

(43) International Publication Date
2 February 2012 (02.02.2012)

PCT

(10) International Publication Number
WO 2012/014484 A2(51) International Patent Classification:
B60L 11/18 (2006.01)(21) International Application Number:
PCT/JP2011/004282(22) International Filing Date:
28 July 2011 (28.07.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
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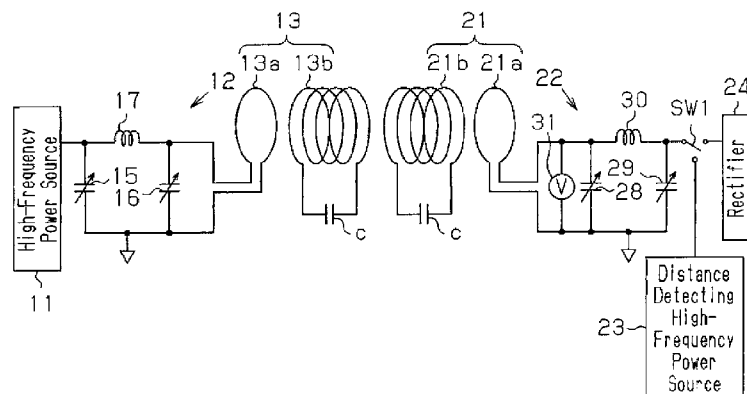
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, 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, PE, PG, PH, PL, PT, RO, RS, RU, 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, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: RESONANCE TYPE NON-CONTACT POWER SUPPLY SYSTEM

[Fig. 2]



(57) Abstract: A power supplying equipment (10) includes a high-frequency power source (11) and a primary-side resonance coil (13b). A movable body equipment (20) includes a secondary-side resonance coil (21b). The movable body equipment (20) includes a distance detecting high-frequency power source (23) between a secondary-side resonance coil (21b) and a rectifier (24). When the distance between a primary-side resonance coil (13b) and the secondary-side resonance coil (21b) is detected, an output from the distance detecting high-frequency power source (23) is supplied to the secondary-side resonance coil (21b) via a secondary matching unit (22, 22A, 23B). When the power supplying equipment (10) supplies power, the distance detecting high-frequency power source (23) is stopped, and the power supplied by the power supplying equipment (10) is supplied to a secondary battery (26) via the secondary matching unit (22, 22A, 22B) and the rectifier (24).

Published:

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

Description

Title of Invention: RESONANCE TYPE NON-CONTACT POWER SUPPLY SYSTEM

Technical Field

[0001] The present invention relates to a resonance type non-contact power supply system. More specifically, the present invention pertains to a resonance type non-contact power supply system that is suitable for charging a secondary battery mounted on a movable body without contact.

Background Art

[0002] Japanese Laid-Open Patent Publication No. 2009-106136 proposes a charging system in which a vehicle mounted electrical storage device is charged by a power source outside the vehicle through wireless reception of charging power through a resonance method. Specifically, the charging system of the above document includes an electric vehicle and a power supply device. The electric vehicle has a secondary self-resonance coil, which is a secondary-side resonance coil, a secondary coil, a rectifier, and an electrical storage device. The power supply device has a high-frequency power driver, a primary coil, and a primary self-resonance coil, which is a primary-side resonance coil. The number of turns of the secondary self-resonance coil is determined based on the voltage of the electrical storage device, the distance between the primary self-resonance coil and the secondary self-resonance coil, and the resonant frequency of the primary self-resonance coil and the secondary self-resonance coil. The distance between the power supply device and the vehicle changes depending on the conditions of the vehicle, for example, the loading state and the tire air pressure. Changes in the distance between the primary self-resonance coil of the power supply device and the secondary self-resonance coil of the vehicle change the resonant frequency of the primary self-resonance coil and the secondary self-resonance coil. Therefore, in the electric vehicle of the above document, a variable capacitor is connected between the ends of the wire forming the secondary self-resonance coil. When charging the electrical storage device, the charging system of the above document calculates the charging power of the electrical storage device based on the detected values of a voltage sensor and a current sensor. The above document discloses that the charging system adjusts the LC resonant frequency of the secondary self-resonance coil by adjusting the capacity of the variable capacitor connected to the secondary self-resonance coil such that the charging power is maximized.

[0003] As described above, an objective of the power supplying method disclosed in the above document is to efficiently supply power from the power supplying section to the

power receiving section even if the distance between the primary self-resonance coil and the secondary self-resonance coil is changed depending on the conditions of the vehicle, for example, the loading state and the tire air pressure. The power supplying method therefore adjusts the capacity of the variable capacitor of the secondary self-resonance coil when charging the electrical storage device such that the charging power of the electrical storage device is maximized. However, such a power supplying method requires calculating the charging power of the electrical storage device based on the detected values of the voltage sensor and the current sensor, and adjusting the capacity of the variable capacitor until the charging power is maximized.

[0004] If the power receiving section (movable body) can detect the distance between the resonance coil of the power supplying section and the resonance coil of the power receiving section, the power receiving section can adjust a matching unit in the power receiving section in accordance with the distance so that the power supplying section efficiently supplies power to the power receiving section. However, if a typical distance sensor is provided in the movable body, and the distance sensor detects the distance between the movable body and power supplying equipment, it is difficult to accurately detect the distance between the primary resonance coil and the secondary resonance coil.

Citation List

Patent Literature

[0005] PTL 1: Japanese Laid-Open Patent Publication No. 2009-106136

Summary of Invention

Technical Problem

[0006] Accordingly, it is an objective of the present invention to provide a resonance type non-contact power supply system that detects the distance between a resonance coil in a power supplying section and a resonance coil provided in a power receiving section, which is a movable component, in the movable body by utilizing a matching unit provided in the power receiving section, and efficiently supplies power from the power supplying section to the power receiving section.

Solution to Problem

[0007] To achieve the foregoing objective and in accordance with one aspect of the present invention, a resonance type non-contact power supply system includes power supplying equipment and movable body equipment. The power supplying equipment includes an alternating-current power source and a primary-side resonance coil for receiving power from the alternating-current power source. The movable body equipment includes a secondary-side resonance coil for receiving power from the primary-side resonance coil, a rectifier for rectifying the power received by the

secondary-side resonance coil, and a secondary battery, to which the power rectified by the rectifier is supplied. The movable body equipment further includes a secondary matching unit and a distance detecting high-frequency power source between the secondary-side resonance coil and the rectifier. When the distance between the primary-side resonance coil and the secondary-side resonance coil is detected, an output of the distance detecting high-frequency power source is supplied to the secondary-side resonance coil via the secondary matching unit. When the power supplying equipment supplies power, the distance detecting high-frequency power source is stopped, and the power supplied by the power supplying equipment is supplied to the secondary battery via the secondary matching unit and the rectifier.

[0008] With this structure, before supplying power from the power supplying equipment to the movable body equipment, the distance between the primary-side resonance coil and the secondary-side resonance coil is detected. During detection of the distance, the output of the distance detecting high-frequency power source is not supplied to the secondary battery, but is supplied to the secondary-side resonance coil. Therefore, the input impedance of the resonance system is not influenced by the charge state of the secondary battery.

[0009] The term <resonance system> includes the primary-side resonance coil and the secondary-side resonance coil. During detection of the distance in the movable body equipment, the <resonance system> includes circuit components arranged between the distance detecting high-frequency power source and the secondary-side resonance coil, for example, the secondary matching unit and the secondary coil, and circuit components arranged between the primary-side resonance coil of the power supplying equipment and the alternating-current power source, for example, the primary coil and a primary matching unit. When the secondary-side resonance coil receives power from the primary-side resonance coil, the <resonance system> includes circuit components located between the alternating-current power source and the primary-side resonance coil, for example, the primary matching unit and the primary coil, the rectifier to which power is supplied from the secondary-side resonance coil and the secondary battery. The <resonance system> further includes circuit components located between the secondary-side resonance coil and the rectifier, for example, the secondary matching unit and the secondary coil.

[0010] Also, the term <input impedance of the resonance system> refers to the impedance of the entire resonance system detected between the ends of the input-side coil to which alternating-current is supplied when the distance between the primary-side resonance coil and the secondary-side resonance coil is detected. For example, when an alternating-current is input from the distance detecting high-frequency power source of the movable body equipment, and a secondary coil device is formed by the secondary

coil and the secondary-side resonance coil, <the input impedance of the resonance system> refers to the impedance of the entire resonance system detected between the ends of the secondary coil. Alternatively, when the secondary coil device only includes the secondary-side resonance coil, the <input impedance of the resonance system> refers to the impedance of the entire resonance system detected between the ends of the secondary-side resonance coil. When the secondary-side resonance coil receives power from the primary-side resonance coil, the <input impedance of the resonance system> refers to the impedance of the entire resonance system detected between the ends of the primary coil when a primary coil device is formed by the primary coil and the primary-side resonance coil. Alternatively, when the primary coil device only includes the primary-side resonance coil, the <input impedance of the resonance system> refers to the impedance of the entire resonance system detected between the ends of the primary-side resonance coil.

[0011] Therefore, the resonance type non-contact power supply system can detect the distance between the primary-side resonance coil and the secondary-side resonance coil by detecting the input impedance of the resonance system. Power is supplied from the power supplying equipment to the movable body equipment with the movable body stopped at the position at which the detected distance is equal to a value suitable for supplying power from the power supplying equipment to the movable body equipment. When power is supplied from the power supplying equipment to the secondary battery of the movable body equipment, the impedance of the secondary matching unit is adjusted to a value at which power is sufficiently supplied from the power supplying equipment to the movable body equipment at the detected distance. When output of the distance detecting high-frequency power source is stopped, power is supplied from the primary-side resonance coil of the power supplying equipment to the secondary-side resonance coil through non-contact resonance. The power received by the secondary-side resonance coil is supplied to the secondary battery via the secondary matching circuit and the rectifier, and thus, the secondary battery is charged. Thus, the resonance type non-contact power supply system detects the distance between the primary-side resonance coil of the power supplying section and the secondary-side resonance coil of the power receiving section in the movable body by utilizing the secondary matching circuit provided in the power receiving section, and efficiently supplies power from the power supplying section to the power receiving section.

[0012] The secondary matching unit is preferably of pi-type, and the distance detecting high-frequency power source supplies power to the secondary matching unit. In this case, the secondary matching unit functions bidirectionally without problem, when power is supplied from the power supplying equipment to the charger of the movable

body equipment, and when the distance between the primary-side resonance coil and the secondary-side resonance coil is detected.

[0013] The movable body equipment preferably further comprises a charger between the rectifier and the secondary battery. The power rectified by the rectifier is supplied to the charger, which can be connected to the secondary battery.

[0014] Even with this structure, before supplying power from the power supplying equipment to the movable body equipment, the distance between the primary-side resonance coil and the secondary-side resonance coil is detected. During detection of the distance, the output of the distance detecting high-frequency power source is not supplied to the charger, but is supplied to the secondary-side resonance coil. Therefore, the input impedance of the resonance system is not influenced by the charger or the charge state of the secondary battery.

[0015] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

[0016] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Brief Description of Drawings

[0017] [fig.1]Fig. 1 is a diagram showing a resonance type non-contact power supply system according to a first embodiment;

[fig.2]Fig. 2 is a circuit diagram that omits part of the resonance type non-contact power supply system of Fig. 1;

[fig.3]Fig. 3 is a diagram illustrating movable body equipment according to a second embodiment;

[fig.4A]Fig. 4A is a circuit diagram showing the structure of the secondary matching unit of Fig. 3;

[fig.4B]Fig. 4B is a circuit diagram showing the operation of the secondary matching unit of Fig. 4A;

[fig.5]Fig. 5 is a circuit diagram showing the structure of a secondary matching unit according to a third embodiment; and

[fig.6]Fig. 6 is a circuit diagram illustrating power supplying equipment according to a fourth embodiment.

Description of Embodiments

[0018] Figs. 1 and 2 show a resonance type non-contact power supply system according to a

first embodiment of the present invention. The resonance type non-contact power supply system charges a vehicle mounted battery.

[0019] As shown in Fig. 1, the resonance type non-contact power supply system includes power supplying equipment 10 and movable body equipment 20. The power supplying equipment 10 is power transmission equipment provided on the ground. The movable body equipment 20 is power receiving equipment mounted on a movable body, which is a vehicle in the first embodiment.

[0020] The power supplying equipment 10 is power supplying equipment, which includes a high-frequency power source 11, a primary matching unit 12, a primary coil device 13, and a power source controller 14. An alternating-current power source, which is the high-frequency power source 11 in this embodiment, receives a power ON/OFF signal from a power source-side controller, which is the power source controller 14 in this embodiment, so as to be turned on or off. The high-frequency power source 11 outputs alternating-current power the frequency of which is equal to a predetermined resonant frequency of the resonance system, for example, a high-frequency power of several MHz.

[0021] As shown in Fig. 2, the primary coil device 13 is a primary-side coil formed by a primary coil 13a and a primary-side resonance coil 13b. The primary coil 13a is connected to the high-frequency power source 11 via the primary matching unit 12. The primary coil 13a and the primary-side resonance coil 13b are arranged to be coaxial. A capacitor C is connected in parallel to the primary-side resonance coil 13b. The primary coil 13a is coupled to the primary-side resonance coil 13b by electromagnetic induction, and the alternating-current power supplied from the high-frequency power source 11 to the primary coil 13a is supplied to the primary-side resonance coil 13b by electromagnetic induction.

[0022] As shown in Fig. 2, the primary matching unit 12 is a primary-side matching unit including a pi-type matching unit. More specifically, the primary matching unit 12 includes two primary variable capacitors 15, 16, which serve as a variable reactance, and a primary inductor 17. The primary variable capacitor 15 is connected to the high-frequency power source 11, and the primary variable capacitor 16 is connected in parallel to the primary coil 13a. The primary inductor 17 is connected between the primary variable capacitors 15, 16. Changing the capacity of the primary variable capacitors 15, 16 changes the impedance of the primary matching unit 12. The primary variable capacitors 15, 16 have a known structure, which includes a rotating shaft driven by, for example, a non-illustrated motor. When the motor is driven in accordance with a drive signal from the power source controller 14, the capacity of each of the primary variable capacitors 15, 16 is changed.

[0023] As shown in Fig. 1, the movable body equipment 20 is movable body-side

equipment, which includes a secondary coil device 21, a secondary matching unit 22, a distance detecting high-frequency power source 23, a rectifier 24, a charger 25, a secondary battery 26, and a vehicle controller 27. The secondary battery 26 is a battery connected to the charger 25. The secondary matching unit 22 is switched between a state in which the secondary matching unit 22 is connected to the distance detecting high-frequency power source 23, and a state in which the secondary matching unit 22 is connected to the rectifier 24 via a switch SW1. The distance detecting high-frequency power source 23 is configured to output an alternating-current power that is smaller approximately by two orders of magnitude than the alternating-current power output by the high-frequency power source 11 when transmitting power.

[0024] More specifically, the secondary coil device 21 is a secondary-side coil formed by a secondary coil 21a and a secondary-side resonance coil 21b as shown in Fig. 2. The secondary coil 21a and the secondary-side resonance coil 21b are arranged to be coaxial. A capacitor C that is different from the one connected to the primary-side resonance coil 13b is connected to the secondary-side resonance coil 21b. The secondary coil 21a is coupled to the secondary-side resonance coil 21b by electromagnetic induction. The alternating-current power supplied to the secondary-side resonance coil 21b from the primary-side resonance coil 13b through resonance is supplied to the secondary coil 21a by electromagnetic induction. The secondary coil 21a is connected to the secondary matching unit 22.

[0025] As shown in Fig. 2, the secondary matching unit 22 is a secondary-side matching unit including a pi-type matching unit. More specifically, the secondary matching unit 22 includes two secondary variable capacitors 28, 29, which serve as a variable reactance, and a secondary inductor 30. The secondary variable capacitor 28 is connected in parallel to the secondary coil 21a. The secondary variable capacitor 29 is selectively connected to one of the distance detecting high-frequency power source 23 and the rectifier 24 via the switch SW1. Changing the capacity of the secondary variable capacitors 28, 29 changes the impedance of the secondary matching unit 22. The secondary variable capacitors 28, 29 have a known structure, which includes a rotating shaft driven by, for example, a non-illustrated motor. When the motor is driven in accordance with a drive signal from the vehicle controller 27, the capacity of each of the secondary variable capacitors 28, 29 is changed.

[0026] An input impedance detecting section, which is a voltage sensor 31 in the first embodiment, is connected in parallel to the secondary coil 21a as shown in Fig. 2.

[0027] The charger 25 shown in Fig. 1 includes a DC/DC converter (not shown), which converts direct-current rectified by the rectifier 24 to a voltage suitable for charging the secondary battery 26. The vehicle controller 27 controls a switching element of the DC/DC converter of the charger 25 when charging the secondary battery 26.

- [0028] The number of turns and the winding diameter of the primary coil 13a, the primary-side resonance coil 13b, the secondary-side resonance coil 21b, and the secondary coil 21a are set in accordance with the magnitude of power supplied (transmitted) from the power supplying equipment 10 to the movable body equipment 20 as required. The switch SW1 represents a change-over contact of a relay. Figs. 1 and 2 show the change-over contact of the relay as a contact relay. However, for example, the change-over contact of the switch SW1 may be formed by a non-contact relay using a semiconductor element.
- [0029] A control device, which is the vehicle controller 27 in this embodiment, is a vehicle-side controller that connects the secondary matching unit 22 and the distance detecting high-frequency power source 23 with each other via the switch SW1 when detecting the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b. Furthermore, when power is supplied from the power supplying equipment 10 to the movable body equipment 20, the vehicle controller 27 switches the switch SW1 so as to connect the secondary matching unit 22 and the rectifier 24 with each other via the switch SW1. When detecting the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b, the vehicle controller 27 also causes the distance detecting high-frequency power source 23 to output an alternating current of a predetermined frequency. Furthermore, when power is supplied from the power supplying equipment 10 to the movable body equipment 20, the vehicle controller 27 controls the distance detecting high-frequency power source 23 so as to stop outputting the alternating current.
- [0030] The vehicle controller 27 includes an on-vehicle CPU and an on-vehicle memory. The on-vehicle memory stores, as a map or a relational expression, data representing the relationship of the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b with respect to the input impedance of the resonance system at the time when the distance detecting high-frequency power source 23 outputs the alternating current of the predetermined frequency. The data is obtained by experiments in advance. When detecting the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b, the vehicle controller 27 detects the input impedance of the resonance system by detecting the voltage between the ends of the secondary coil 21a using the voltage sensor 31. The vehicle controller 27 calculates the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b based on the detected input impedance of the resonance system and the map or the relational expression. In this manner, the vehicle controller 27 functions as a distance calculating section, which calculates the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b. That is, the vehicle controller 27 and the voltage sensor 31 form a distance

detecting section that detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b.

[0031] The power source controller 14 and the vehicle controller 27 communicate with each other via a non-illustrated wireless communication device. The power source controller 14 executes power supplying operation upon receipt of a power supply request signal transmitted from the vehicle controller 27.

[0032] (Operation)

Operation of the resonance type non-contact power supply system configured as described above will now be described.

[0033] When the secondary battery 26 mounted on the vehicle is charged, the vehicle needs to be parked (stopped) at the charging position where the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b is equal to a predetermined distance. It is therefore necessary to detect the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b before supplying power from the power supplying equipment 10 to the charger 25 of the movable body equipment 20. When detecting the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b, the vehicle controller 27 switches the switch SW1 to the state in which the secondary matching unit 22 and the distance detecting high-frequency power source 23 are connected to each other. In this state, when the distance detecting high-frequency power source 23 outputs an alternating-current power of a predetermined frequency, power is transmitted from the secondary coil device 21 to the primary coil device 13 without contact. At this time, the output of the distance detecting high-frequency power source 23 is not supplied to the charger 25, but is supplied only to the secondary-side resonance coil 21b. Therefore, the input impedance of the resonance system is not influenced by the charger 25 or the charge state of the secondary battery 26. In this state, the vehicle controller 27 calculates the input impedance of the secondary coil 21a based on the detection signal of the voltage sensor 31, and detects (calculates, computes) the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b based on the value of the input impedance and the map or the relational expression.

[0034] When the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b detected as described above is suitable for charging, the vehicle controller 27 switches the switch SW1 to the state in which the secondary matching unit 22 and the rectifier 24 are connected to each other. The vehicle controller 27 then adjusts the secondary variable capacitors 28, 29 such that the impedance of the secondary matching unit 22 becomes equal to a value at which power is efficiently supplied from the power supplying equipment 10 to the movable body

equipment 20 at the detected distance. Subsequently, the vehicle controller 27 transmits a power supply request signal to the power source controller 14 via the wireless communication device. When receiving the power supply request signal from the vehicle controller 27, the power source controller 14 starts supplying power.

[0035] If the detected distance is not suitable for charging, the vehicle controller 27 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b in the same manner as described above, after the vehicle is moved. If the detected distance is suitable for charging, the vehicle controller 27 transmits the power supply request signal to the power source controller 14 after switching the switch SW1 and adjusting the impedance of the secondary matching unit 22 in the same manner as described above.

[0036] The power source controller 14 that has received the power supply request signal applies an AC voltage having a resonant frequency to the primary coil 13a by the high-frequency power source 11 of the power supplying equipment 10. The power is then supplied from the primary-side resonance coil 13b to the secondary-side resonance coil 21b through non-contact resonance. The power received by the secondary-side resonance coil 21b is supplied to the charger 25 via the secondary matching unit 22 and the rectifier 24. Thus, the secondary battery 26 connected to the charger 25 is charged. The vehicle controller 27 determines whether charging has been completed based on, for example, the elapsed time from when the voltage of the secondary battery 26 has become equal to a predetermined voltage. When charging of the secondary battery 26 is completed, the vehicle controller 27 transmits a charging completion signal to the power source controller 14. The power source controller 14 stops the power transmission when receiving the charging completion signal.

[0037] The present embodiment provides the following advantages.

[0038] (1) The resonance type non-contact power supply system includes the power supplying equipment 10 and the movable body equipment 20. The power supplying equipment 10 includes the alternating-current power source, which is the high-frequency power source 11 in the first embodiment, and the primary-side resonance coil 13b, which receives power from the alternating-current power source. The movable body equipment 20 receives power from the power supplying equipment 10 without contact. That is, the movable body equipment 20 includes the secondary-side resonance coil 21b, which receives power from the primary-side resonance coil 13b, the rectifier 24, which rectifies the power supplied to the secondary-side resonance coil 21b, the charger 25, which receives the power that has been rectified by the rectifier 24, and the secondary battery 26 connected to the charger 25. The movable body equipment 20 includes the secondary matching unit 22 and the distance detecting high-frequency power source 23 between the secondary-side resonance coil 21b and the

rectifier 24. For detecting the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b, the output of the distance detecting high-frequency power source 23 is supplied to the secondary-side resonance coil 21b via the secondary matching unit 22. When the power supplying equipment 10 supplies power, the distance detecting high-frequency power source 23 is stopped, and the power output from the power supplying equipment 10 is supplied to the charger 25 via the secondary matching unit 22 and the rectifier 24. By using the secondary matching unit 22 provided in the power receiving section, that is, the movable body equipment 20, the power supply system of the first embodiment detects, on the movable body, the distance between the resonance coil of the power supplying section, that is, the primary-side resonance coil 13b and the resonance coil of the power receiving section, which is the movable body, that is, the secondary-side resonance coil 21b. The power supply system efficiently supplies power from the power supplying section to the power receiving section using the distance detected as described above.

[0039] (2) The movable body equipment 20 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b. Thus, the driver can easily move the movable body to the charging position where the movable body efficiently receives power from the power supplying equipment 10. Therefore, the secondary battery 26 mounted on the movable body is efficiently charged.

[0040] (3) The pi-type matching unit that includes two secondary variable capacitors 28, 29 and the secondary inductor 30 is used as the secondary matching unit 22. The impedance of the resonance system is roughly adjusted by adjusting one of the variable capacitors, for example, the secondary variable capacitor 28, and the impedance of the resonance system is finely adjusted by adjusting the other variable capacitor, for example, the secondary variable capacitor 29. In this manner, the impedance of the resonance system is easily adjusted.

[0041] (4) The movable body equipment 20 includes the input impedance detecting section (the voltage sensor 31), which detects the input impedance of the resonance system in a state in which an alternating-current power is output from the distance detecting high-frequency power source 23, and the distance calculating section (the vehicle controller 27). The distance calculating section calculates the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b based on the relationship of the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b with respect to the input impedance of the resonance system. Therefore, the movable body equipment 20 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b without communicating with the power supplying equipment 10.

[0042] Figs. 3 and 4 show a second embodiment. In the second embodiment, the structure of

the power supplying equipment 10 is the same as that in the first embodiment, but the structure of the secondary matching unit 22 and the connection state of the distance detecting high-frequency power source 23 differ from the first embodiment. Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the first embodiment and detailed explanations are omitted.

[0043] As shown in Fig. 3, the movable body equipment 20 includes the secondary coil device 21, a secondary matching unit 22A, the distance detecting high-frequency power source 23, the rectifier 24, the charger 25, the secondary battery 26, and the vehicle controller 27. The distance detecting high-frequency power source 23 is connected to the secondary matching unit 22A. The secondary battery 26 is a battery connected to the charger 25.

[0044] As shown in Figs. 4A and 4B, the secondary matching unit 22A is formed by a pi-type matching unit. More specifically, the secondary matching unit 22A includes two secondary variable capacitors 28, 29, the secondary inductor 30, and a switch SW2. The secondary variable capacitor 28 is connected to the secondary coil 21a, and the secondary variable capacitor 29 is connected to the rectifier 24. One end of the secondary inductor 30 is connected to the secondary coil 21a and the secondary variable capacitor 28, and the other end of the secondary inductor 30 is connected to the rectifier 24 and the secondary variable capacitor 29 via the switch SW2. The output terminal of the distance detecting high-frequency power source 23 is connected between the other end of the secondary inductor 30 and the switch SW2. The switch SW2 represents a contact of a relay. Figs. 4A and 4B show the contact of the relay of the switch SW2 as a contact relay. However, the switch SW2 may be formed by a non-contact relay using a semiconductor element. In Figs. 4A and 4B, the voltage sensor 31 is omitted.

[0045] In the second embodiment, when detecting the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b, the vehicle controller 27 maintains the switch SW2 open as shown in Fig. 4A, and commands the distance detecting high-frequency power source 23 to output an alternating-current power. The alternating-current power output from the distance detecting high-frequency power source 23 is not supplied to the rectifier 24, but is supplied to the secondary coil 21a. In this state, like the first embodiment, the vehicle controller 27 calculates the input impedance of the resonance system based on the detection signal of the voltage sensor 31. Based on the calculation result, the vehicle controller 27 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b.

[0046] At times other than when detecting the distance, the vehicle controller 27 maintains

the switch SW2 closed as shown in Fig. 4B, and commands the distance detecting high-frequency power source 23 to stop outputting the alternating-current power. When the power supplying equipment 10 executes non-contact power supply, the power received by the secondary-side resonance coil 21b is supplied to the charger 25 via the secondary matching unit 22A and the rectifier 24. Thus, the secondary battery 26 connected to the charger 25 is charged.

[0047] In addition to the advantages (2) to (4) of the first embodiment, the second embodiment has the following advantages.

[0048] (5) The secondary matching unit 22A is of pi-type. The switch SW2 is located between the secondary inductor 30 and the secondary variable capacitor 29. The distance detecting high-frequency power source 23 is connected between the switch SW2 and the secondary inductor 30, and supplies power to the secondary matching unit 22A. Thus, the secondary matching unit 22A functions bidirectionally without problem, when the high-frequency power source 11 supplies power from the power supplying equipment 10 to the charger 25 of the movable body equipment 20, and when the distance detecting high-frequency power source 23 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b. In the second embodiment, when power is supplied from the power supplying equipment 10 to the movable body equipment 20, for example, the distance detecting high-frequency power source 23 does not need to be disconnected from the secondary matching unit 22A using a switch.

[0049] Fig. 5 shows a third embodiment. The structure of a secondary matching unit 22B according to the third embodiment differs from the secondary matching unit 22A of the above embodiments. The structure of the resonance type non-contact power supply system except the secondary matching unit 22B is the same as the second embodiment. As shown in Fig. 5, the secondary matching unit 22B includes two secondary variable capacitors 28, 29 and two secondary inductors 32, which are connected in series to each other. The secondary variable capacitor 28 is connected to the secondary coil 21a, and the secondary variable capacitor 29 is connected to the rectifier 24. One end of one of the secondary inductors 32 is connected to the secondary coil 21a and the secondary variable capacitor 28. The other secondary inductor 32 is connected to the rectifier 24 and the secondary variable capacitor 29. The output terminal of the distance detecting high-frequency power source 23 is connected to a contact between the two secondary inductors 32. Fig. 5 omits the voltage sensor 31.

[0050] When detecting the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b, the vehicle controller 27 outputs alternating-current power from the distance detecting high-frequency power source 23 with the charger 25 in a high impedance state. More specifically, the vehicle controller 27, for example,

outputs a command signal to the charger 25 to maintain the switching element of the DC/DC converter of the charger 25 in an OFF state, and turns on the distance detecting high-frequency power source 23. When the distance detecting high-frequency power source 23 outputs an alternating-current power with the charger 25 in the high impedance state, the alternating-current power from the distance detecting high-frequency power source 23 is not supplied to the charger 25, but is supplied to the secondary-side resonance coil 21b. The vehicle controller 27 receives the detection signal of the voltage sensor 31 in this state. The vehicle controller 27 calculates the input impedance of the resonance system based on the detection signal of the voltage sensor 31. Based on the calculation result, the vehicle controller 27 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b.

- [0051] At times other than when detecting the distance, the vehicle controller 27 adjusts the secondary matching unit 22B, and controls the switching element of the DC/DC converter of the charger 25 in a state in which output of an alternating-current power from the distance detecting high-frequency power source 23 is stopped.
- [0052] In addition to the advantages (2) to (4) of the first embodiment, the third embodiment has the following advantages.
- [0053] (6) The secondary matching unit 22B is of pi-type. When detecting the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b, the vehicle controller 27 commands the charger 25 to maintain the charger 25 in the high impedance state. Thus, when the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b is detected, the power supplied from the distance detecting high-frequency power source 23 to the secondary matching unit 22B is not supplied to the charger 25, but is supplied to the secondary-side resonance coil 21b. As described above, in the third embodiment, the output power from the distance detecting high-frequency power source 23 is not supplied to the charger 25, but is supplied to the secondary-side resonance coil 21b by putting the charger 25 in the high impedance state instead of additionally providing a switch such as a relay.
- [0054] Fig. 6 shows a fourth embodiment. The structure of the power supplying equipment 10 according to the fourth embodiment differs from that of the first embodiment. The movable body equipment 20 has the same structure as the first embodiment. Like or the same reference numerals are given to those components that are like or the same as the corresponding components of the first embodiment, and detailed explanations are omitted.
- [0055] As shown in Fig. 6, the power supplying equipment 10 is provided with a terminal resistor 18. The terminal resistor 18 is selectively connected to the resonance system

via a switch SW3. The switch SW3 selectively connects the primary matching unit 12 to either the high-frequency power source 11 or the terminal resistor 18 in accordance with the command from the power source controller 14. When the movable body equipment 20 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b, the switch SW3 is switched to the state in which it connects the primary matching unit 12 to the terminal resistor 18. When the high-frequency power source 11 supplies power to the movable body equipment 20, the switch SW3 is switched to the state in which it connects the primary matching unit 12 to the high-frequency power source 11. That is, when the movable body equipment 20 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b, the resonance system is disconnected from the high-frequency power source 11 and is connected to the terminal resistor 18. The switch SW3 is formed by, for example, a change-over contact of a relay. Fig. 6 shows the change-over contact of the relay as a contact type relay. However, the switch SW3 may be formed by a non-contact relay using a semiconductor element.

[0056] When receiving the power supply request signal transmitted from the vehicle controller 27, the power source controller 14 switches the switch SW3 such that it connects the primary matching unit 12 to the high-frequency power source 11, and then supplies power.

[0057] In addition to the advantages (1) to (4) of the first embodiment, the fourth embodiment has the following advantages.

[0058] (7) The power supplying equipment 10 includes the terminal resistor 18, which is selectively connected to the resonance system via the switch SW3. When the movable body equipment 20 detects the distance, the resonance system is disconnected from the alternating-current power source (the high-frequency power source 11) by the switch SW3, and is connected to the terminal resistor 18. Even if the resonance system is connected to the high-frequency power source 11 during detection of the distance, the movable body equipment 20 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b as long as power is not supplied from the high-frequency power source 11 to the resonance system. In this case, however, since there is some influence of the high-frequency power source 11 on the impedance of the resonance system, the accuracy in detecting the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b is reduced. Therefore, in the fourth embodiment, the resonance system is disconnected from the high-frequency power source 11 by the switch SW3, and is connected to the terminal resistor 18 when the distance is detected. Therefore, in the fourth embodiment, since there is no influence of the high-frequency power source 11 on the impedance of the resonance system when the distance is detected, the accuracy in detecting the distance

between the primary-side resonance coil 13b and the secondary-side resonance coil 21b is increased.

[0059] The present invention is not restricted to the illustrated embodiments but may be embodied in the following forms.

[0060] The resonance type non-contact power supply system does not need to detect the distance based on the data representing the relationship of the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b with respect to the input impedance of the resonance system. For example, the resonance type non-contact power supply system may detect the distance based on the data representing the relationship of the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b with respect to the output voltage of the primary coil 13a. In this case, a voltage sensor for detecting the output voltage of the primary coil 13a is provided in the power supplying equipment 10. The vehicle controller 27 detects (calculates) the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b by receiving the detection result of the voltage sensor in the power supplying equipment 10 from the power source controller 14 through wireless communication.

[0061] For the resonance type non-contact power supply system to perform non-contact power supply between the power supplying equipment 10 and the movable body equipment 20, the resonance system does not necessarily include all of the primary coil 13a, the primary-side resonance coil 13b, the secondary coil 21a, and the secondary-side resonance coil 21b. That is, the resonance system only needs to have at least the primary-side resonance coil 13b and the secondary-side resonance coil 21b. For example, instead of forming the primary coil device 13 by the primary coil 13a and the primary-side resonance coil 13b, the primary coil 13a may be omitted. In this case, the primary-side resonance coil 13b is connected to the high-frequency power source 11 via the primary matching unit 12. Alternatively, instead of forming the secondary coil device 21 by the secondary coil 21a and the secondary-side resonance coil 21b, the secondary coil 21a, for example, may be omitted. In this case, the secondary-side resonance coil 21b is connected to the rectifier 24 via the secondary matching unit 22. However, a resonance system of a configuration with all of the primary coil 13a, the primary-side resonance coil 13b, the secondary coil 21a, and the secondary-side resonance coil 21b is easier to be adjusted to a resonance state. Further, when the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b is great, a resonance system of a configuration with all of the primary coil 13a, the primary-side resonance coil 13b, the secondary coil 21a, and the secondary-side resonance coil 21b can more easily maintain the resonance state.

[0062] In a case where the secondary coil 21a is omitted, the voltage sensor 31, which forms

a distance estimating section, detects the voltage between the ends of the secondary-side resonance coil 21b. For example, when estimating the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b based on the detected voltage value, the power supplying equipment 10 detects voltage of the secondary-side resonance coil 21b instead of detecting the output voltage of the secondary coil 21a. The vehicle controller 27 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b from a map or a relational expression representing the relationship between the value of the voltage and the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b.

- [0063] As in the first embodiment, in a case of a structure in which the distance detecting high-frequency power source 23 is selectively switched between a state in which it is connected to the secondary matching unit 22 and a state in which it is connected to the rectifier 24 via the switch SW1, the secondary matching unit 22 does not need to be of pi-type, but may be a T-type or an L-type matching unit.
- [0064] The primary matching unit 12 provided in the power supplying equipment 10 is not limited to be of pi-type, but may be a T-type or an L-type matching unit.
- [0065] Each of the primary matching unit 12 and the secondary matching units 22, 22A, 22B does not need to include two variable capacitors and the inductor. Each of the primary matching unit 12 and the secondary matching units 22, 22A, 22B may have a structure including a variable inductor as the inductor, or a structure including a variable inductor and two non-variable capacitors.
- [0066] The primary matching unit 12 may be omitted from the power supplying equipment 10. However, when the primary matching unit 12 is omitted, it takes time and effort to adjust the frequency of the alternating-current power output from the high-frequency power source 11 to efficiently supply power from the power supplying section to the power receiving section.
- [0067] The terminal resistor 18 of the fourth embodiment is not limited to be provided in the power supplying equipment 10 of the first embodiment, but may be provided in the power supplying equipment 10 of the second embodiment, the third embodiment, or other embodiments. The terminal resistor 18 is formed such that the primary matching unit 12 is selectively connected to one of the high-frequency power source 11 and the terminal resistor 18 via the switch SW3. When the movable body equipment 20 detects the distance between the primary-side resonance coil 13b and the secondary-side resonance coil 21b, the switch SW3 disconnects the resonance system from the high-frequency power source 11 and connects the resonance system to the terminal resistor 18.
- [0068] The axes of the primary coil 13a, the primary-side resonance coil 13b, the secondary-

side resonance coil 21b, and the secondary coil 21a do not need to extend along the horizontal direction or the vertical direction, but may extend diagonally with respect to the horizontal direction.

- [0069] A vehicle serving as the movable body is not limited to a type that requires a driver, but may be an unmanned carrier.
- [0070] The movable body is not limited to a vehicle, but may be a robot.
- [0071] The charger 25 does not need to have a booster circuit. For example, the charger 25 may be configured to charge the secondary battery 26 with an alternating current output by the secondary coil device 21 after only being rectified through the rectifier 24.
- [0072] The charger 25 may be omitted from the movable body equipment 20. In this case, the power rectified by the rectifier 24 is supplied directly to the secondary battery 26. Whether the charger 25 is omitted or not, the power supplying equipment 10 may be configured to adjust the output power of the high-frequency power source 11.
- [0073] The diameter of the primary coil 13a and the diameter of the secondary coil 21a are not limited to being equal to the diameter of the primary-side resonance coil 13b and the diameter of the secondary-side resonance coil 21b, respectively, but may be smaller or greater.
- [0074] The primary-side resonance coil 13b and the secondary-side resonance coil 21b are not limited to be formed by a wire wound into a helical shape, but may be formed by a wire wound into a spiral shape on a plane.
- [0075] The capacitors C connected to the primary-side resonance coil 13b and the secondary-side resonance coil 21b may be omitted. However, a configuration with capacitors C connected to the primary-side resonance coil 13b and the secondary-side resonance coil 21b lowers the resonant frequency compared to a configuration without capacitors C. If the resonant frequency is the same, the size of the primary-side resonance coil 13b and the secondary-side resonance coil 21b can be reduced with the structure in which the capacitors C are connected to the primary-side resonance coil 13b and the secondary-side resonance coil 21b, compared to a case where the capacitors C are omitted.

Claims

- [Claim 1] A resonance type non-contact power supply system comprising power supplying equipment and movable body equipment, wherein the power supplying equipment includes an alternating-current power source and a primary-side resonance coil for receiving power from the alternating-current power source, and the movable body equipment includes a secondary-side resonance coil for receiving power from the primary-side resonance coil, a rectifier for rectifying the power received by the secondary-side resonance coil, and a secondary battery to which the power rectified by the rectifier is supplied, and wherein :
- the movable body equipment further includes a secondary matching unit and a distance detecting high-frequency power source between the secondary-side resonance coil and the rectifier, when the distance between the primary-side resonance coil and the secondary-side resonance coil is detected, an output from the distance detecting high-frequency power source is supplied to the secondary-side resonance coil via the secondary matching unit, and when the power supplying equipment supplies power, the distance detecting high-frequency power source is stopped, and the power supplied by the power supplying equipment is supplied to the charger via the secondary matching unit and the rectifier.
- [Claim 2] The resonance type non-contact power supply system according to claim 1, wherein the secondary matching unit is of pi-type, and the distance detecting high-frequency power source supplies power to the secondary matching unit.
- [Claim 3] The resonance type non-contact power supply system according to claim 2, further comprising a control device that puts the charger into a high impedance state when the distance between the primary-side resonance coil and the secondary-side resonance coil is detected.
- [Claim 4] The resonance type non-contact power supply system according to any one of claims 1 to 3, comprising a resonance system, wherein the movable body equipment includes: an input impedance detecting section, which detects input impedance of the resonance system when an alternating-current power is output from

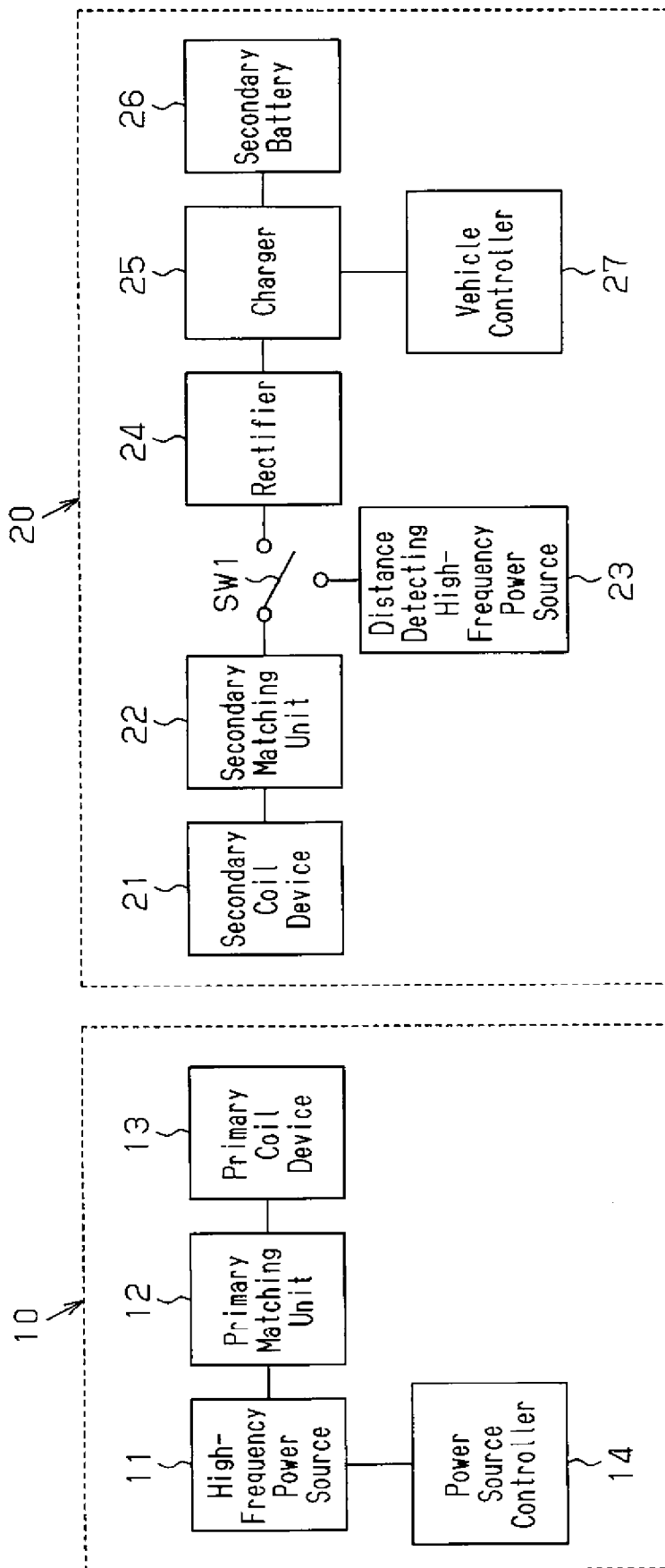
the distance detecting high-frequency power source; and
a distance calculating section, which calculates the distance between the primary-side resonance coil and the secondary-side resonance coil based on a relationship of the distance between the primary-side resonance coil and the secondary-side resonance coil with respect to the input impedance of the resonance system.

[Claim 5] The resonance type non-contact power supply system according to any one of claims 1 to 4, wherein the matching unit is a pi-type matching unit including two variable capacitors and an inductor located between the variable capacitors.

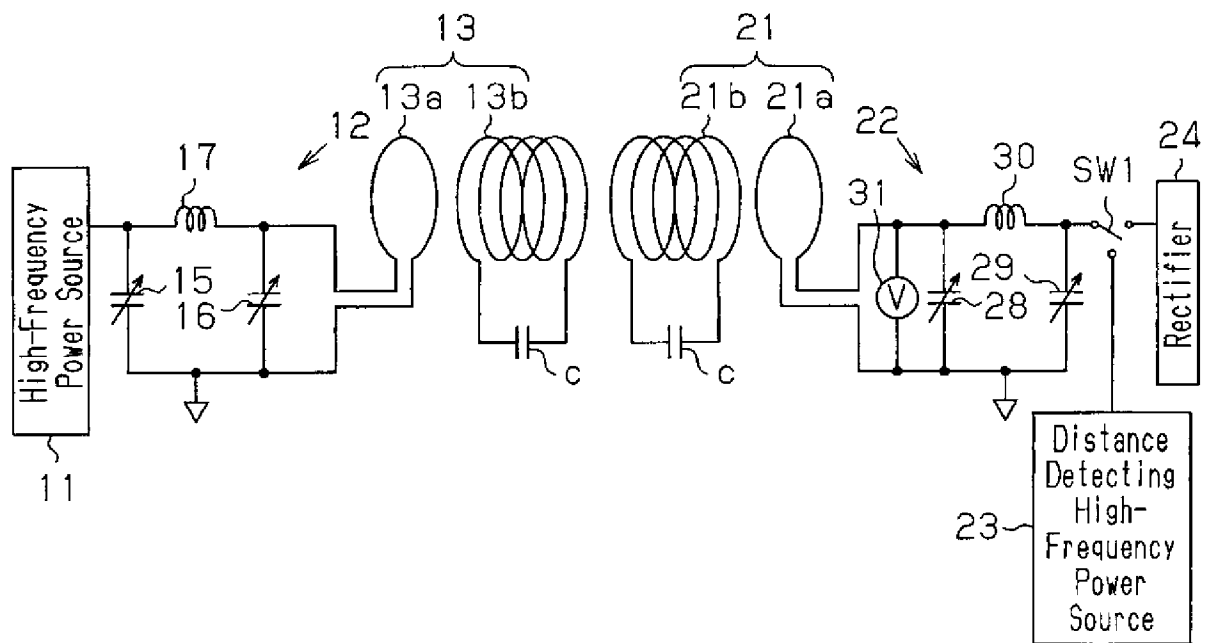
[Claim 6] The resonance type non-contact power supply system according to any one of claims 1 to 4, wherein the movable body is a vehicle.

[Claim 7] The resonance type non-contact power supply system according to any one of claims 1 to 6, wherein the movable body equipment further comprises a charger provided between the rectifier and the secondary battery, the power rectified by the rectifier is supplied to the charger, and the secondary battery is connected to the charger.

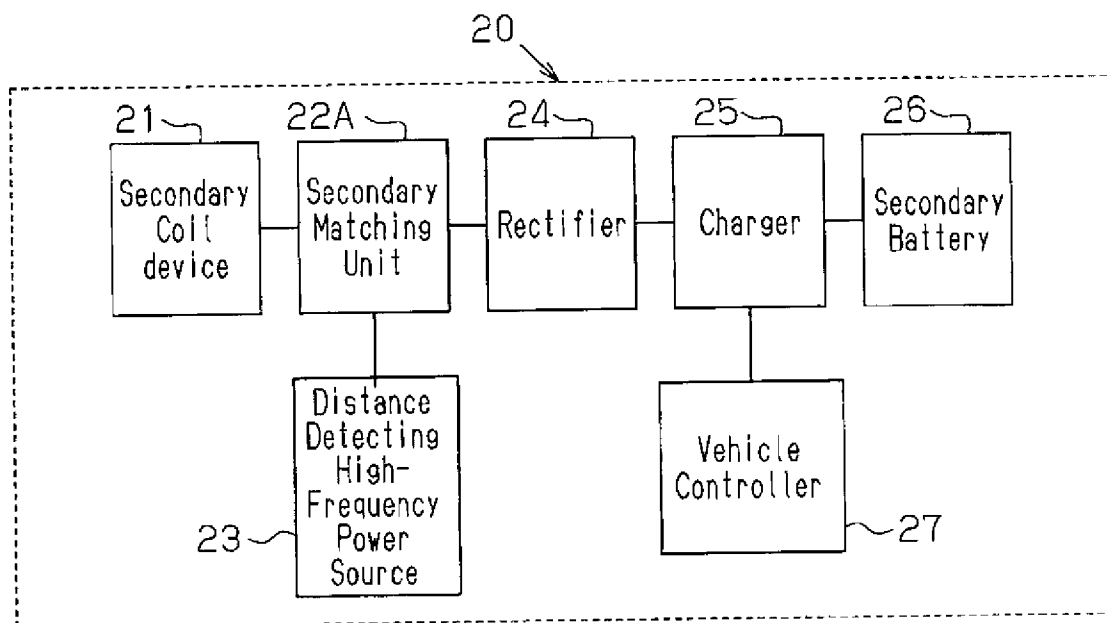
[Fig. 1]



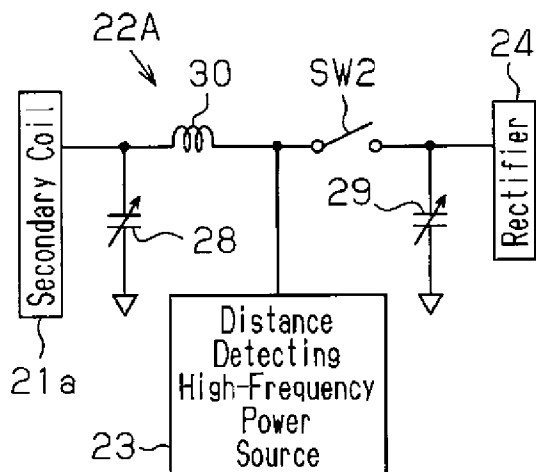
[Fig. 2]



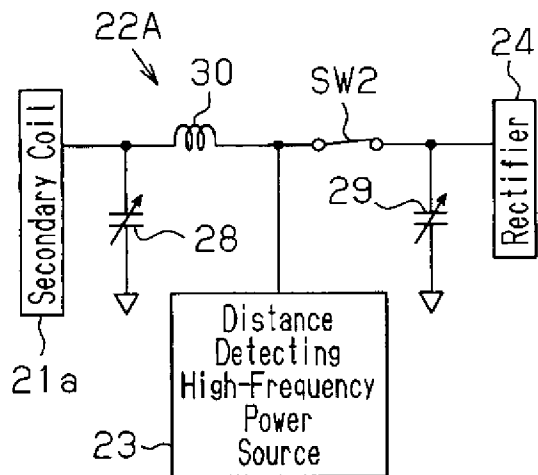
[Fig. 3]



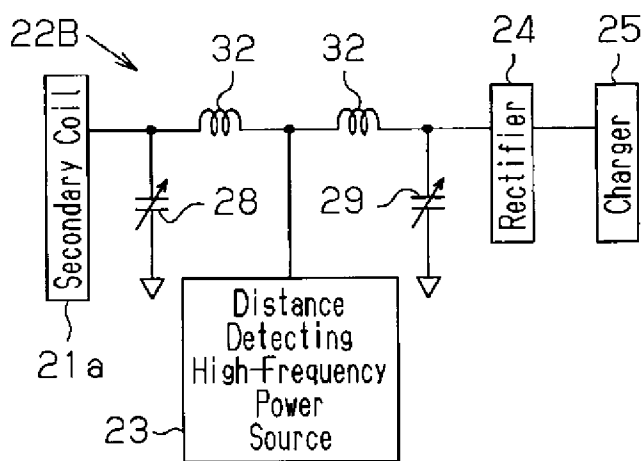
[Fig. 4A]



[Fig. 4B]



[Fig. 5]



[Fig. 6]

