



(51) International Patent Classification:

B60L 5/00 (2006.01) **H02J 7/02** (2006.01)
B60L 11/18 (2006.01)

(21) International Application Number:

PCT/JP2011/004281

(22) International Filing Date:

28 July 2011 (28.07.2011)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

2010-170591 29 July 2010 (29.07.2010) JP

(71) Applicants (for all designated States except US):

KABUSHIKI KAISHA TOYOTA JIDOSHOKKI [JP/JP]; 2-1, Toyoda-cho, Kariya-shi, Aichi, 4488671 (JP). **TOYOTA JIDOSHA KABUSHIKI KAISHA** [JP/JP]; 1, Toyota-cho, Toyota-shi, Aichi, 4718571 (JP).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **TAKADA,**

Kazuyoshi [JP/JP]; c/o KABUSHIKI KAISHA TOYOTA JIDOSHOKKI, 2-1, Toyoda-cho, Kariya-shi, Aichi, 4488671 (JP). **SUZUKI, Sadanori** [JP/JP]; c/o KABUSHIKI KAISHA TOYOTA JIDOSHOKKI, 2-1, Toyoda-cho, Kariya-shi, Aichi, 4488671 (JP). **SAKODA, Shimpei** [JP/JP]; c/o KABUSHIKI KAISHA TOYOTA JIDOSHOKKI, 2-1, Toyoda-cho, Kariya-shi, Aichi, 4488671 (JP). **YAMAMOTO, Yukihiro** [JP/JP]; c/o KABUSHIKI KAISHA TOYOTA JIDOSHOKKI, 2-1,

Toyoda-cho, Kariya-shi, Aichi, 4488671 (JP). **ICHIKAWA, Shinji** [JP/JP]; c/o TOYOTA JIDOSHA KABUSHIKI KAISHA, 1, Toyota-cho, Toyota-shi, Aichi, 4718571 (JP). **NAKAMURA, Toru** [JP/JP]; c/o TOYOTA JIDOSHA KABUSHIKI KAISHA, 1, Toyota-cho, Toyota-shi, Aichi, 4718571 (JP).

(74) Agents: **ONDA, Hironori** et al.; 12-1, Ohmiya-cho 2-chome, Gifu-shi, Gifu, 5008731 (JP).

(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, 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.

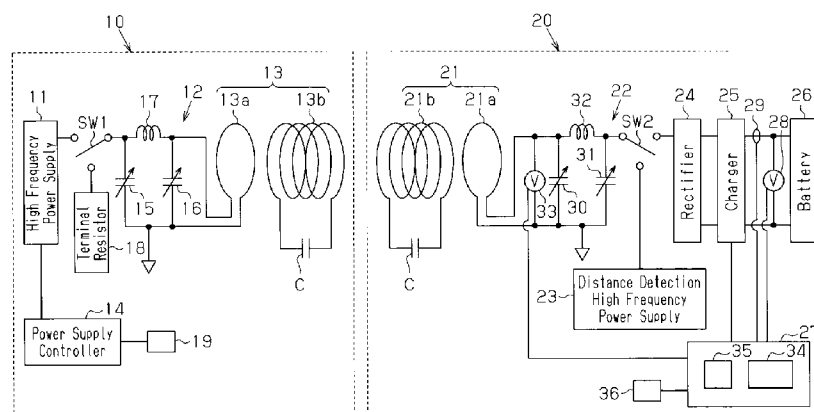
(84) Designated States (unless otherwise indicated, for every

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. 1]



(57) Abstract: A resonance type non-contact power supply system including power supplying equipment and movable body equipment. The power supplying equipment includes an AC power supply, a primary resonance coil, which receives power from the AC power supply, and a controller, which controls the AC power supply. The movable body equipment includes a secondary resonance coil, a rectifier, a power storage device, a distance detector, and a high frequency power supply. The secondary resonance coil receives power from the primary resonance coil. The distance detector and high frequency power supply cooperate with each other to detect the distance between the primary resonance coil and the secondary resonance coil. When the distance detector detects the distance, the controller holds the AC power supply in a standby state. After the distance detector detects the distance, the controller activates the AC power supply to supply power.



Published:

— with international search report (Art. 21(3))

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

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, and more particularly, to a resonance type non-contact power supply system desirable for use when charging a power storage device of a movable body in a non-contact manner.

Background Art

[0002] PTL 1 describes a charging system for a vehicle. The charging system uses resonance to charge a power storage device, which is installed in the vehicle, with power received from a power supply located outside the vehicle in a wireless manner. More specifically, the charging system of the above document includes an electric vehicle and a power supplying device. The electric vehicle includes a secondary self-resonance coil (secondary resonance coil), a secondary coil, a rectifier, and the power storage device. The power supplying device includes a high-frequency power driver, a primary coil, and a primary self-resonance coil (primary resonance coil). The number of windings in the secondary self-resonance coil is determined based on the voltage of the power storage device, the distance between the primary and secondary self-resonance coils, and the resonant frequency of the primary and secondary self-resonance coils. The distance between the power supply device and the vehicle changes depending on the situation of the vehicle, such as, the weight of the vehicle and the air pressure of the tires. Changes in the distance between the primary self-resonance coil of the power supply device and the secondary self-resonance coil of the vehicle varies the resonant frequency of the primary and secondary self-resonance coils. Thus, a variable capacitor is connected between the conductive wires of the secondary self-resonance coil. When charging the power storage device, the charging system calculates the charging power for the power storage device based on the detections of a voltage sensor and a current sensor and adjusts the capacitance of the variable capacitor to maximize the charging power. This adjusts the LC resonant frequency of the secondary self-resonance coil.

Citation List

Patent Literature

[0003] PTL 1: Japanese Laid-Open Patent Publication No. 2009-106136

Summary of Invention

Technical Problem

[0004] PTL 1 discloses a process that efficiently supplies power from a power supplying side to a power receiving side even when the situation of the vehicle changes the distance between the primary and secondary self-resonance coils. When the power storage device is charged, this process adjusts the capacitance of the variable capacitor for the secondary self-resonance coil to maximize the charging power for the power storage device. In this case, it is assumed that the distance between the primary and secondary self-resonance coils changes depending on the situation of the vehicle in a state in which the vehicle is parked at the proper charging position. Since the vehicle is parked at the predetermined charging position, there is no mention of detection of the distance between the primary resonance coil, which supplies power, and the secondary resonance coil, which receives power.

[0005] When parking a vehicle at a predetermined charging position, the resonance state of the resonance system is detected to determine the distance between the power supplying resonance coil and the power receiving resonance coil. When the vehicle reaches a position at which the distance allows for power to be efficiently received by the power receiving side from the power supplying side, the vehicle is stopped. In this case, a power supplying device is required to be able to supply charging power from the power supplying side before the vehicle starts parking. Further, the vehicle continues to detect the resonance state of the resonance system until locating the proper charging position. This consumes unnecessary power before charging starts.

[0006] It is an object of the present invention to provide a resonance type non-contact power supply system that detects the distance between a power supplying resonance coil and a power receiving resonance coil at a movable body side, stops a movable body at a position where power is efficiently supplied from the power supplying side to the power receiving side, and reduces power consumption.

Solution to Problem

[0007] To achieve the object, one aspect of the present invention provides a resonance type non-contact power supply system including power supplying equipment and movable body equipment. The power supplying equipment includes an AC power supply, a primary resonance coil, and a controller. The primary resonance coil receives power from the AC power supply, and the controller controls the AC power supply. The movable body equipment includes a secondary resonance coil, a rectifier, a power storage device, a distance detector, and a high frequency power supply. The secondary resonance coil receives power from the primary resonance coil. The rectifier rectifies the power received by the secondary resonance coil. The power storage device is supplied with the power rectified by the rectifier. The distance detector and the high frequency power supply cooperate with each other to detect the distance between the

primary resonance coil and the secondary resonance coil. When the distance detector performs distance detection, the controller holds the AC power supply in a standby state. After the distance detector completes the distance detection, the controller activates the AC power supply to supply power.

[0008] The standby state refers to a state in which the supply of power from the AC power supply is stopped but at least signals can be transferred between the AC power supply and the controller in a manner similar to a standby state of a computer. Further, the activation of the AC power to supply power refers to a state in which the AC power supply supplies the movable body equipment with power used for charging.

[0009] In this invention, the distance between the secondary resonance coil and the primary resonance coil is detected before power is supplied from the power supplying equipment to the power storage device in the movable body equipment. During the distance detection, the high frequency power supply, which is used for distance detection, outputs high frequency power to the resonance system. Further, the distance detector detects the distance between the secondary resonance coil and the primary resonance coil based on the input impedance of the resonance system. The resonance system includes the first and second resonance coils. In addition, during distance detection in the movable body system, the resonance system includes a circuit element (e.g., matching unit and secondary coil) arranged between the distance detection high frequency power supply and the secondary resonance coil and a circuit element (e.g., primary coil and matching unit) arranged between the primary resonance coil of the power supplying equipment and the AC power supply. When the secondary resonance coil receives power from the primary resonance coil, the resonance system further includes a circuit element (e.g., matching unit and primary coil) arranged between the AC power supply and the primary resonance coil, the rectifier supplied with power from the secondary resonance coil, the power storage device, and a circuit element (e.g., matching unit and secondary coil) arranged between the secondary resonance coil and the rectifier. Further, the impedance of the resonance system refers to the impedance of the entire resonance system (primary coil unit and secondary coil unit) measured across the two terminals of the primary coil unit, which receives alternating current during the distance detection. Thus, the measurement of the input impedance of the resonance system detects the distance between the secondary resonance coil and the primary resonance coil. During the distance detection, the AC power supply is maintained in the standby state. Accordingly, the distance between the power supplying resonance coil and the power receiving resonance coil is detected at the movable body side (i.e., the distance detector), the movable body may be stopped at a position where power is efficiently supplied from the power supplying side to the power receiving side, and power consumption is reduced.

Brief Description of Drawings

[0010] [fig.1]Fig. 1 is a schematic diagram showing a resonance type non-contact power supply system according to one embodiment of the present invention.

[fig.2]Fig. 2 is a flowchart showing the operation of the system of Fig. 1.

Description of Embodiments

[0011] A resonance type non-contact power supply system according to one embodiment of the present invention will now be described with reference to Figs. 1 and 2.

[0012] Referring to Fig. 1, the resonance type non-contact power supply system includes power supplying equipment 10 (power transmitting equipment), which is arranged on the ground, and movable body equipment 20, which is installed in a vehicle (automobile) that serves as a movable body.

[0013] The power supplying equipment 10 includes a high frequency power supply 11, which serves as an AC power supply, a primary matching unit 12, a primary coil unit 13, and a power supply controller 14, which serves as a power supplying side controller. The high frequency power supply 11 is controlled by control signals from the power supply controller 14. The high frequency power supply 11 outputs AC power having a frequency that is equal to the resonant frequency preset for the resonance system, for example, high frequency power having a frequency of several megahertz.

[0014] The primary coil unit 13 includes a primary coil 13a and a primary resonance coil 13b. The primary matching unit 12 and a switch SW1 connects the primary coil 13a to the high frequency power supply 11. The primary coil 13a is coaxial with the primary resonance coil 13b, and a capacitor C is connected in parallel to the primary resonance coil 13b. The primary coil 13a is coupled by electromagnetic induction to the primary resonance coil 13b. AC power supplied from the high frequency power supply 11 to the primary coil 13a is further supplied through electromagnetic induction to the primary resonance coil 13b.

[0015] The primary matching unit 12 includes two variable capacitors 15 and 16 and an inductor 17, which form a variable reactance. The variable capacitor 15 is connected by the switch SW1 to the high frequency power supply 11. The variable capacitor 16 is connected in parallel to the primary coil 13a. The inductor 17 is connected between the two variable capacitors 15 and 16. The primary matching unit 12 varies the capacitance of each of the variable capacitors 15 and 16 to change its impedance. The variable capacitors 15 and 16 are known configuration in which rotational shafts (not shown) are driven by motors. The motors are driven in accordance with a drive signal from the power supply controller 14.

[0016] The power supplying equipment 10 includes a terminal resistor 18, which is con-

nectable by the switch SW1 to the resonance system. In response to commands from the power supply controller 14, the switch SW1 selectively connects the primary matching unit 12 to the high frequency power supply 11 or the terminal resistor 18. When the movable body equipment 20 performs distance detection, the switch SW1 is connected to the terminal resistor 18. More specifically, during distance detection, the resonance system is disconnected from the high frequency power supply 11 and connected to the terminal resistor 18. The switch SW is a form C contact relay. In Fig. 1, the relay is shown as a form C contact, or contact type. However, the relay may be of a non-contact type that uses a semiconductor element. The power supplying equipment 10 also includes a communication device 19 that performs wireless communication with the movable body equipment 20.

- [0017] The movable body equipment 20 includes a secondary coil unit 21, a secondary matching unit 22, a distance detection high frequency power supply 23, a rectifier 24, a charger 25, a rechargeable battery 26, which is connected to the charger 25 and which serves as a power storage device, and a vehicle controller 27. A switch SW2 selectively connects the secondary matching unit 22 to the distance detection high frequency power supply 23 or the rectifier 24. The distance detection high frequency power supply 23 outputs AC power that is only a few hundredth of the power transmitted from the high frequency power supply 11.
- [0018] The movable body equipment 20 includes a voltage sensor 28, which detects the voltage of the rechargeable battery 26, and a current sensor 29, which detects the current flowing from the rectifier 24 via the charger 25 to the rechargeable battery 26. The vehicle controller 27 computes the state of charge of the rechargeable battery 26 based on the detections of the voltage sensor 28 and the current sensor 29. The charger 25 includes a DC/DC converter (not shown), which converts the current rectified by the rectifier 24 into voltage that is suitable for charging the rechargeable battery 26. The vehicle controller 27 controls a switching element in the DC/DC converter of the charger 25 during charging. The charger 25 includes a DC/DC converter (not shown), which converts the current rectified by the rectifier 24 into voltage that is suitable for charging the rechargeable battery 26. The vehicle controller 27 controls a switching element in the DC/DC converter of the charger 25 during charging.
- [0019] The secondary coil unit 21 includes a secondary coil 21a and a secondary resonance coil 21b. The secondary coil 21a is coaxial with the secondary resonance coil 21b, and a capacitor C is connected to the secondary resonance coil 21b. The secondary coil 21a is coupled by electromagnetic induction to the secondary resonance coil 21b. AC power supplied from the primary resonance coil 13b to the secondary resonance coil 21b is further supplied through electromagnetic induction to the secondary coil 21a. The secondary coil 21a is connected to the secondary matching unit 22.

- [0020] The number of windings and the winding diameter of the primary coil 13a, primary resonance coil 13b, secondary resonance coil 21b, and secondary coil 21a are set in accordance with the power supplied (transmitted) from the power supplying equipment 10 to the movable body equipment 20.
- [0021] The secondary matching unit 22 includes two variable capacitors 30 and 31 and an inductor 32, which form a variable reactance. The inductor 32 is connected between the two variable capacitors 30 and 31. The variable capacitor 30 is connected in parallel to the secondary coil 21a. The variable capacitor 31 is connected to the switch SW2. The secondary matching unit 22 varies the capacitance of each of the variable capacitors 30 and 31 to change its impedance. The variable capacitors 30 and 31 are known configuration in which rotational shafts (not shown) are driven by motors. The motors are driven in accordance with a drive signal from the vehicle controller 27.
- [0022] A voltage sensor 33, which forms a distance detector, is connected in parallel to the secondary coil 21a. When detecting the distance between the secondary resonance coil 21b and the primary resonance coil 13b, the vehicle controller 27 controls the switch SW2 so that the switch SW2 connects the distance detection high frequency power supply 23 and the secondary matching unit 22. The vehicle controller 27 detects the distance between the secondary resonance coil 21b and the primary resonance coil 13b based on the detection signal of the voltage sensor 33 in a state in which the resonance system is supplied with high frequency power from the distance detection high frequency power supply 23.
- [0023] In this embodiment, when the movable body equipment 20 performs distance detection, the primary matching unit 12, the primary coil 13a, the primary resonance coil 13b, the secondary resonance coil 21b, the secondary coil 21a, and the secondary matching unit 22 form the resonance system. Further, when the secondary resonance coil 21b receives power from the primary resonance coil 13b, the primary matching unit 12, the primary coil 13a, the primary resonance coil 13b, the secondary resonance coil 21b, the secondary coil 21a, the secondary matching unit 22, the rectifier 24, the charger 25, and the rechargeable battery 26 form the resonance system.
- [0024] The vehicle controller 27 includes a CPU 34 and a memory 35. The memory 35 stores a map or relationship expression obtained from data showing the relationship of the distance between the primary resonance coil 13b and the secondary resonance coil 21b and an input impedance of the resonance system when the distance detection high frequency power supply 23 outputs alternating current at a predetermined frequency. The data is obtained beforehand through experiments. During distance detection, the vehicle controller 27 detects the voltage across the two terminals of the secondary coil 21a with the voltage sensor 33 to measure the input impedance. Based on the detected input impedance and the map or relationship expression, the vehicle controller 27

computes the distance between the primary and secondary resonance coils 13b and 21b. The vehicle controller 27 functions as a distance computer. Further, the vehicle controller 27 and the voltage sensor 33 form the distance detector.

[0025] Further, the memory 35 stores a map or relationship expression obtained from data showing the relationship of the state of charge of the rechargeable battery 26 when the vehicle is accurately parked at the predetermined parking position during charging and the capacitance of each of the variable capacitors 30 and 31 in the secondary matching unit 22 when, in such a state, the secondary resonance coil 21b and rectifier 24 are matched with each other. After charging starts, the vehicle controller 27 adjusts the secondary matching unit 22 in correspondence with the state of charge of the rechargeable battery 26. In this manner, the vehicle controller 27 functions as an adjustment unit.

[0026] A notification unit (not shown) is arranged in the vehicle to notify a driver during distance detection that the distance from the vehicle to the power supplying equipment 10 is suitable for the power supplying equipment 10 to perform efficient non-contact power supply. It is preferable that the notification unit be a display allowing the driver to visually recognize when the vehicle is located at the position in which the suitable distance is obtained. The notification unit may also be a device that uses a voice to allow for audible recognition. When parking the vehicle at the charging position, the vehicle controller 27 drives the notification unit.

[0027] The movable body equipment 20 includes a communication device 36 to perform wireless communication with the power supplying equipment 10. The power supply controller 14 and the vehicle controller 27 are communicable with each other through the communication devices. The power supply controller 14 and the vehicle controller 27 exchange necessary information during a period from when the vehicle is parked at a predetermined charging position, where the power supplying equipment 10 performs charging, to when the charging ends.

[0028] The operation of the resonance type non-contact power supply system will now be described.

[0029] When charging the rechargeable battery 26, which is installed in the vehicle, the vehicle must be parked at a charging position at which the secondary resonance coil 21b and the primary resonance coil 13b are separated from each other by a predetermined distance. Thus, before power is supplied from the power supplying equipment 10 to the charger 25 of the movable body equipment 20, the movable body equipment 20 detects the distance between the secondary resonance coil 21b and the primary resonance coil 13b. After the vehicle moves in accordance with the detected distance information and reaches the predetermined parking position, the vehicle controller 27 transmits a power supplying request signal to the power supply controller

14. In response to the power supplying request signal, the power supply controller 14 starts supplying power.

[0030] The operation from when parking is started to when charging is started will now be described with reference to the flowchart of Fig. 2. In step S1, parking is started and the vehicle controller 27 transmits a parking start signal to the power supply controller 14. In step S2, when receiving the parking start signal, the power supply controller 14 switches the switch SW1 to a state connecting the primary matching unit 12 and the terminal resistor 18. Then, the power supply controller 14 provides the vehicle controller 27 with a transmission indicating the connection. The power supply controller 14 holds the high frequency power supply 11 in a standby state and does not activate it until receiving a transmission from the vehicle controller 27 indicating that distance detection has been completed. In step S3, when recognizing that the terminal resistor 18 has been connected to the primary matching unit 12, the vehicle controller 27 starts detecting the distance between the primary resonance coil 13b and the secondary resonance coil 21b.

[0031] More specifically, the vehicle controller 27 switches the switch SW2 to a state connecting the secondary matching unit 22 and the distance detection high frequency power supply 23. In this state, the movable body equipment 20 outputs AC power having a predetermined frequency from the distance detection high frequency power supply 23. This transmits power in a non-contact manner from the secondary coil unit 21 to the primary coil unit 13. Here, the output of the distance detection high frequency power supply 23 is supplied to the resonance system but not to the charger 25. Further, in the power supplying equipment 10, the primary matching unit 12 is disconnected from the high frequency power supply 11 and connected to the terminal resistor 18. Thus, the input impedance of the resonance system is not affected by the high frequency power supply 11, the charger 25, and the state of charge of the rechargeable battery 26. In this state, the vehicle controller 27 computes the input impedance of the secondary coil 21a based on the detection of the voltage sensor 33. Further, the vehicle controller 27 detects (computes) the distance between the secondary resonance coil 21b and the primary resonance coil 13b based on the value of the input impedance and the map or relationship expression. The vehicle controller 27 also drives the notification unit to notify the driver of whether or not the detected distance is suitable for efficiently receiving power in a non-contact manner from the power supplying equipment 10.

[0032] In step S4, the vehicle is moved toward the charging position. The driver of the vehicle refers to the notification device to determine whether or not the vehicle has reached the position (charging position) that is suitable for the movable body equipment 20 to efficiently receive power in a non-contact manner from the power

supplying equipment 10. When reaching the charging position, the driver stops the vehicle. More specifically, in step S4, the driver moves the vehicle to the predetermined parking position (charging position) based on the distance information received by the vehicle controller 27. In step S5, when the vehicle is moved to the predetermined parking position, the vehicle controller 27 completes the distance detection and sends a transmission indicating the completion to the power supply controller 14. Further, the vehicle controller 27 switches the switch SW2 to a state connecting the secondary matching unit 22 and the rectifier 24. The vehicle controller 27 also stops the output of the distance detection high frequency power supply 23.

[0033] In step S6, when recognizing that the vehicle controller 27 has completed distance detection, the power supply controller 14 switches the switch SW1 to a state connecting the primary matching unit 12 and the high frequency power supply 11. In step S7, the power supply controller 14 activates the high frequency power supply 11. As a result, the high frequency power supply 11, which has been in the standby state, outputs predetermined high frequency power to charge the rechargeable battery 26 in the movable body equipment 20.

[0034] The detection of the distance between the primary resonance coil 13b and the secondary resonance coil 21b based on the impedance of the resonance system is performed by supplying high frequency power to the resonance system from the distance detection high frequency power supply 23 of the movable body equipment 20. High frequency power is not supplied to the resonance system from the power supplying equipment 10. During the distance detection, the high frequency power supply 11 is held in the standby state. Thus, in contrast with a structure in which the high frequency power supply 11 supplies power in such a case, unnecessary power consumption is prevented even during the period until when the vehicle reaches the charging position.

[0035] Next, in step S8, prior to the charging, power transmission matching is performed. More specifically, the primary matching unit 12 and the secondary matching unit 22 are adjusted when necessary so that the resonance state of the resonance system becomes satisfactory for the vehicle that is located at the parking position. Afterward, in step S9, charging is started.

[0036] Then, AC power of the resonant frequency is supplied from the high frequency power supply 11 of the power supplying equipment 10 to the primary coil 13a, and power is supplied from the primary resonance coil 13b to the secondary resonance coil 21b through non-contact resonance. The power received by the secondary resonance coil 21b is supplied via the secondary matching unit 22 and the rectifier 24 to the charger 25. This charges the rechargeable battery 26, which is connected to the charger 25. When charging starts, the state of charge of the rechargeable battery 26 changes.

This changes the impedance of the rechargeable battery 26 and changes the impedance of the resonance system from a proper state. During the charging, the vehicle controller 27 adjusts the secondary matching unit 22 to obtain the impedance corresponding to the state of charge based on the map or relationship expression, which is stored in the memory 35 and which indicates the relationship of the state of charge of the rechargeable battery 26 and the suitable impedance corresponding to the state of charge. This performs charging in a proper state. The vehicle controller 27 determines that charging has been completed, for example, based on the time elapsed from when the voltage of the rechargeable battery 26 becomes equal to a predetermined voltage. When the charging ends, the vehicle controller 27 transmits a charge completion signal to the power supply controller 14. When receiving the charge completion signal, the power supply controller 14 ends the power transmission.

[0037] The above embodiment has the advantages described below.

[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 AC power supply (high frequency power supply 11), the primary resonance coil 13b, which is supplied with power from the high frequency power supply 11, and the power supply controller 14, which controls the AC power supply. The movable body equipment 20 includes the secondary resonance coil 21b, which is supplied with power from the primary resonance coil 13b. Further, the movable body equipment 20 includes the rectifier 24, which rectifies the power received from the secondary resonance coil 21b, the charger 25, which is supplied with rectified power from the rectifier 24, the rechargeable battery 26, which is connected to the charger 25, and the distance detector and distance detection high frequency power supply 23, which detect the distance between the primary resonance coil 13b and the secondary resonance coil 21b. When detecting the distance between the primary resonance coil 13b and the secondary resonance coil 21b in the movable body equipment 20, the power supply controller 14 holds the high frequency power supply 11 in a standby state. After the distance detection is completed, the power supply controller 14 activates the high frequency power supply 11 to supply power. Accordingly, the distance between the power supplying resonance coil and the power receiving resonance coil is detected at the movable body side (vehicle), the movable body is stopped at a position where power is efficiently supplied from the power supplying side to the power receiving side, and power consumption is reduced at the power supplying side.

[0039] (2) The power supplying equipment 10 includes the terminal resistor 18, which is connectable by the switch SW1 to the resonance system. When the movable body equipment 20 performs distance detection, the resonance system is disconnected from

the AC power supply (high frequency power supply 11) and connected to the terminal resistor 18. Even when the resonance system is connected to the high frequency power supply 11 during distance detection, as long as power is not supplied from the high frequency power supply 11 to the resonance system, the movable body equipment 20 can perform distance detection. In such a state, however, the high frequency power supply 11 slightly affects the impedance of the resonance system. This lowers the distance detection accuracy. In the present embodiment, during distance detection, the resonance system is disconnected from the high frequency power supply 11 and connected to the terminal resistor 18. This eliminates the influence of the high frequency power supply 11 on the impedance of the resonance system and increases the distance detection accuracy.

[0040] (3) The vehicle in which the movable body equipment 20 is installed includes the notification device that notifies the driver of whether or not the detected distance is suitable for efficiently receiving power in a non-contact manner from the power supplying equipment 10. Accordingly, the driver of the vehicle may determine with the notification device whether or not the vehicle has reached the position (charging position) that is suitable for efficiently receiving power in a non-contact manner from the power supplying equipment 10. In this manner, the vehicle can easily be moved to and stopped at the charging position.

[0041] (4) The movable body equipment 20 includes the secondary matching unit 22 and a unit for detecting the state of charge of the rechargeable battery 26 (i.e., the vehicle controller 27, the voltage sensor 28, and the current sensor 29). The vehicle controller 27 adjusts the secondary matching unit 22 so that the impedance of the resonance system allows for efficient non-contact power supply even when the impedance of the rechargeable battery 26 changes in correspondence with the state of charge during charging. Accordingly, charging is efficiently performed even when the state of charge of the rechargeable battery 26 changes.

[0042] It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the present invention may be embodied in the following forms.

[0043] The terminal resistor 18 is not necessarily required. The terminal resistor 18 may be eliminated, and the power supplying equipment 10 may be formed so that the primary matching unit 12 is constantly connected to the high frequency power supply 11. However, this structure decreases the distance detection accuracy in comparison to a structure that disconnects the resonance system from the high frequency power supply 11 and connects the resonance system to the terminal resistor 18.

[0044] In the above embodiment, the movable body equipment 20 switches the switch SW2

between a state in which the distance detection high frequency power supply 23 is connected to the secondary matching unit 22 and a state in which the distance detection high frequency power supply 23 is disconnected from the resonance state. Instead, the switch SW2 may be eliminated. In this case, the distance detection high frequency power supply 23 is connected between the secondary matching unit 22 and the rectifier 24. Further, when outputting high frequency power from the distance detection high frequency power supply 23 during distance detection, the impedance may be increased at a circuit component located toward the charger 25 from the switch SW2. In this case, the high frequency power output from the distance detection high frequency power supply 23 during distance detection is not supplied to the circuit component located toward the charger 25 from the switch SW2 but supplied to a circuit component located toward the secondary resonance coil 21b from the switch SW2. Thus, the state of charge of the rechargeable battery 26 does not adversely affect the impedance of the resonance system even when the charger 25 is not disconnected from the resonance system.

[0045] To perform non-contact power supplying between the power supplying equipment 10 and the movable body equipment 20, the resonance type non-contact power supply system does not necessarily require all of the primary coil 13a, the primary resonance coil 13b, the secondary coil 21a, and the secondary resonance coil 21b. The resonance type non-contact power supply system only requires the primary resonance coil 13b and the secondary resonance coil 21b. More specifically, instead of forming the primary coil unit 13 with the primary coil 13a and the primary resonance coil 13b, the primary resonance coil 13b may be connected by the primary matching unit 12 to the high frequency power supply 11. Further, instead of forming the secondary coil unit 21 with the secondary coil 21a and the secondary resonance coil 21b, the secondary resonance coil 21b may be connected by the secondary matching unit 22 to the rectifier 24. However, it is more preferable that the resonance type non-contact power supply system include all of the primary coil 13a, the primary resonance coil 13b, the secondary coil 21a, and the secondary resonance coil 21b. This facilitates adjustment of the resonance state and easily maintains a resonance state even when the distance increases between the primary resonance coil 13b and the secondary resonance coil 21b.

[0046] When the secondary coil 21a is eliminated, the voltage sensor 33, which forms the distance detector, measures the voltage across the two terminals of the secondary resonance coil 21b. Further, the vehicle controller 27 detects the distance between the primary resonance coil 13b and the secondary resonance coil 21b from a map or expression that indicates the relationship of the measured voltage and the distance between the primary resonance coil 13b and the secondary resonance coil 21b.

- [0047] The vehicle, which serves as a movable body, refers to an electric vehicle including a motor that generates power for driving the vehicle. Such a vehicle includes an electric vehicle, a hybrid vehicle, which uses an engine in addition to a motor as a power source, and a vehicle that uses a fuel cell in addition to the rechargeable battery 26 as a DC power supply for driving the vehicle. Further, the vehicle is not limited to a vehicle that requires a driver and may be an automated vehicle.
- [0048] The movable body is not limited to a vehicle and may be, for example, a robot, which moves away from the power supplying equipment when charging is not performed.
- [0049] The primary matching unit 12 and the secondary matching unit 22 each do not have to include two variable capacitors and an inductor. For example, a matching unit may include a variable inductor that serves as the inductor. Alternatively, a matching unit may include a variable inductor and two non-variable capacitors.
- [0050] The primary matching unit 12 and the secondary matching unit 22 may be eliminated. However, it is preferable that the primary matching unit 12 and the secondary matching unit 22 be included since power can be efficiently supplied from the power supplying side to the power receiving side when finely adjusting the impedance of the resonance system.
- [0051] Instead of arranging the rectifier 24 and the charger 25 independently from each other, the rectifier 24 may be incorporated in the charger 25.
- [0052] 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 rechargeable 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.
- [0053] The power storage device is not limited to the rechargeable battery 26 as long as it is a DC power supply that can be charged and discharged. For example, the power storage device may be a capacitor having a large capacitance.
- [0054] The high frequency power supply 11 may be formed so that the frequency of the output AC voltage is variable or invariable.
- [0055] The capacitors C connected to the primary resonance coil 13b and the secondary resonance coil 21b may be eliminated. However, connection of the capacitors C enables the resonant frequency to be decreased, whereas the resonant frequency would not be decreased when the capacitors C are eliminated. Further, as long as the resonant frequency is the same, connection of the capacitors C enables miniaturization of the primary resonance coil 13b and the secondary resonance coil 21b, whereas such miniaturization would be difficult when the capacitors C are eliminated.
- [0056] The present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be

modified within the scope and equivalence of the appended claims.

Claims

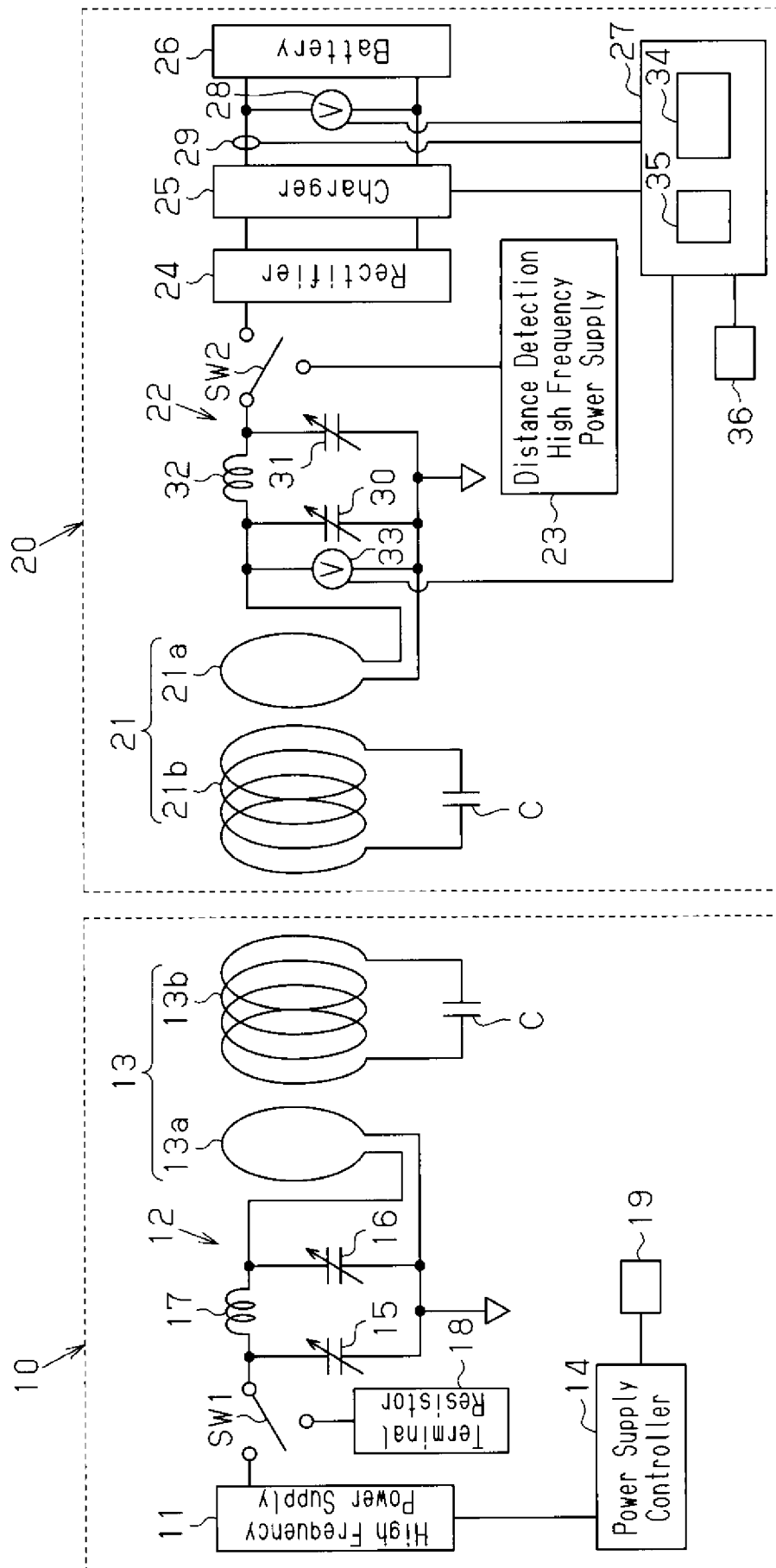
- [Claim 1] A resonance type non-contact power supply system comprising:
power supplying equipment including an AC power supply, a primary resonance coil, and a controller, wherein the primary resonance coil receives power from the AC power supply, and the controller controls the AC power supply; and
movable body equipment including a secondary resonance coil, a rectifier, a power storage device, a distance detector, and a high frequency power supply, wherein the secondary resonance coil receives power from the primary resonance coil, the rectifier rectifies the power received by the secondary resonance coil, the power storage device is supplied with the power rectified by the rectifier, and the distance detector and the high frequency power supply cooperate with each other to detect the distance between the primary resonance coil and the secondary resonance coil;
wherein when the distance detector performs distance detection, the controller holds the AC power supply in a standby state; and
after the distance detector completes the distance detection, the controller activates the AC power supply to supply power.
- [Claim 2] The resonance type non-contact power supply system according to claim 1, wherein
the power supplying equipment further includes a switch and a terminal resistor, which is connectable by the switch to a resonance system including the primary and secondary resonance coils, and
when the distance detection is performed, the switch disconnects the resonance system from the AC power supply and connects the resonance system to the terminal resistor.
- [Claim 3] The resonance type non-contact power supply system according to claim 1, wherein
the distance detection unit detects the distance between the primary resonance coil and the secondary resonance coil based on an input impedance of the resonance system when the high frequency power supply outputs high frequency power, and
the resonance system includes the primary resonance coil and the secondary resonance coil.
- [Claim 4] The resonance type non-contact power supply system according to any one of claims 1 to 3, wherein the movable body equipment includes:

a secondary matching unit; and
an adjustment unit that adjusts the secondary matching unit during charging based on data showing the relationship of a state of charge of the power storage device and a suitable impedance for the secondary matching unit.

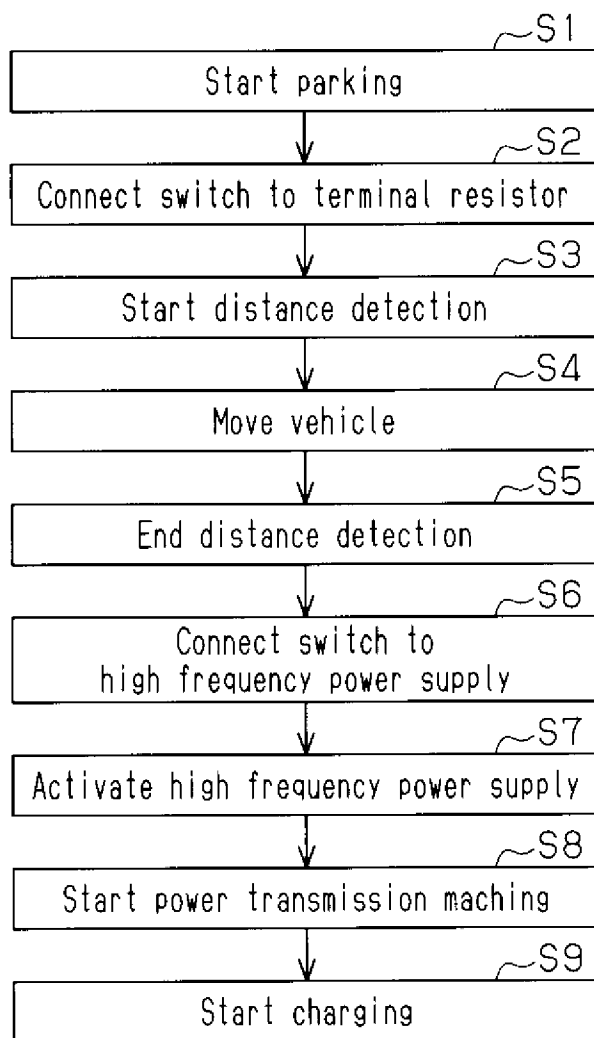
[Claim 5] The resonance type non-contact power supply system according to any one of claims 1 to 4, wherein the movable body equipment is installed and used in an electric vehicle.

[Claim 6] The resonance type non-contact power supply system according to any one of claims 1 to 5, wherein the movable body equipment further includes a charger provided between the rectifier and the power storage device, the power rectified by the rectifier is supplied to the charger, and the power storage device is connected to the charger.

[Fig. 1]



[Fig. 2]



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2011/004281

A. CLASSIFICATION OF SUBJECT MATTER

INV. B60L5/00 B60L11/18 H02J7/02
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60L H02J

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2010/067763 A1 (TOYOTA JIDOSHOKKI KK [JP]; TOYOTA MOTOR CO LTD [JP]; SAKODA SHIMPEI [J] 17 June 2010 (2010-06-17) figures 1, 2 -----	1-6
A	US 2010/164295 A1 (ICHIKAWA KATSUEI [JP] ET AL) 1 July 2010 (2010-07-01) figures 1-9 -----	1-6
A	JP 2003 189508 A (FURUKAWA ELECTRIC CO LTD) 4 July 2003 (2003-07-04) abstract -----	1-6



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

29 November 2011

Date of mailing of the international search report

07/12/2011

Name and mailing address of the ISA/

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

Authorized officer

Roider, Anton

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/JP2011/004281

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010067763 A1	17-06-2010	CN 102239622 A	09-11-2011
		EP 2357717 A1	17-08-2011
		KR 20110081886 A	14-07-2011
		US 2011241440 A1	06-10-2011
		WO 2010067763 A1	17-06-2010

US 2010164295 A1	01-07-2010	CN 101771297 A	07-07-2010
		JP 2010154700 A	08-07-2010
		US 2010164295 A1	01-07-2010

JP 2003189508 A	04-07-2003	NONE	
