not be dedicated for input of the emergency power feeding command. Any operating unit may be employed as long as discharging the ECU 300 in the vehicle is allowed with the operating unit employed for another function. For example, a vehicle may be constituted such that striking a vehicle start switch (a start button) repeatedly inputs the emergency power feeding command. In Step S52, if the emergency power feeding command is not input, the process proceeds to Step S55 and discharge is not performed. On the other hand, in the case where the emergency power feeding command is input in Step S52, the process proceeds to Step S53. To simultaneously perform AC discharge and DC discharge, the ECU 300 conducts the relays 211 and 707 in FIG. 1 to operate the inverter 201.

[0090] In Embodiment 3 as well, in the case where the house and the vehicle are coupled with both the DC power path and the AC power path, in particular, like the case where the combo connector of SAE J1772 standard is used, when to perform discharge from both paths can be determined, thus both paths can supply large electric power to the house.

[0091] Finally, the following summarizes Embodiments 1 to 3 with reference to the drawings again. Now referring to FIG. 1, the power supply device for a vehicle includes the on-vehicle battery 110, which is a power supply, the alternating current coupling unit (the alternating current inlet) 220, the direct current coupling unit (the DC inlet) 702, the communication unit 370, and the control unit (the ECU) 300. The alternating current coupling unit 220 is configured to transmit and receive alternating current power between the on-vehicle battery 110 and an external device for a vehicle. The direct current coupling unit 702 is configured to transmit and receive direct current power between the on-vehicle battery 110 and the external device. The communication unit 370 is configured to obtain information on the external device for a house or a

similar building from the external device through communications. The control unit 300 is configured to determine whether to discharge electric power from the on-vehicle battery 110 to the external device via the alternating current coupling unit 220 or not and whether to discharge electric power from the on-vehicle battery 110 to the external device via the direct current coupling unit 702 or not, based on the information obtained from the communication unit 370.

[0092] Preferably, as illustrated in FIG. 5 and FIG. 6, the external device includes the DC/AC converter 904, the DC/DC converter 902, and the external control unit 800. The DC/AC converter 904 is coupled to the alternating current coupling unit 220. The DC/AC converter 904 is configured to convert electric power. The DC/DC converter 902 is coupled to the direct current coupling unit 702. The DC/DC converter 902 is configured to convert electric power. The external control unit 800 is configured to monitor a state of the DC/AC converter 904 and the DC/DC converter 902. The external control unit 800 is configured to transmit a monitoring result to the communication unit 370. The ECU 300 is configured to obtain the monitoring result from the external control unit 800 as the information.

[0093] More preferably, as illustrated in FIG. 9, when both the DC/AC converter 904 and the DC/DC converter 902 normally operate, the ECU 300 performs a control to discharge electric power from the on-vehicle battery 110 to the external device via the direct current coupling unit 702 without use of the alternating current coupling unit 220.

[0094] More preferably, as illustrated in FIG. 9, when the monitoring result shows that the DC/AC converter 904 normally operates and the DC/DC converter 902 does not normally operate, the ECU 300 performs control to discharge electric power from the on-vehicle battery 110 to the external device via the alternating current coupling unit 220 without use of the direct current coupling unit 702.

[0095] More preferably, as illustrated in FIG. 9, when the monitoring result shows that both the DC/AC converter 904 and the DC/DC converter 902 are not able to normally operate, the ECU 300 inhibits discharge from the on-vehicle battery 110 to the external device.

[0096] Preferably, as illustrated in FIG. 10, in the case where the ECU 300 does not obtain the information from the communication unit 370, when an operator provides an emergency power feeding command, the ECU 300 performs control to discharge electric power from the on-vehicle battery 110 to the external device using both of a path via the alternating current coupling unit 220 and a path via the direct current coupling unit 702.

CLAIMS

1. A power supply device for a vehicle, the power supply device comprising:
 - a power supply;
 - an alternating current coupling unit configured to transmit and receive alternating current power between the power supply and an external device for the vehicle;
 - a direct current coupling unit configured to transmit and receive direct current power between the power supply and the external device;
 - a communication unit configured to obtain information on the external device from the external device through communications; and
 - an electronic control unit configured to determine: (i) whether or not to discharge electric power from the power supply to the external device via the alternating current coupling unit based on the information obtained from the communication unit; and (ii) whether or not to discharge electric power from the power supply to the external device via the direct current coupling unit based on the information obtained from the communication unit.

2. The power supply device for a vehicle according to claim 1, wherein:
 - the external device includes:
 - a first power conversion unit coupled to the alternating current coupling unit, the first power conversion unit being configured to convert electric power;
 - a second power conversion unit coupled to the direct current coupling unit, the second power conversion unit being configured to convert electric power; and
 - an external control unit configured to monitor a state of the first power conversion unit and the second power conversion unit to transmit a monitoring result to the communication unit, wherein
 - the electronic control unit is configured to obtain the monitoring result from the external control unit as the information.

3. The power supply device for a vehicle according to claim 2, wherein the electronic control unit is configured to perform control to discharge electric power from the power supply to the external device via the direct current coupling unit without use of the alternating current coupling unit when both the first power conversion unit and second power conversion unit normally operate.

4. The power supply device for a vehicle according to claim 2, wherein the electronic control unit is configured to perform control to discharge electric power from the power supply to the external device via the alternating current coupling unit without use of the direct current coupling unit when the monitoring result shows that the first power conversion unit normally operates and the second power conversion unit does not normally operate.

5. The power supply device for a vehicle according to claim 2, wherein the electronic control unit is configured to inhibit discharge from the power supply to the external device when the monitoring result shows that both the first power conversion unit and the second power conversion unit are not able to normally operate.

6. The power supply device for a vehicle according to claim 1, wherein the electronic control unit is configured to perform control to discharge electric power from the power supply to the external device using both of a path via the alternating current coupling unit and a path via the direct current coupling unit when the electronic control unit does not obtain the information from the communication unit and an emergency power feeding command is input by an operator.

7. The power supply device for a vehicle according to claim 1, wherein the electronic control unit is configured to inhibit discharge of electric power from the power supply to the external device when the electronic control unit does not obtain the information from the communication unit and an emergency power feeding command

is not input by an operator.

FIG. 1

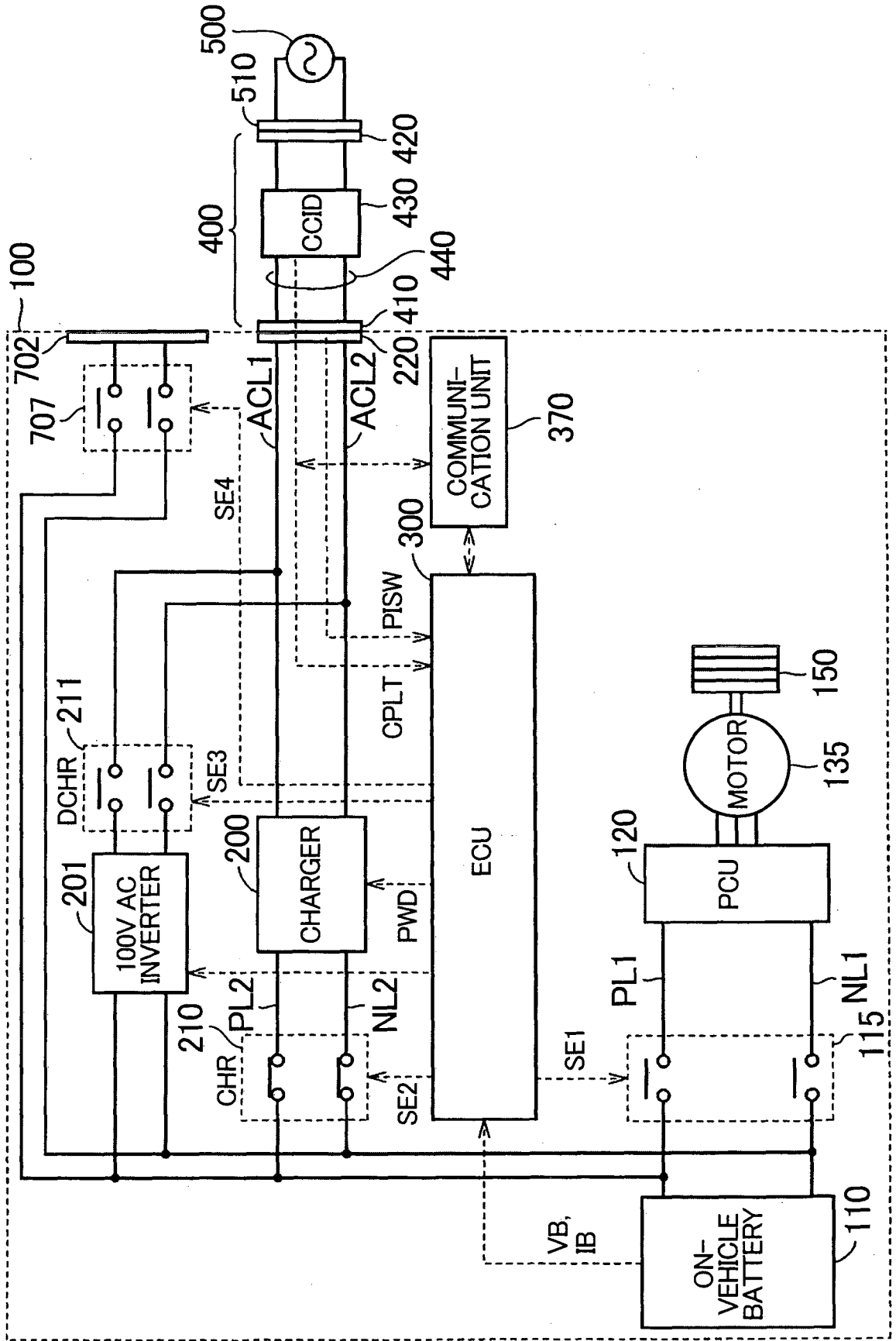
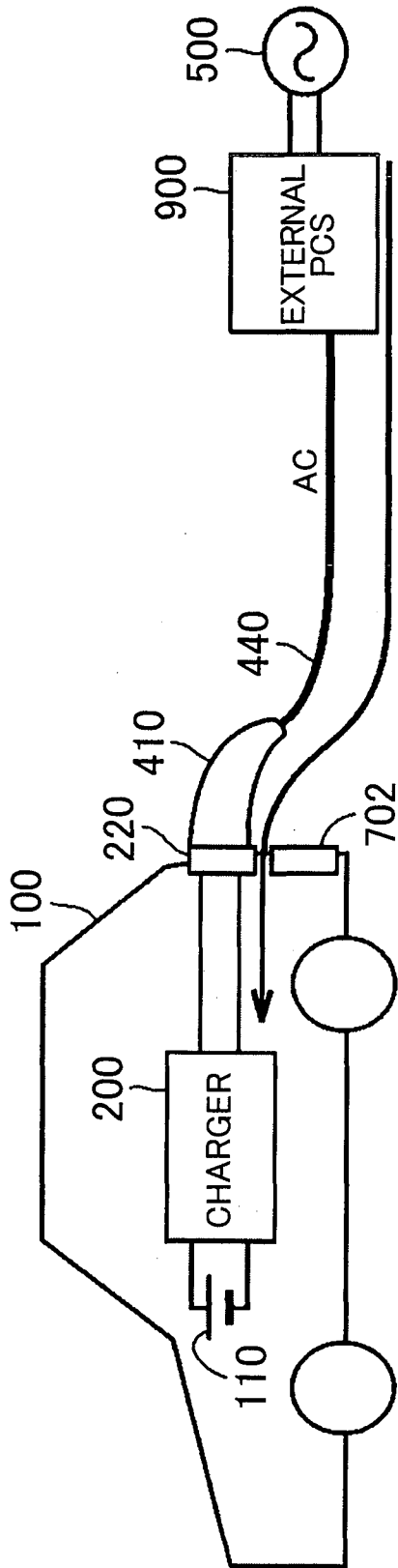
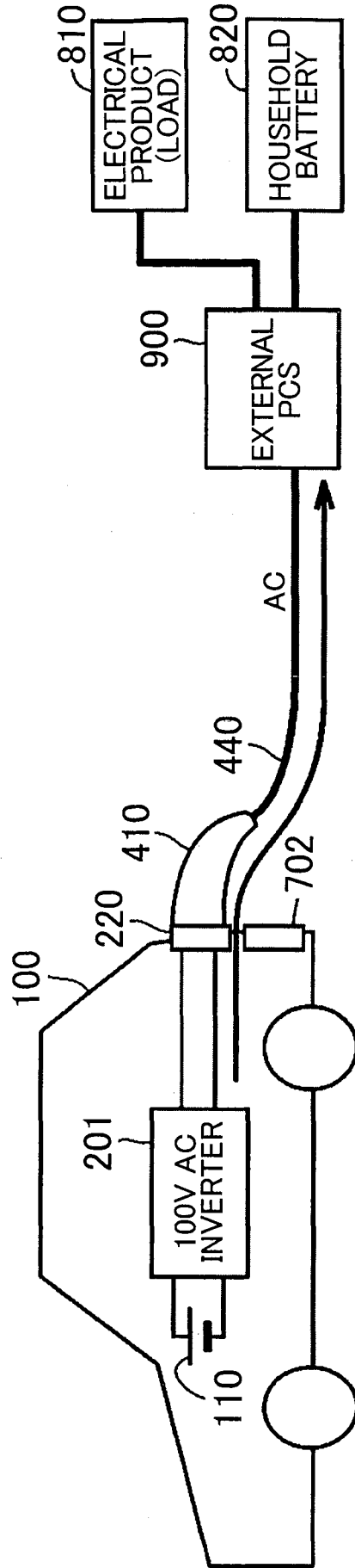


FIG. 2



CHARGE USING ALTERNATING CURRENT POWER FROM EXTERNAL ALTERNATING CURRENT POWER SUPPLY



DRIVE EXTERNAL ALTERNATING CURRENT ELECTRICAL DEVICE BY ALTERNATING CURRENT POWER FROM VEHICLE

FIG. 3

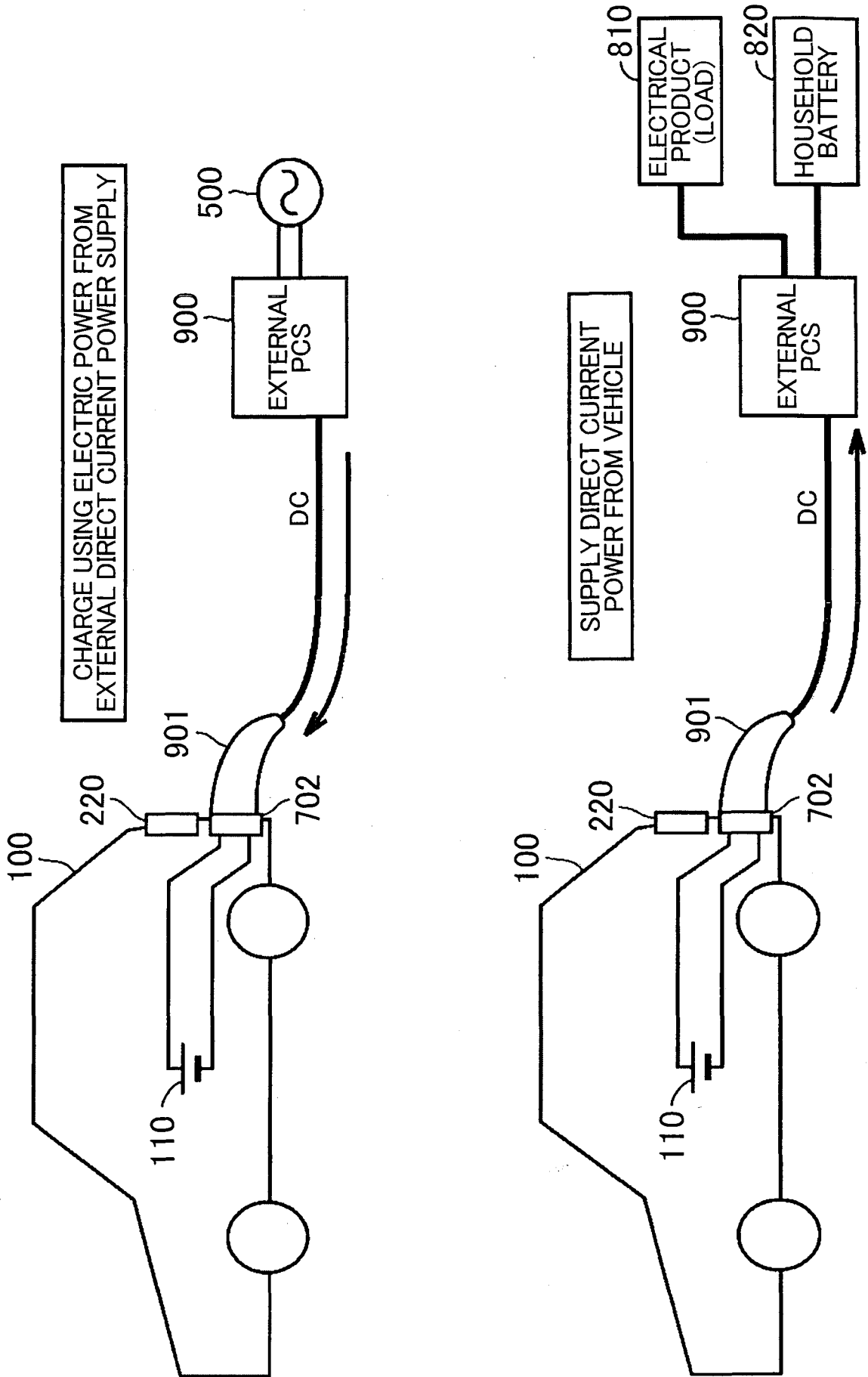


FIG. 4

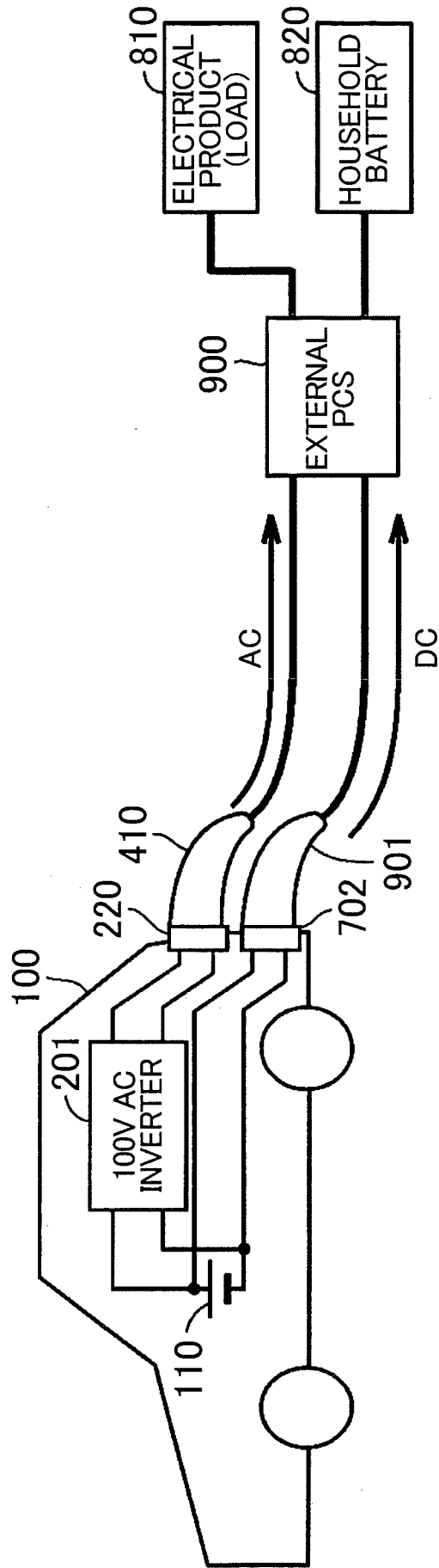


FIG. 5

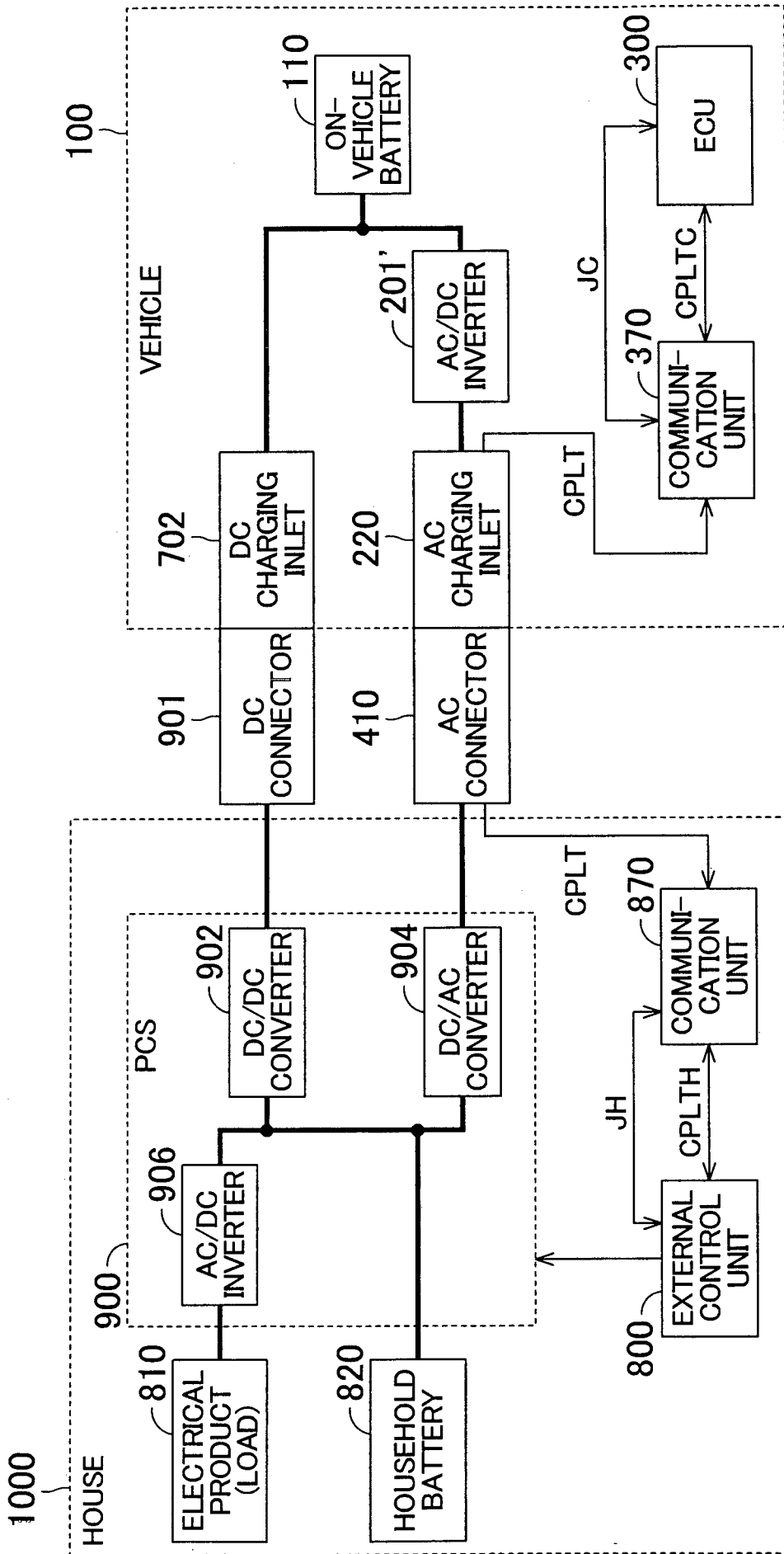


FIG. 6

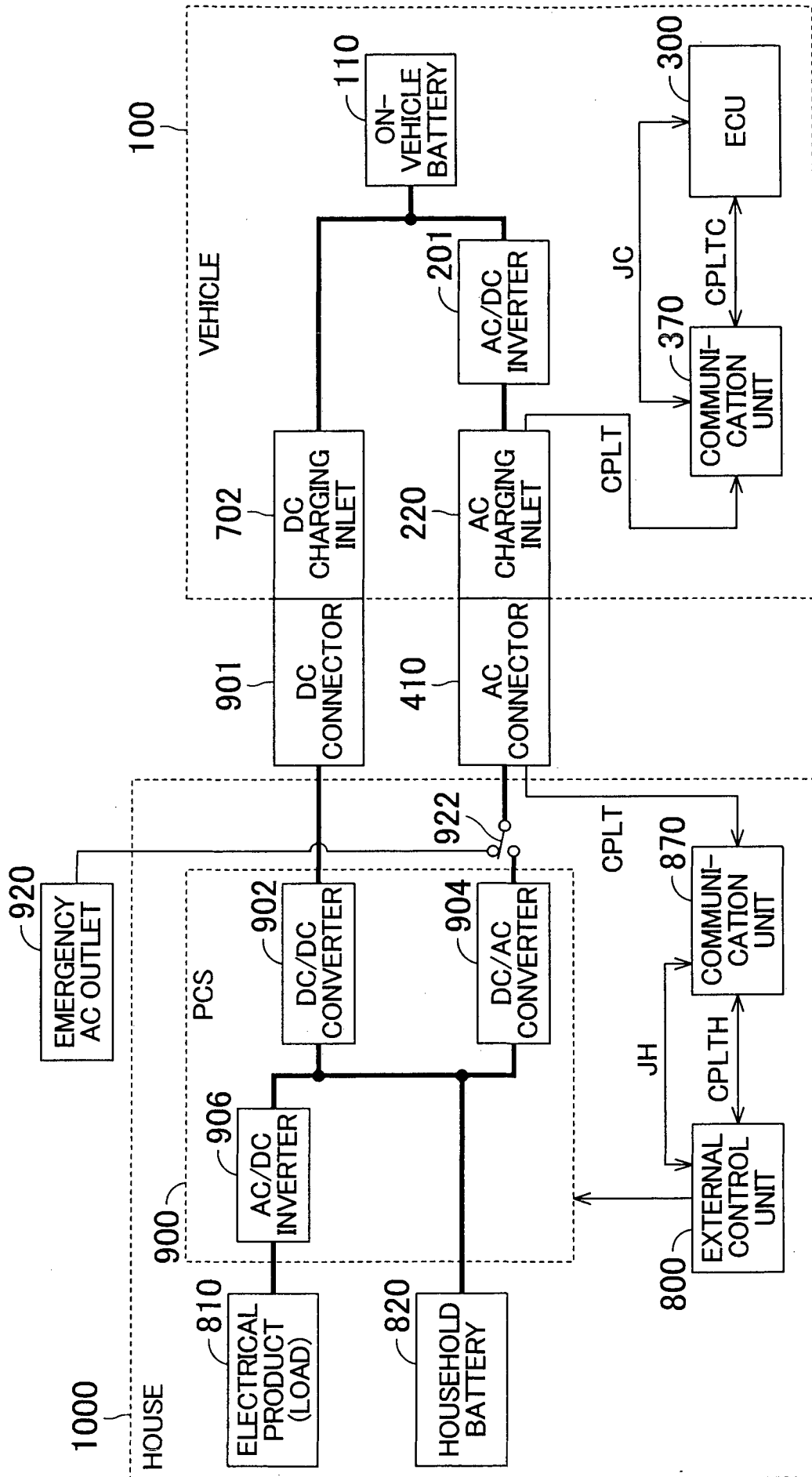


FIG. 7

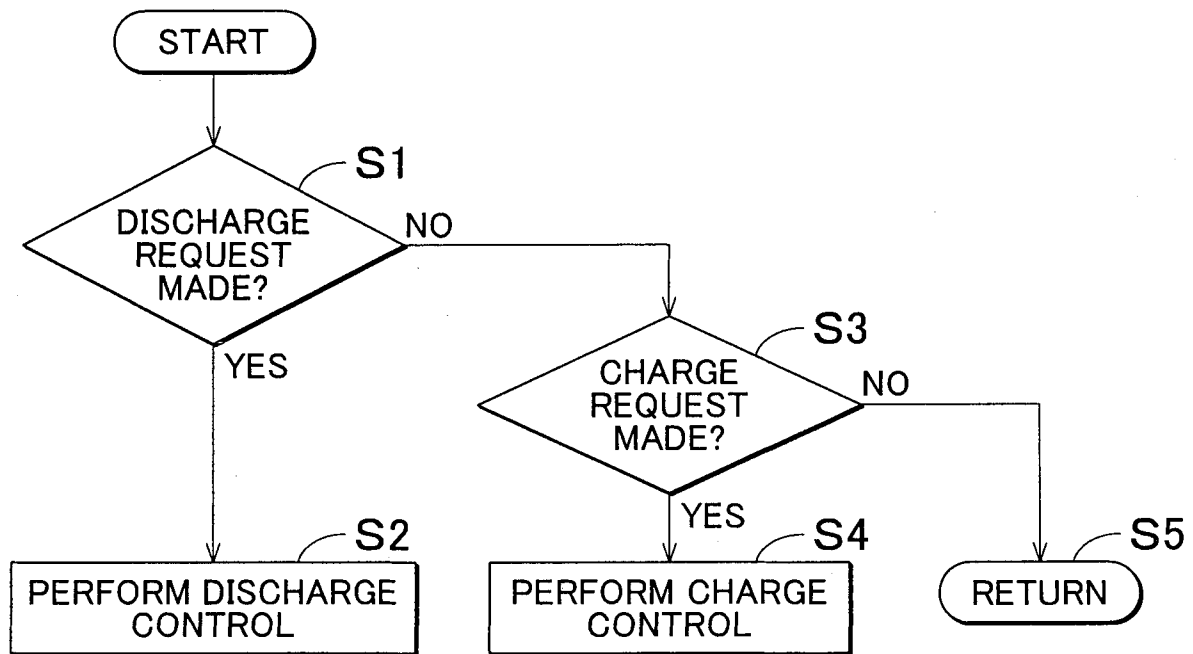


FIG. 8

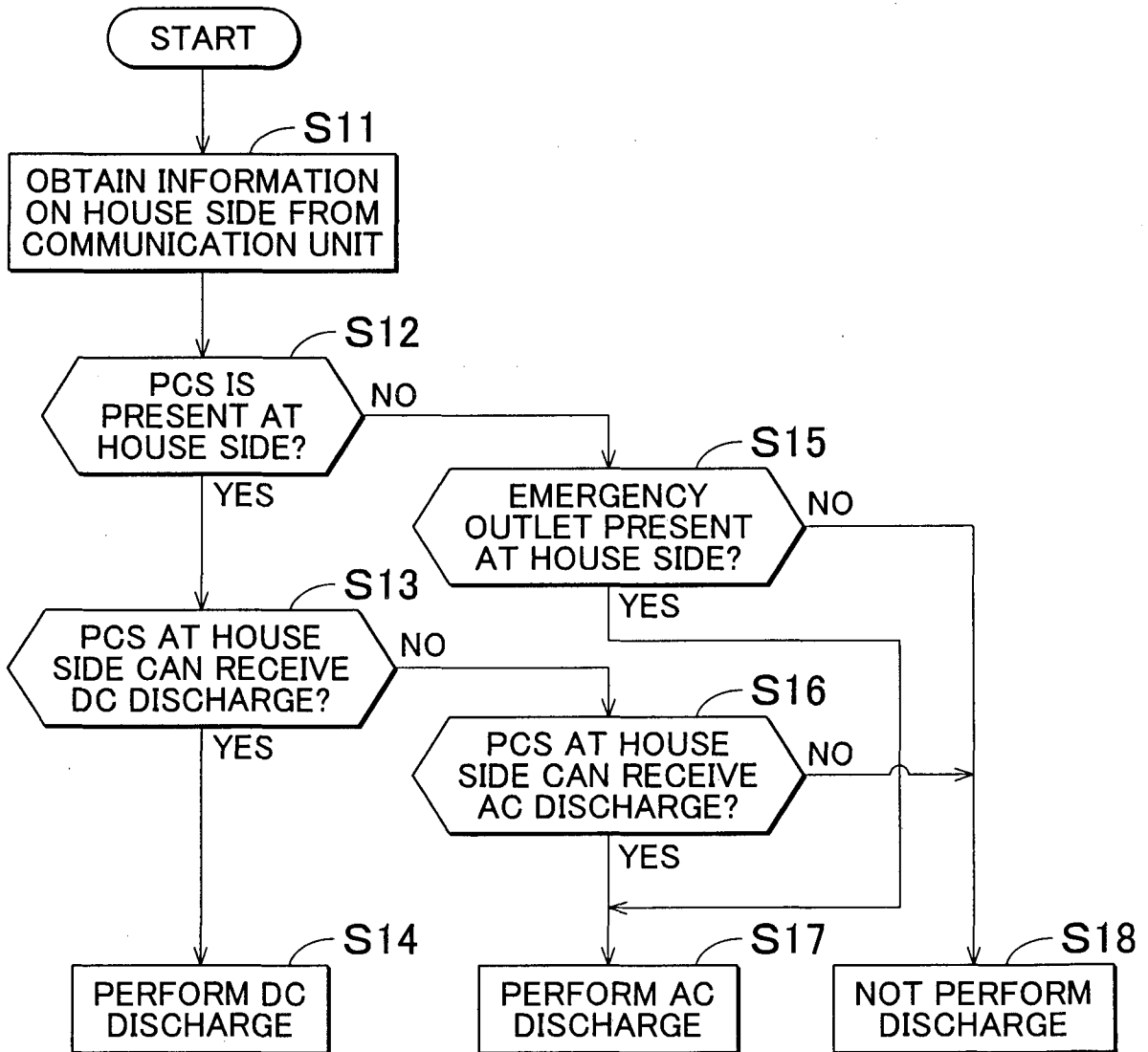


FIG. 9

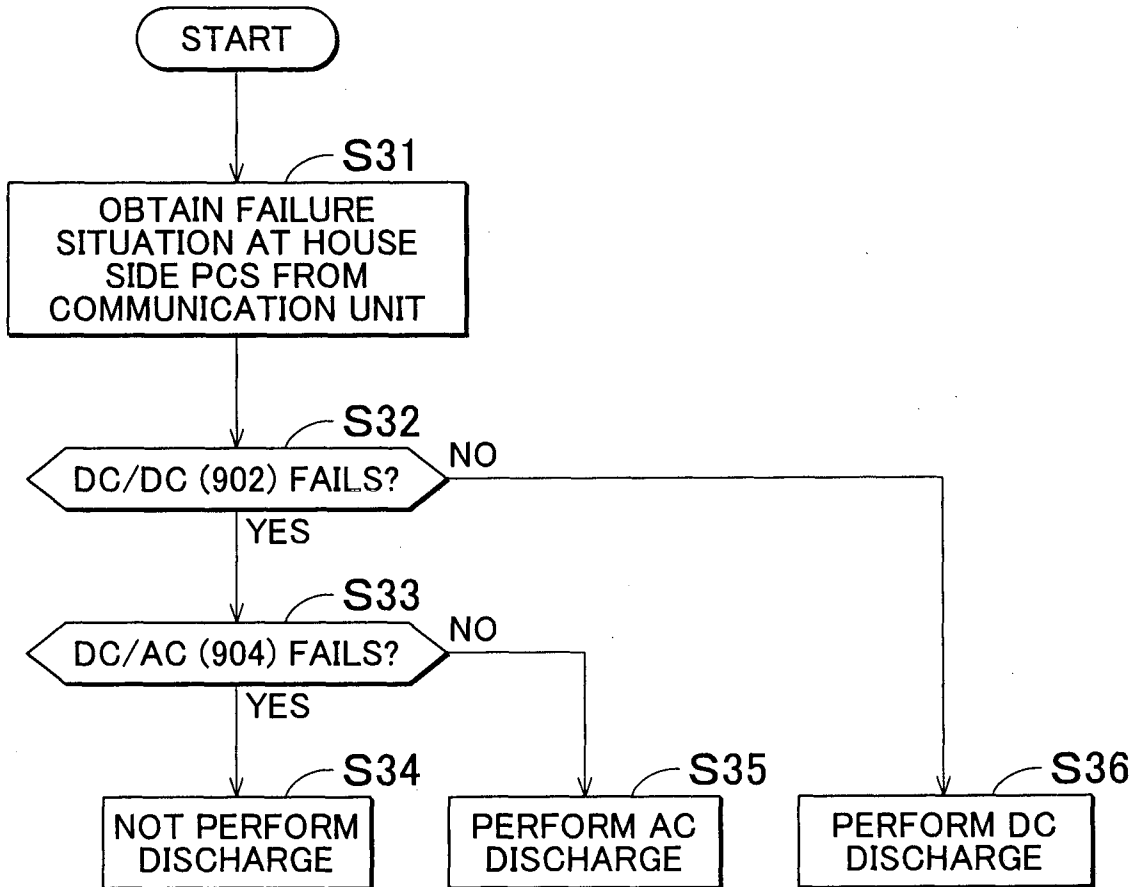


FIG. 10

