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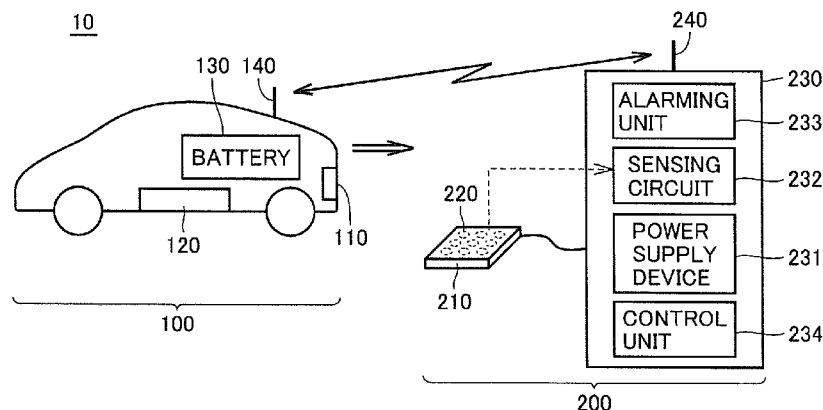
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(54) Title: CONTACTLESS POWER TRANSMITTING DEVICE AND CONTACTLESS POWER TRANSFER SYSTEM

FIG. 1



(57) **Abstract:** The contactless power transmitting device (a power transmitting device (200)) includes: a sensing unit (a sensing circuit (232)) that senses an output of the metal sensing coil; and a control unit (234) that controls an alarming unit (233) to perform an alarming operation in aligning a power receiving device (a power receiving unit (120)) mounted in a vehicle (100) with (a power transmitting unit (210)) of power transmitting device (200) when the metal sensing coil provides an output below a reference value. The reference value is set to be smaller when vehicle (100) is located inside a prescribed range as measured from power transmitting device (200) than when vehicle (100) is located outside the prescribed range as measured from power transmitting device (200).

Description

Title of Invention: CONTACTLESS POWER TRANSMITTING DEVICE AND CONTACTLESS POWER TRANSFER SYSTEM

Technical Field

[0001] The present invention relates to a contactless power transmitting device and a contactless power transfer system.

Background Art

[0002] Conventionally, a variety of types of contactless power transmitting devices and systems have been proposed. For example, Japanese Patent Laying-Open No. 2012-016125 (PTL 1) describes a power transmitting device having a surface with a plurality of metal sensing coils mounted thereon in an array.

Citation List

Patent Literature

- [0003] [PTL 1] Japanese Patent Laying-Open No. 2012-016125
[PTL 2] Japanese Patent Laying-Open No. 2011-160600
[PTL 3] Japanese Patent Laying-Open No. 2010-252498
[PTL 4] Japanese Patent Laying-Open No. 2013-017247
[PTL 5] Japanese Patent Laying-Open No. 2013-154815
[PTL 6] Japanese Patent Laying-Open No. 2013-146154
[PTL 7] Japanese Patent Laying-Open No. 2013-146148
[PTL 8] Japanese Patent Laying-Open No. 2013-110822
[PTL 9] Japanese Patent Laying-Open No. 2013-126327

Summary of Invention

Technical Problem

[0004] A metal sensing coil may be used in sensing a metallic foreign matter in a method, as follows: For example, when a power receiving device is disposed over a power transmitting device, a plurality of metal sensing coils are disposed on an upper surface of the power transmitting device. When contactlessly transferring electric power, the power transmitting device generates an electromagnetic field. In doing so, if any metallic foreign matter is present around the metal sensing coil, the metal sensing coil's inductance value (L value) varies. As a result, the contactless power transfer is performed with the metal sensing coil having induced therein a voltage, a current and the like that are different (or vary) from those provided when there is no metallic foreign matter present. This variation can be exploited to detect the metallic foreign matter.

[0005] Contactless power transfer can be utilized to charge a battery of a vehicle. In that case, for example, the power receiving device is provided to the vehicle and the power transmitting device is provided on the ground. To contactlessly transfer electric power, the power transmitting device and the power receiving device are aligned, and accordingly, the vehicle approaches the power transmitting device. As the vehicle includes a large number of metallic parts, the metal sensing coil may sense that the vehicle is per se a metallic foreign matter.

[0006] An object of the present invention is to provide a contactless power transmitting device and contactless transfer system including a metal sensing coil, that can minimize erroneously recognizing a vehicle as a metallic foreign matter and can still satisfactorily sense metallic foreign matters.

Solution to Problem

[0007] The present invention in summary provides a contactless power transmitting device comprising: a sensing unit that senses an output of a metal sensing coil; and a control unit that controls an alarming unit to perform an alarming operation in aligning a power receiving device mounted in a vehicle with the contactless power transmitting device when the metal sensing coil provides an output below a reference value. The reference value is set to be smaller when the vehicle is located inside a prescribed range as measured from the contactless power transmitting device than when the vehicle is located outside the prescribed range as measured from the contactless power transmitting device.

[0008] If metal is present around the contactless power transmitting device, the metal sensing coil provides a reduced output, and the output falls below a reference value. When the metal sensing coil's output falls below the reference value, an alarming operation is performed, which is an operation performed when any metallic foreign matter is sensed. The vehicle configured as described above allows the reference value to be set to be smaller when the vehicle is located inside a prescribed range as measured from the contactless power transmitting device (i.e., when the vehicle is close to the contactless power transmitting device) than when the vehicle is located outside the prescribed range as measured from the contactless power transmitting device (i.e., when the vehicle is remote from the contactless power transmitting device). The reference that is set appropriately can prevent the vehicle close to the contactless power transmitting device from having a metallic part or the like of the vehicle to have an effect to trigger the alarming operation. In other words, it can prevent the vehicle from having its metallic parts or the like erroneously sensed as a metallic foreign matter.

[0009] Preferably, in the aligning, when the vehicle enters the prescribed range, the control

unit controls the contactless power transmitting device to temporarily halt sensing for metallic foreign matters, and once the aligning has been completed, the control unit controls the contactless power transmitting device to resume sensing for metallic foreign matters.

- [0010] When the vehicle is close to the contactless power transmitting device and the alignment is conducted, the vehicle's metallic parts also approach the contactless power transmitting device and may thus affect the metal sensing coil to provide an output varying from moment to moment. In that case, it may be difficult to rely on the metal sensing coil's varying output to accurately determine whether any metallic foreign matter is present, which may result in erroneous sensing. The above configuration can temporarily halt sensing for metallic foreign matters when the vehicle is close to the contactless power transmitting device and the alignment is conducted. This can prevent erroneous sensing.
- [0011] Alternatively, preferably, the control unit controls the contactless power transmitting device to continue sensing for metallic foreign matters while the vehicle enters the prescribed range, and once any metallic foreign matter has been sensed, the control unit controls the alarming unit to perform the alarming operation.
- [0012] This allows a metallic foreign matter to be also sensed before the alignment is completed.
- [0013] Preferably, the contactless power transmitting device further comprises: a power transmitting coil; a power supply device that supplies the power transmitting coil with electric power; and a communication unit that performs communication with the vehicle. The control unit controls the power supply device to supply the power transmitting coil with weak electric power, and before the aligning, once any metallic foreign matter has been sensed, the control unit controls the communication unit to inform the vehicle that the metallic foreign matter is present when the communication is established.
- [0014] This allows metallic foreign matters to be sensed for via a weak current that is supplied to the power transmitting coil for the alignment. In other words, the weak current that is supplied to the power transmitting coil can create an electromagnetic field and thereby cause the metal sensing coil to provide an output.
- [0015] Preferably, once the aligning has been completed, the control unit controls the power supply device to supply the power transmitting coil with larger electric power than the weak electric power to transmit the larger electric power to the vehicle, and if any metallic foreign matter is sensed with the larger electric power transmitted, the control unit controls the power supply device to stop supplying the power transmitting coil with the larger electric power.
- [0016] Thus, for example, while the charging is conducted, the electric power that is charged

can be utilized to sense for metallic foreign matters.

[0017] The present invention in another aspect provides a contactless power transfer system. The contactless power transfer system comprises: a contactless power transmitting device; a power receiving device mounted in a vehicle; a sensing unit that senses an output of a metal sensing coil; and a control unit that controls an alarming unit to perform an alarming operation in aligning the power receiving device with the contactless power transmitting device when the metal sensing coil provides an output below a reference value. The reference value is set to be smaller when the vehicle is located inside a prescribed range as measured from the contactless power transmitting device than when the vehicle is located outside the prescribed range as measured from the contactless power transmitting device.

[0018] The contactless power transfer system thus configured can also prevent the vehicle from having its metallic parts or the like erroneously sensed as a metallic foreign matter.

Advantageous Effects of Invention

[0019] The present invention can thus provide a contactless power transmitting device and contactless transfer system including a metal sensing coil, that can minimize erroneously recognizing a vehicle as a metallic foreign matter and can still satisfactorily sense metallic foreign matters.

Brief Description of Drawings

[0020] [fig.1]Fig. 1 is a diagram for schematically illustrating a configuration of a power transfer system.

[fig.2]Fig. 2 is a diagram for schematically illustrating a configuration of a vehicle.

[fig.3]Fig. 3 is a diagram for illustrating a principle of sensing a metallic foreign matter (i.e., of a metallic foreign matter sensor).

[fig.4]Fig. 4 is a flowchart for illustrating a process performed in contactless charging.

[fig.5]Fig. 5 is a flowchart for illustrating a process performed in contactless charging including temporarily halting a metallic foreign matter sensing operation.

[fig.6]Fig. 6 is a flowchart for illustrating a process performed when a metallic foreign matter is sensed before the vehicle is adjacent.

[fig.7]Fig. 7 is a flowchart for illustrating a process performed when a metallic foreign matter is sensed during charging.

[fig.8]Fig. 8 is a diagram for illustrating a reference value used in each metallic foreign matter sensing operation in contactless charging.

Description of Embodiments

[0021] Hereinafter reference will be made to the drawings to describe the present invention in embodiments. In the drawings, identical or corresponding components are

identically denoted and will not be described repeatedly.

[0022] Fig. 1 is a diagram for schematically illustrating a configuration of a power transfer system 10. Power transfer system 10 allows a contactless power transmitting device or a power transmitting device 200 (or an infrastructure's side) to transfer electric power to a power receiving unit 120 of a vehicle 100 contactlessly. This allows vehicle 100 to be contactlessly charged, for example.

[0023] Vehicle 100 is for example an electric vehicle, a hybrid vehicle or the like that can use electrical energy to travel. Vehicle 100 includes a camera 110, power receiving unit 120, a battery 130, and a communication unit 140. Camera 110 picks up an image, which can be confirmed by a driver/passenger, and the user can use the image to align vehicle 100 with power transmitting device 200. Power receiving unit 120 receives electric power from power transmitting device 200 contactlessly. Power receiving unit 120 includes a coil for receiving electric power (i.e., a power receiving coil). Battery 130 is used as a power source of vehicle 100. Communication unit 140 is used to communicate with a communication unit 240 (for example wirelessly).

[0024] Power transmitting device 200 is a device for transmitting electric power contactlessly. Power transmitting device 200 includes a power transmitting unit 210, a metal sensing coil unit 220, and a power supply stand 230. Power transmitting unit 210 includes a coil for transmitting electric power (i.e., a power transmitting coil). Power supply stand 230 includes a power supply device 231, a sensing circuit 232, an alarming unit 233, and a control unit 234. Power supply device 231 generates contactlessly transferrable electric power (alternating current electric power) and supplies power transmitting unit 210 therewith. Communication unit 240 is used to communicate with communication unit 140. Control unit 234 controls components included in power transmitting device 200. Control unit 234 can also control vehicle 100 via communication unit 240.

[0025] Alarming unit 233 performs an alarming operation. The alarming operation is an operation to inform vehicle 100, a user and/or the like of information of a metallic foreign matter. The alarming operation may be implemented by alarming unit 233 and control unit 234 cooperating with each other. For example, alarming unit 233 includes an alarm (not shown). In that case, the alarm operates to inform the user that a metallic foreign matter is present. The alarming operation includes a variety of operations, such as informing the user that a metallic foreign matter has been sensed (or found), informing the user to urge the user to remove the metallic foreign matter, and informing the user that as the metallic foreign matter is present, charging has been interrupted.

[0026] In contactless charging, the power receiving coil included in vehicle 100 at power receiving unit 120 and the power transmitting coil included in power transmitting

device 200 at power transmitting unit 210 are aligned opposite to each other. After the coils have been aligned completely, (the power transmitting coil of) power transmitting unit 210 transfers electric power via an electromagnetic field to (the power receiving coil of) power receiving unit 120 contactlessly.

[0027] The power transmitting coil and the power receiving coil each have a capacitor connected thereto and they are designed to resonate at a transmission frequency. Resonance intensity is represented by a Q value, which is preferably equal to or larger than 100.

[0028] When there is a metallic foreign matter present between power receiving unit 120 and power transmitting unit 210, it may affect power transfer. For example, a portion of electric power used to transfer electric power may be consumed by the metallic foreign matter. This results in inefficient power transfer, the metallic foreign matter generating heat, and the like. Power transfer system 10 allows metal sensing coil unit 220 and sensing circuit 232 to be used to sense a metallic foreign matter introduced between power receiving unit 120 and power transmitting unit 210. Metal sensing coil unit 220 includes a plurality of metal sensing coils, which may be referred to in an embodiment as a "scanning coil", as will be described hereinafter with reference to Fig. 3. Metal sensing coil unit 220 is only required to be disposed to be capable of sensing a metallic foreign matter, and as one example, as shown in Fig. 1, it is disposed at an upper portion of power transmitting unit 210. Sensing circuit 232 functions as a sensing unit to sense voltage, current and/or the like caused in metal sensing coil unit 220. Metal sensing coil unit 220 and sensing circuit 232 are used to sense for metallic foreign matters, as will be described more specifically hereinafter with reference to Fig. 3.

[0029] Fig. 2 is a diagram for schematically illustrating a configuration of vehicle 100. Vehicle 100 includes an electric control unit (ECU) 160 serving as a control unit to control components included in vehicle 100. Vehicle 100 is a so-called hybrid vehicle. As such, vehicle 100 includes a hybrid travelling scheme. Note that ECU 160 can also control power transmitting device 200 of Fig. 1 via communication unit 140.

[0030] The hybrid travelling scheme allows an internal combustion engine (an engine) 133 and motor generators MG1, MG2 to be used to drive a driving wheel 134. Power split device 132 is coupled with engine 133 and motor generators MG1 and MG2 to distribute a driving force among them. Motor generator MG2 has a rotation shaft coupled with driving wheel 134 by reduction and differential gears (not shown). Furthermore, a power storage device (or battery) 130 stores electric power therein, which is converted by a power control unit (PCU) 131 to electric power for driving motor generators MG1, MG2. Motor generators MG1, MG2 generate electric power, which may be converted by PCU 131 to electric power for charging battery 130. The electric

power of battery 130 is used not only for hybrid travelling but also for auxiliaries, for example.

[0031] Vehicle 100 includes power receiving unit 120. Power receiving unit 120 includes a power receiving coil 121, a capacitor 122, a power conversion device 123, and a power measurement unit 124. Power receiving coil 121 receives electric power from the power transmitting coil in power transmitting unit 210 of Fig. 1 contactlessly. Capacitor 122 is connected to power receiving coil 121. Power receiving coil 121 and capacitor 122 are designed to resonate at a transmission frequency. Power conversion device 123 converts the electric power that power receiving coil 121 has received to electric power suitable for charging battery 130. Power measurement unit 124 can measure the electric power in power receiving unit 120. As one example, power measurement unit 124 measures electric power transmitted from power conversion device 123 to battery 130, as shown in Fig. 2.

[0032] ECU 160 can refer to a resultant measurement that is obtained via power measurement unit 124 to determine whether (power receiving coil 121 of) power receiving unit 120 has been appropriately aligned with power transmitting unit 210 of power transmitting device 200 shown in Fig. 1. ECU 160 determines that the alignment has appropriately been done for example when weak electric power transmitted from power transmitting unit 210 is received by power receiving unit 120 at a maximum level or therearound.

[0033] Communication unit 140 communicates outside vehicle 100. For example, communication unit 140 wirelessly communicates with communication unit 240 shown in Fig. 1.

[0034] Furthermore, vehicle 100 includes an alarming unit 150. Alarming unit 150 responds to the alarming operation of power transmitting device 200 of Fig. 1 by performing an alarming operation to alarm the user. The alarming operation is performed for example via a display device, a speaker (not shown), and/or the like.

[0035] By the above configuration, vehicle 100 can receive electric power contactlessly from power transmitting device 200 shown in Fig. 1 and charge battery 130 therewith (i.e., perform contactless charging). Contactless charging is done with vehicle 100 and power transmitting device 200 in communication.

[0036] Fig. 3 is a diagram for illustrating a principle of sensing for metallic foreign matters via metal sensing coil unit 220 and sensing circuit 232 (i.e., of a so called "metallic foreign matter sensor"). Power transmitting unit 210 is configured with the power transmitting coil, the capacitor and the like accommodated in a casing (or bobbin) for example. Power transmitting unit 210 is supplied with electric power from power supply device 231. Metal sensing coil unit 220 includes a plurality of scanning coils 221. Scanning coil 221 is for example a planar coil antenna, and each scanning coil

221 is arranged on a single plane. Metal sensing coil unit 220 can also be said to be an antenna coil array. When metal sensing coil unit 220 is placed in an electromagnetic field, each scanning coil 221 has a voltage, a current and/or the like (i.e., an output) induced therein, depending on the electromagnetic field's intensity, distribution and other states. The induced output is transmitted to sensing circuit 232 and sensed thereby. Sensing circuit 232 provides a sensed result P, which is used in a contactless power feeding system (e.g., the Fig. 1 power transfer system 10).

[0037] Specifically, sensing circuit 232 transmits sensed result P to control unit 234 (see Fig. 1). Control unit 234 receives the sensed result and therefrom determines whether any metallic foreign matter is present. Determining from the sensed result whether any metallic foreign matter is present can be described as follows: When power transmitting unit 210 transmits electric power, each scanning coil 221 has an output induced therein. At the time, if any metallic foreign matter is present around scanning coil 221, scanning coil 221 has its L value varied (e.g., reduced). This results in scanning coil 221 providing a varying (e.g., reduced) induced output. This variation can be exploited to determine whether any metallic foreign matter is present. Furthermore, which scanning coil 221 is close to the metallic foreign matter, i.e. where the metallic foreign matter is located, is also determined. By these decisions, a metallic foreign matter is sensed. If any metallic foreign matter is present, the Fig. 1 power transfer system 10 operates to perform the alarming operation via alarming unit 233, as has been set forth above. Furthermore, contactless charging may be suspended (or stopped).

[0038] Whether any metallic foreign matter is present is determined by comparing at least one of induced voltage and induced current, i.e., a value of an induced output, with a reference value. Specifically, if the induced output is below the reference value, it is determined that a metallic foreign matter is present, and the alarming operation is performed. If the induced output is equal to or larger than the reference value, it is determined that no metallic foreign matter is present.

[0039] For example, when there is a metal piece near scanning coil 221, scanning coil 221 has an L value smaller than that which scanning coil 221 has when there is no metal piece near scanning coil 221. Accordingly, when there is a metal piece near scanning coil 221, scanning coil 221 has a voltage and a current induced therein smaller than those which scanning coil 221 has induced therein when there is no metal piece near scanning coil 221.

[0040] Determining whether any metallic foreign matter is present, or the metallic foreign matter sensing operation, as described above, is accompanied by the following issue: In general, a vehicle includes a large number of metallic parts. Accordingly, when the vehicle approaches the scanning coil, the scanning coil has its L value reduced, and ac-

cordingly has a reduced induced voltage and a reduced induced current. As a result, in the metallic foreign matter sensing operation, the vehicle may per se be erroneously recognized as a metallic foreign matter.

- [0041] Again, with reference to Fig. 1, power transfer system 10 in the present embodiment refers to a positional relationship of (power receiving unit 120 of) vehicle 100 and (power transmitting unit 210 of) power transmitting device 200 to appropriately set a reference value in the metallic foreign matter sensing operation. Specifically, when vehicle 100 is located outside a prescribed range as measured from power transmitting device 200, the reference value is set to a first reference value. In contrast, when vehicle 100 is located inside the prescribed range as measured from power transmitting device 200, the reference value is set to a second reference value smaller than the first reference value.
- [0042] The second reference value smaller than the first reference value can prevent vehicle 100 close to the scanning coil and accordingly having its induced output (or at least one of its induced voltage and its induced current) reduced from being erroneously determined to be a metallic foreign matter to accordingly start the alarming operation.
- [0043] Note that in the embodiment, when vehicle 100 is located in a range outside the prescribed range as measured from power transmitting device 200, that range will be referred to as a first reference range, and the metallic foreign matter sensing operation performed in the first reference range will be referred to as a "MODE 1". When vehicle 100 is located in a range inside the prescribed range as measured from power transmitting device 200, that range will be referred to as a second reference range, and the metallic foreign matter sensing operation performed in the second reference range will be referred to as a "MODE 2".
- [0044] Being inside the prescribed range is being inside such a range that a metallic part of vehicle 100 has an effect to vary the scanning coil's induced output relatively significantly, and it is for example when vehicle 100 is adjacent to the power transmitting device 200 power transmitting unit 210. For example, when vehicle 100 has its bottom surface at least partially overlying power transmitting unit 210, it can be said that vehicle 100 is adjacent to power transmitting unit 210.
- [0045] Fig. 4 is a flowchart for illustrating a process performed in charging the vehicle contactlessly. Fig. 4 indicates an infrastructure's side and a vehicle's side, which indicate a process performed in power transmitting device 200 (see Fig. 1) and a process performed in vehicle 100 (see Fig. 1), respectively. The process performed on the infrastructure's side is performed by control unit 234 (see Fig. 1). The process performed on the vehicle's side is performed by ECU 160 (see Fig. 2).
- [0046] With reference to Fig. 4, initially, on the infrastructure's side, the power supply stand is set ON (Step S101). This setting is done for example via the user's operation or the

like. This places power supply device 231 and sensing circuit 232 in an operable state.

[0047] Furthermore, on the vehicle's side, a noncontact switch is set ON. This setting is also done for example via the user's operation or the like. This places the vehicle in a contactlessly chargeable state. The contactlessly chargeable state indicates that, with reference to Fig. 2, battery 130 is chargeable with electric power that power receiving unit 120 receives (i.e., electric power (to be) charged).

[0048] On the infrastructure's side, after Step S101 is performed, the power transmitting coil is supplied with small electric power (Step S102). The small electric power is electric power rather smaller than electric power supplied to the power transmitting coil for contactless charging (that is to say, weak electric power). In the present embodiment, the small electric power is used to perform the metallic foreign matter sensing operation and also align the power receiving device (or power receiving unit 120) with power transmitting device 200. Specifically, vehicle 100 is aligned with power transmitting device 200, based on a voltage received when the vehicle receives the small electric power from the power transmitting coil. On the other hand, the scanning coil is exposed to an alternating current magnetic field created around the power transmitting coil, and the scanning coil thus has a voltage and a current induced therein. After Step S102 is performed, the control proceeds to Step S103.

[0049] On the infrastructure's side, Step S103 is performed to start a metallic foreign matter sensing operation. The metallic foreign matter sensing operation, as performed here, is "MODE 1", and the reference value is set to the first reference value. After Step S103 is performed, the infrastructure's side communicates with the vehicle's side wirelessly.

[0050] On the infrastructure's side, the control proceeds to Step S104 to determine whether the infrastructure's side has established wireless communications with the vehicle's side. If the infrastructure's side has established wireless communications with the vehicle's side (YES in Step S104), the control proceeds to Step S105. If the infrastructure's side does not establish wireless communications with the vehicle's side (NO in Step S104), then Step S104 is repeated until the infrastructure's side establishes wireless communications with the vehicle's side. Note that if the small electric power used for the metallic foreign matter sensing operation is different in magnitude from the small electric power used for the alignment, then, after Step S104 is performed, the electric power supplied to the power transmitting coil may be switched from the electric power for the metallic foreign matter sensing operation to the electric power for the alignment.

[0051] On the vehicle's side, the control proceeds to Step S202 to determine whether the vehicle's side has established wireless communications with the infrastructure's side. If the vehicle's side has established wireless communications with the infrastructure's side (YES in Step S202), the control proceeds to Step S203. If the vehicle's side does

not establish wireless communications with the infrastructure's side (NO in Step S202), then Step S202 is repeated until the vehicle's side establishes wireless communications with the infrastructure's side.

- [0052] The vehicle's side starts positional detection (Step S203). More specifically, the vehicle's side performs the positional detection via camera 110 (see Fig. 1), based on a level of weak electric power received, and/or the like. After the positional detection is started, the user performs an operation or the like to cause the vehicle to approach the infrastructure.
- [0053] On the vehicle's side, the control proceeds to Step S204 to determine whether the vehicle is adjacent to the infrastructure. If the vehicle is adjacent to the infrastructure (YES in Step S204), the control proceeds to Step S205. If the vehicle is not adjacent to the infrastructure (NO in Step S204), Step S204 is repeated until the vehicle is adjacent to the infrastructure. The information of whether the vehicle is adjacent to the infrastructure is transmitted to the infrastructure's side via wireless communications.
- [0054] On the infrastructure's side, Step S105 is performed to determine from the information received from the vehicle's side whether the vehicle is adjacent to the infrastructure. If the vehicle is adjacent to the infrastructure (YES in Step 105), the control proceeds to Step S106. If the vehicle is not adjacent to the infrastructure (NO in Step S105), Step S105 is repeated until the vehicle is adjacent to the infrastructure.
- [0055] On the infrastructure's side, Step S106 is performed to continue sensing for metallic foreign matters, and also switch the metallic foreign matter sensing operation to MODE 2 and set the reference value to the second reference value.
- [0056] On the vehicle's side, Step S205 is performed to determine whether the vehicle is stopped, i.e., whether the alignment has been completed. For example, the control determines that the vehicle is stopped when the user performs an operation or the like to place the vehicle in a READY-OFF state (i.e., a state in which the vehicle is incapable of travelling), set the shift position at the parking (P) position, or the like. If the vehicle is stopped (YES in Step S205), the control proceeds to Step S206. If the vehicle is not stopped (NO in Step S205), Step S205 is repeated until the vehicle stops. The information of whether the vehicle is stopped is transmitted to the infrastructure's side via wireless communications.
- [0057] On the infrastructure's side, the control proceeds to Step S107 to refer to the information that is received from the vehicle's side to confirm that the vehicle is stopped.
- [0058] On the vehicle's side, Step S206 is performed to issue an instruction to start charging. The instruction to start charging is transmitted to the infrastructure's side via wireless communications.
- [0059] On the infrastructure's side, the control proceeds to Step S108 to start transmitting electric power charged according to the information received from the vehicle's side.

- [0060] On the vehicle's side, the control proceeds to Step S207 to start receiving the electric power charged.
- [0061] Thereafter, on the infrastructure's side, the control proceeds to Step S109 to complete the charging, and on the vehicle's side, the control proceeds to Step S208 to complete the charging.
- [0062] As can be seen in the Fig. 4 flowchart, before the vehicle is adjacent to the infrastructure, the metallic foreign matter sensing operation is set to MODE 1, and once the vehicle has been adjacent to the infrastructure, the metallic foreign matter sensing operation is set to MODE 2. This can prevent the vehicle from being erroneously sensed as a metallic foreign matter and thus allows a metallic foreign matter to be better sensed.
- [0063] Note that while the metallic foreign matter sensing operation is performed via determining whether the scanning coil's induced output falls below a reference value, the operation may alternatively be performed via determining at what rate the scanning coil's induced output changes.
- [0064] For vehicle 100 of some types, the scanning coil's L value changes in a varying manner. As a result, when the vehicle is adjacent to the power transmitting device and the vehicle is also moving, the scanning coil provides a varying induced output, and accordingly, whether any metal foreign matter is present cannot be accurately determined, which may results in erroneous sensing. Accordingly, when the vehicle is adjacent to the power transmitting device, the metallic foreign matter sensing operation may temporarily be halted.
- [0065] Fig. 5 is a flowchart for illustrating a process performed in contactless charging including temporarily halting the metallic foreign matter sensing operation. The Fig. 5 Steps S301-S303 performed on the infrastructure's side and The Fig. 5 Steps S401-S406 performed on the vehicle's side are identical to the Fig. 4 Steps S101-S103 performed on the infrastructure's side and the Fig. 4 Steps S201-S206 performed on the vehicle's side, respectively, and accordingly, will not be described repeatedly.
- [0066] With reference to Fig. 5, the control proceeds to Step S304 to determine whether any metallic foreign matter has been sensed. This is done to determine whether any metallic foreign matter is sensed before the vehicle is adjacent to the infrastructure. If there is not any metallic foreign matter sensed (NO in Step S304), the control proceeds to Step S305. If any metallic foreign matter is sensed (YES in Step S304), the control proceeds to Step S304A. Step S304A will be described hereinafter with reference to Fig. 6.
- [0067] On the infrastructure's side, Step S305 is performed to determine whether the infrastructure's side has established wireless communications with the vehicle's side. If the infrastructure's side has established wireless communications with the vehicle's side

(YES in Step S305), the control proceeds to Step S306. If the infrastructure's side does not establish wireless communications with the vehicle's side (NO in Step S305), Step S305 is repeated. Furthermore, the control also proceeds to Step S306 after Step S304A is performed.

- [0068] On the infrastructure's side, Step S306 is performed to determine whether the vehicle is adjacent to the infrastructure. If the vehicle is adjacent to the infrastructure (YES in Step 306), the control proceeds to Step S307. If the vehicle is not adjacent to the infrastructure (NO in Step S306), Step S306 is repeated until the vehicle is adjacent to the infrastructure.
- [0069] On the infrastructure's side, Step S307 is performed to interrupt the metallic foreign matter sensing operation. Thereafter the control proceeds to Step S308 to confirm that the vehicle is stopped.
- [0070] On the infrastructure's side, the control proceeds to Step S309 to resume the metallic foreign matter sensing operation. At the time, the metallic foreign matter sensing operation is "MODE 2", and the reference value is set to the second reference value.
- [0071] On the infrastructure's side, the control proceeds to Step S310 to start charging. Similarly, on the vehicle's side, the control proceeds to Step S407 to start charging. After the charging has been started (or while the charging is performed), a process is performed, as will be described hereinafter with reference to Fig. 7.
- [0072] As can be seen in the Fig. 5 flowchart, the metallic foreign matter sensing operation is interrupted (or temporarily halted) after the vehicle is adjacent to the infrastructure before the vehicle stops. While the operation is temporarily halted, no erroneous sensing is made.
- [0073] Fig. 6 is a flowchart for illustrating a process performed in the Fig. 5 Step S304A.
- [0074] With reference to Fig. 6, on the infrastructure's side, the control proceeds to Step S501 to determine whether the infrastructure's side has established wireless communications with the vehicle's side. If the infrastructure's side has established wireless communications with the vehicle's side (YES in Step S501), the control proceeds to Step S502. If the infrastructure's side does not establish wireless communications with the vehicle's side (NO in Step S501), Step S501 is repeated.
- [0075] Furthermore, on the infrastructure's side, Step S502 is performed to cause the infrastructure's side to inform the vehicle's side that a metallic foreign matter has been sensed, i.e., that a metallic foreign matter is present. The vehicle's side is thus informed that the metallic foreign matter is present before the vehicle is adjacent to the infrastructure.
- [0076] On the infrastructure's side, the control proceeds to Step S503 to continue the metallic foreign matter sensing operation.
- [0077] On the vehicle's side, the control proceeds to Step S603 to inform a passenger (or a

driver) that the metallic foreign matter is present according to information received from the infrastructure's side. This is done via alarming unit 233 of Fig. 1, alarming unit 150 of Fig. 2 and/or the like performing an alarming operation. Note that in Step S603, the metallic foreign matter sensing operation is performed via the weak electric power used for the positioning, and heat generated by metallic foreign matters is substantially negligible. Furthermore, charging has not yet been performed, which can prevent charging done with electric power transferred inefficiently. With these problems avoided, cancelling starting the alignment, urging the user to get out of the vehicle to remove a metallic foreign matter, and/or the like would impair convenience. To avoid this, Step S603 is performed preferably with the alarming operation informing the user that the metallic foreign matter is present without urging the user to remove the metallic foreign matter.

[0078] On the vehicle's side, the control proceeds to Step S604 to start positional detection and thereafter start the alignment. In Step S605 the alignment operation (or a parking operation) is continued, and thereafter in Step S606 the vehicle stops and the alignment is completed.

[0079] Once the alignment has been completed, then, on the vehicle's side, the control proceeds to Step S607 to interrupt an operation (that starts) charging. Then, the control proceeds to Step S608 to inform the user (or the driver) to urge the user to remove the metallic foreign matter and that the operation is interrupted. Thus, the metallic foreign matter is removed for example by the user.

[0080] As can be seen in the Fig. 6 flowchart, if any metallic foreign matter is sensed before the vehicle is adjacent to the infrastructure, then before the alignment is conducted the user is informed that the metallic foreign matter is present. This allows the user to remove the metallic foreign matter or the like and thus prepare for charging.

[0081] Fig. 7 is a flowchart for illustrating a process performed when a metallic foreign matter is sensed during charging. The Fig. 7 Steps S701 and S702 performed on the infrastructure's side and The Fig. 7 Steps S801 and S802 performed on the vehicle's side are identical to the Fig. 5 Steps S309 and S310 performed on the infrastructure's side and the Fig. 5 Steps S406 and S407 performed on the vehicle's side, respectively, and accordingly, will not be described repeatedly.

[0082] Once the charging has been started, then, on the infrastructure's side, the control proceeds to Step S703 to switch the metallic foreign matter sensing operation to a MODE 2-2. MODE 2-2 provides a metallic foreign matter sensing operation performed with a reference value adapted to a level of an induced output of the scanning coil that corresponds to electric power charged. This will be described hereinafter with reference to Fig. 8.

[0083] On the infrastructure's side, the control proceeds to Step S704 to determine whether

any metallic foreign matter has been sensed. If any metallic foreign matter has been sensed (YES in Step S704), the control proceeds to Step S705. If there is not any metallic foreign matter sensed (NO in Step S704), the control proceeds to Step S705.

[0084] In Step S705 whether the charging has been completed is determined. If the charging has been completed (YES in Step S705), the process of the flowchart ends. If the charging is not completed (NO in Step S705), the control returns to Step S704.

[0085] On the infrastructure's side, the control proceeds to Step S706 to interrupt the charging. On the other hand, the metallic foreign matter sensing operation continues. The information that the charging has been interrupted is transmitted to the vehicle's side. Note that if the charging is interrupted, the power transmitting coil is still supplied with weak electric power to continue the metallic foreign matter sensing operation.

[0086] On the vehicle's side, Step S803 is performed according to the information received from the infrastructure's side to inform the user that the charging has been interrupted and to urge the user to remove the metallic foreign matter. This is done via alarming unit 233 of Fig. 1, alarming unit 150 of Fig. 2 and/or the like performing an alarming operation. The user thus informed for example gets off the vehicle to remove the metallic foreign matter.

[0087] On the infrastructure's side, the control proceeds to Step S707 to determine whether the metallic foreign matter has been removed. If the metallic foreign matter has been removed (YES in Step S707), the control proceeds to Step S708. If metallic foreign matter is not removed (NO in Step S707), Step S707 is repeated.

[0088] On the infrastructure's side, in Step S708, the control awaits the charging. Information that the charging is awaited is transmitted to the vehicle's side.

[0089] On the vehicle's side, the control proceeds to Step S805 to determine that the charging may be resumed according to the information received from the infrastructure's side indicating that the charging is awaited. The decision that the charging may be resumed can be done for example via an operation done by the user as the user has removed the metallic foreign matter and accordingly considers that the charging may be resumed. The decision that the charging may be resumed is transmitted to the infrastructure's side. Thereafter the control proceeds to Step S806 to resume the charging.

[0090] On the infrastructure's side, the control proceeds to Step S709 to resume the charging according to the decision received from the vehicle's side indicating that the charging may be resumed. That is, the electric power supplied to the power transmitting coil is re-switched from the weak electric power to the electric power charged.

[0091] Thereafter, on the infrastructure's side, the control proceeds to Step S710 to complete the charging, and on the vehicle's side, the control proceeds to Step S807 to complete

the charging.

[0092] As can be seen in the Fig. 7 flowchart, if any metallic foreign matter is sensed during the charging, then the charging is interrupted and the user is informed that the metallic foreign matter is present. This for example prevents the metallic foreign matter from being present and thus contributing to inefficient charging. Furthermore, while the charging is performed, the metallic foreign matter sensing operation is performed with a reference value set to an appropriate value corresponding to electric power charged. This allows a metallic foreign matter to be sensed appropriately.

[0093] Thus the present embodiment provides power transfer system 10 (see Fig. 1) allowing a metallic foreign matter sensing operation to be performed with differently set reference values. More specifically, when the vehicle is adjacent to the power transmitting device (or located inside a prescribed range) the metallic foreign matter sensing operation is in MODE 1 and accordingly has a reference value, whereas when the vehicle is not adjacent to the power transmitting device (or is located outside the prescribed range) the metallic foreign matter sensing operation is in MODE 2 and accordingly has a reference value set to have a value larger than that for MODE 1. Furthermore, when the power transmitting coil is supplied with small electric power (i.e., weak electric power, weak current, or the like), the metallic foreign matter sensing operation is in MODE 1 or MODE 2 and accordingly has a reference value, whereas when the power transmitting coil is supplied with electric power to be charged larger than the small electric power, the metallic foreign matter sensing operation is in MODE 2-2 and accordingly has a reference value set to have a value larger than that for MODE 1 or MODE 2.

[0094] This is done because the electric power charged is stronger than the weak electric power, and accordingly, creates an intense electromagnetic field around power transmitting device 200 and as a result the scanning coil also has higher voltage induced therein.

[0095] Fig. 8 is a diagram for illustrating reference values in the metallic foreign matter sensing operation in MODE 1, MODE 2, and MODE 2-2 in contactless charging. In the Fig. 8 graph, the axis of abscissa represents time (t) and the axis of ordinate represents the scanning coil's induced output (e.g., induced voltage (V)). This graph shows the metallic foreign matter sensing operation switched in mode sequentially from MODE 1 to MODE 2 and then to MODE 2-2 as time elapses.

[0096] With reference to Fig. 8, initially, for time t_0 - t_1 , the vehicle is distant from the power transmitting device, and accordingly, the metallic foreign matter sensing operation is performed in MODE 1. The power transmitting coil is supplied with small electric power (e.g., a weak current). This state corresponds for example in Fig. 5 to Step S303. MODE 1 has a reference value, which is herein referred to as a first reference value.

The first reference value is a value of an output expected to be induced in the scanning coil when there is no metallic foreign matter. When there is a metallic foreign matter for example flying to a vicinity of power transmitting device 200, the scanning coil has an induced voltage dropping below the first reference value. The metallic foreign matter can thus be sensed.

[0097] Note that, for time $t1-t2$, the metallic foreign matter sensing operation is interrupted, and accordingly, it is unnecessary to determine a reference value. This state corresponds for example in Fig. 5 to Steps S307-S308.

[0098] For time $t2-t3$, the vehicle is adjacent to the power transmitting device, and accordingly, the metallic foreign matter sensing operation is performed in MODE 2. The power transmitting coil is supplied with weak electric power. This state corresponds for example in Fig. 5 to Step S309. MODE 2 has a reference value, which is herein referred to as a second reference value. Once the second reference value has been set, the vehicle adjacent to the power transmitting device will never result in an induced output smaller than the second reference value. That is, there is no possibility that the vehicle may be erroneously sensed as a metallic foreign matter. When vehicle 100 is adjacent to power transmitting device 200 and in that condition there is a metallic foreign matter for example flying to a vicinity of power transmitting device 200, the scanning coil has an induced voltage dropping below the second reference value. The metallic foreign matter can thus be sensed.

[0099] After time $t3$, the vehicle has been aligned with the power transmitting device and is thus charged, and accordingly, the metallic foreign matter sensing operation is performed in MODE 2-2. The power transmitting coil is supplied with large electric power for charging. This state corresponds for example in Fig. 7 to Step S703. MODE 2-2 has a reference value, which is herein referred to as a third reference value. Note that the third reference value is larger than the first reference value and the second reference value.

[0100] Finally, the present invention in embodiments will be summarized, as follows: With reference to Fig. 1 to Fig. 3, an embodiment provides a contactless power transmitting device (power transmitting device 200) comprising: a sensing unit (sensing circuit 232) that senses an output of a metal sensing coil (scanning coil 221); and control unit 234 that controls alarming unit 233 to perform an alarming operation in aligning a power receiving device (power receiving unit 120) mounted in vehicle 100 with (power transmitting unit 210 of) power transmitting device 200 when the metal sensing coil (scanning coil 221) provides an output below a reference value. The reference value is set to be smaller when vehicle 100 is located inside a prescribed range as measured from power transmitting device 200 than when vehicle 100 is located outside the prescribed range as measured from power transmitting device 200.

- [0101] Preferably, as shown in Fig. 5, in the alignment, when vehicle 100 enters the prescribed range, control unit 234 controls power transmitting device 200 to temporarily halt sensing for metallic foreign matters (Step S307), and once the alignment has been completed, control unit 234 controls power transmitting device 200 to resume sensing for metallic foreign matters (Step S309).
- [0102] Alternatively, preferably, as shown in shown in Fig. 4, control unit 234 controls power transmitting device 200 to continue sensing for metallic foreign matters while vehicle 100 enters the prescribed range (Step S106), and once any metallic foreign matter has been sensed, control unit 234 controls alarming unit 233 to perform the alarming operation.
- [0103] Preferably, as shown in Fig. 3, power transmitting device 200 further comprises: a power transmitting coil (power transmitting unit 210); power supply device 231 that supplies the power transmitting coil (power transmitting unit 210) with electric power; and a communication unit that performs communication with vehicle 100 (communication unit 240 shown in Fig. 1). For example, as shown in Figs. 5 and 6, control unit 234 controls power supply device 231 to supply the power transmitting coil with weak electric power for the alignment and sensing for metal (Step S302), and before the alignment, once any metallic foreign matter has been sensed (YES in step S304), and the communication has been established, control unit 234 controls the communication unit to inform the vehicle that the metallic foreign matter is present (Step S502).
- [0104] For example, as shown in Figs. 5 and 7, once the alignment has been completed, control unit 234 controls the power supply device to supply the power transmitting coil with larger electric power than the weak electric power to transmit the larger electric power to the vehicle (Step S310), and if any metallic foreign matter is sensed with the larger electric power transmitted (YES in Step S705), control unit 234 controls the power supply device to stop supplying the power transmitting coil with the larger electric power (Step S705).
- [0105] Furthermore, an embodiment provides power transfer system 10 comprising: a contactless power transmitting device (power transmitting device 200), a power receiving device (power receiving unit 120) mounted in vehicle 100, a sensing unit (sensing circuit 232) that senses an output of a metal sensing coil (scanning coil 221); and a control unit (control unit 234 and ECU 160) that controls alarming units 150 and 233 to perform an alarming operation in aligning the power receiving device (power receiving unit 120) with (power transmitting unit 210 of) power transmitting device 200 when the metal sensing coil (scanning coil 221) provides an output below a reference value. The reference value is set to be smaller when vehicle 100 is located inside a prescribed range as measured from power transmitting device 200 than when

vehicle 100 is located outside the prescribed range as measured from power transmitting device 200.

- [0106] It should be understood that the embodiments disclosed herein have been described for the purpose of illustration only and in a non-restrictive manner in any respect. The scope of the present invention is defined by the terms of the claims, rather than the embodiments described above, and is intended to include any modifications within the meaning and scope equivalent to the terms of the claims.

Reference Signs List

- [0107] 10: power transfer system; 100: vehicle; 110: camera; 120: power receiving unit; 121: power receiving coil; 122: capacitor; 123: power conversion device; 124: power measurement unit; 130: battery; 132: power split device; 134: driving wheel; 140, 240: communication unit; 150, 233: alarming unit; 200: power transmitting device; 210: power transmitting unit; 220: metal sensing coil unit; 221: scanning coil; 230: power supply stand; 231: power supply device; 232: sensing circuit; 234: control unit; MG1, MG2: motor generator.

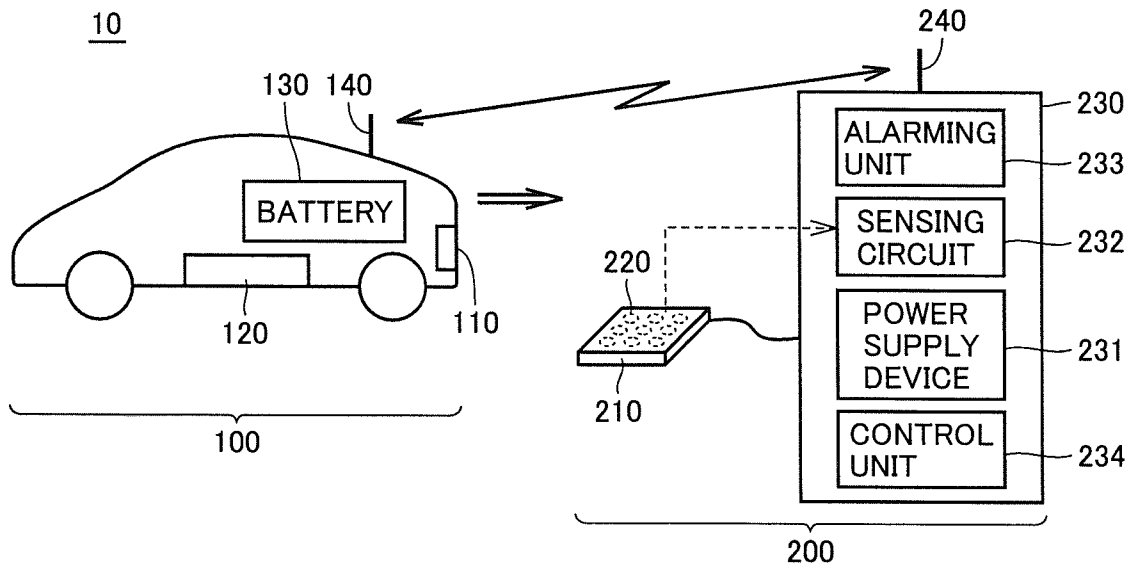
Claims

- [Claim 1] A contactless power transmitting device comprising:
a sensing unit that senses an output of a metal sensing coil; and
a control unit that controls an alarming unit to perform an alarming operation in aligning a power receiving device mounted in a vehicle with the contactless power transmitting device when said metal sensing coil provides an output below a reference value,
said reference value being set to be smaller when said vehicle is located inside a prescribed range as measured from the contactless power transmitting device than when said vehicle is located outside said prescribed range as measured from the contactless power transmitting device.
- [Claim 2] The contactless power transmitting device according to claim 1, wherein in said aligning, when said vehicle enters said prescribed range, said control unit controls the contactless power transmitting device to temporarily halt sensing for metallic foreign matters, and once said aligning has been completed, said control unit controls the contactless power transmitting device to resume said sensing for metallic foreign matters.
- [Claim 3] The contactless power transmitting device according to claim 1, wherein said control unit controls the contactless power transmitting device to continue said sensing for metallic foreign matters while said vehicle enters said prescribed range, and once any metallic foreign matter has been sensed, said control unit controls said alarming unit to perform said alarming operation.
- [Claim 4] The contactless power transmitting device according to any one of claims 1-3, further comprising:
a power transmitting coil;
a power supply device that supplies said power transmitting coil with electric power; and
a communication unit that performs communication with said vehicle, wherein said control unit controls said power supply device to supply said power transmitting coil with weak electric power, and before said aligning, once any metallic foreign matter has been sensed, said control unit controls said communication unit to inform said vehicle that the metallic foreign matter is present when said communication is established.

- [Claim 5] The contactless power transmitting device according to claim 4, wherein once said aligning has been completed, said control unit controls said power supply device to supply said power transmitting coil with larger electric power than said weak electric power to transmit said larger electric power to said vehicle, and if any metallic foreign matter is sensed with said larger electric power transmitted, said control unit controls said power supply device to stop supplying said power transmitting coil with said larger electric power.
- [Claim 6] A contactless power transfer system comprising:
a contactless power transmitting device;
a power receiving device mounted in a vehicle;
a sensing unit that senses an output of a metal sensing coil; and
a control unit that controls an alarming unit to perform an alarming operation in aligning said power receiving device with said contactless power transmitting device when said metal sensing coil provides an output below a reference value,
said reference value being set to be smaller when said vehicle is located inside a prescribed range as measured from said contactless power transmitting device than when said vehicle is located outside said prescribed range as measured from said contactless power transmitting device.

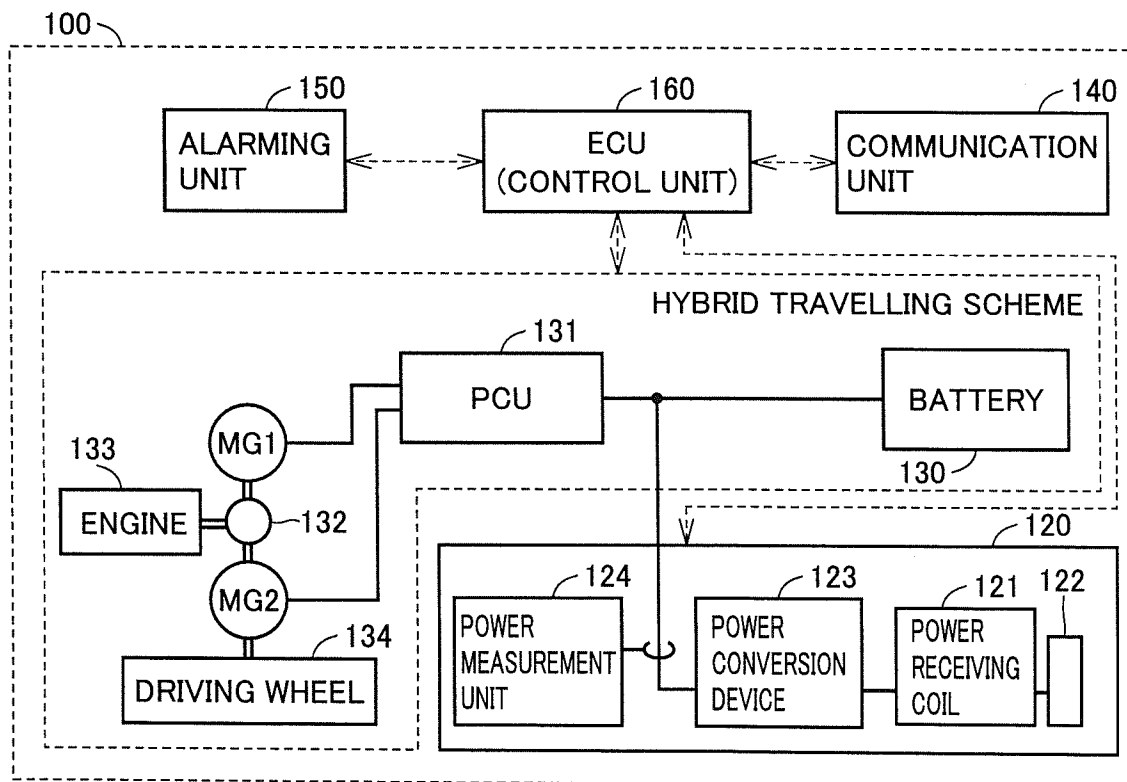
[Fig. 1]

FIG. 1



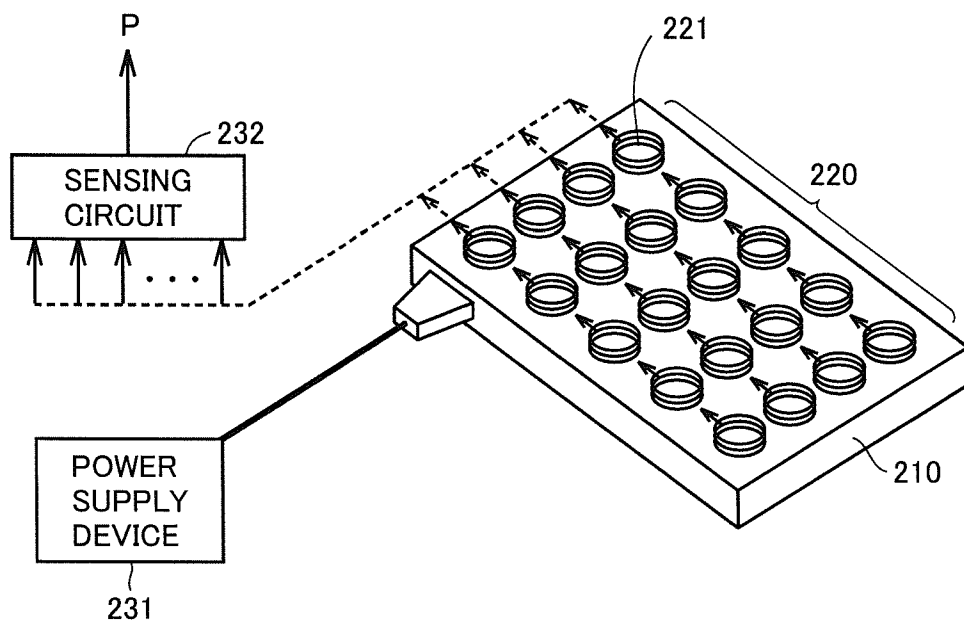
[Fig. 2]

FIG. 2



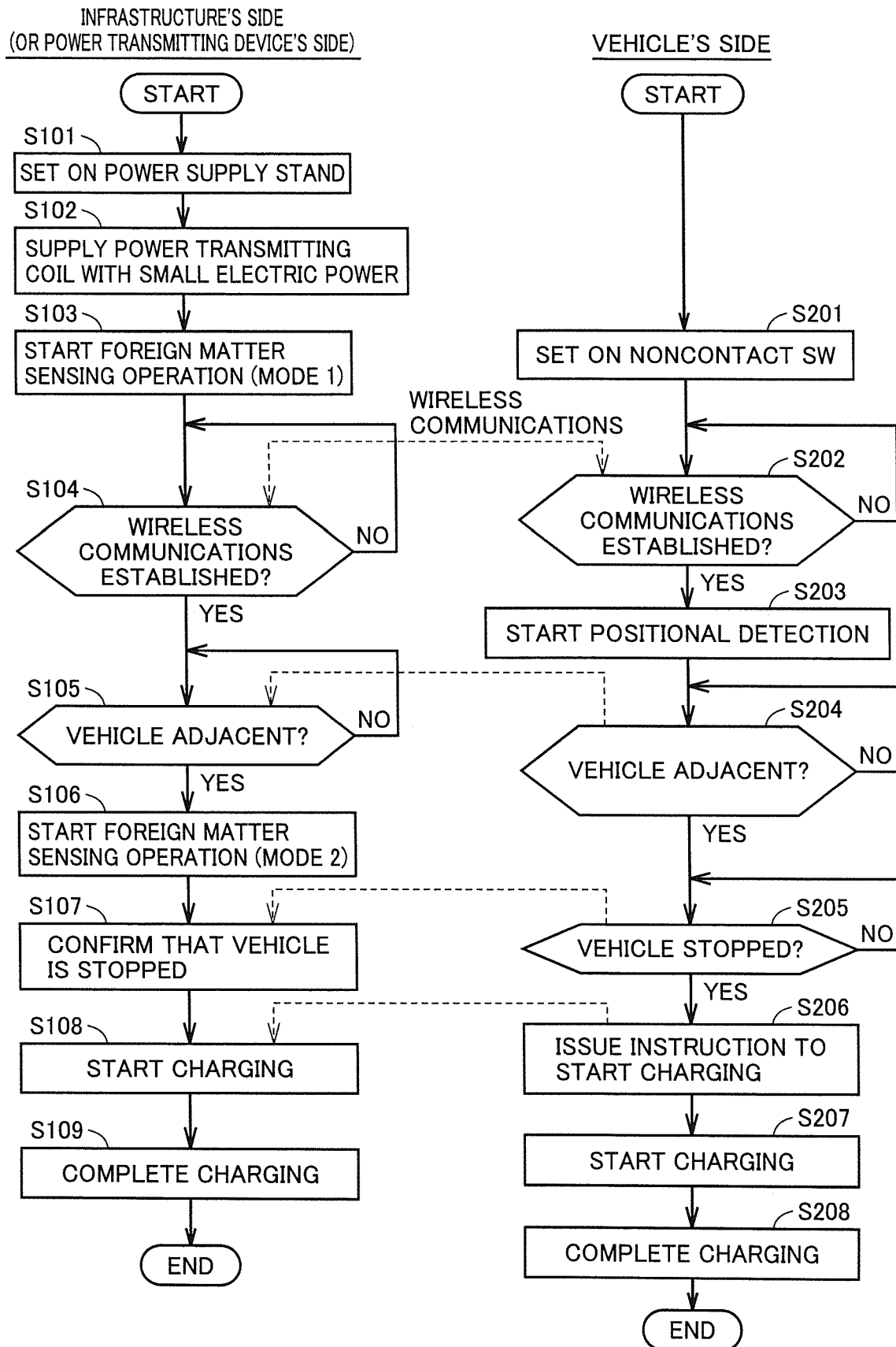
[Fig. 3]

FIG.3



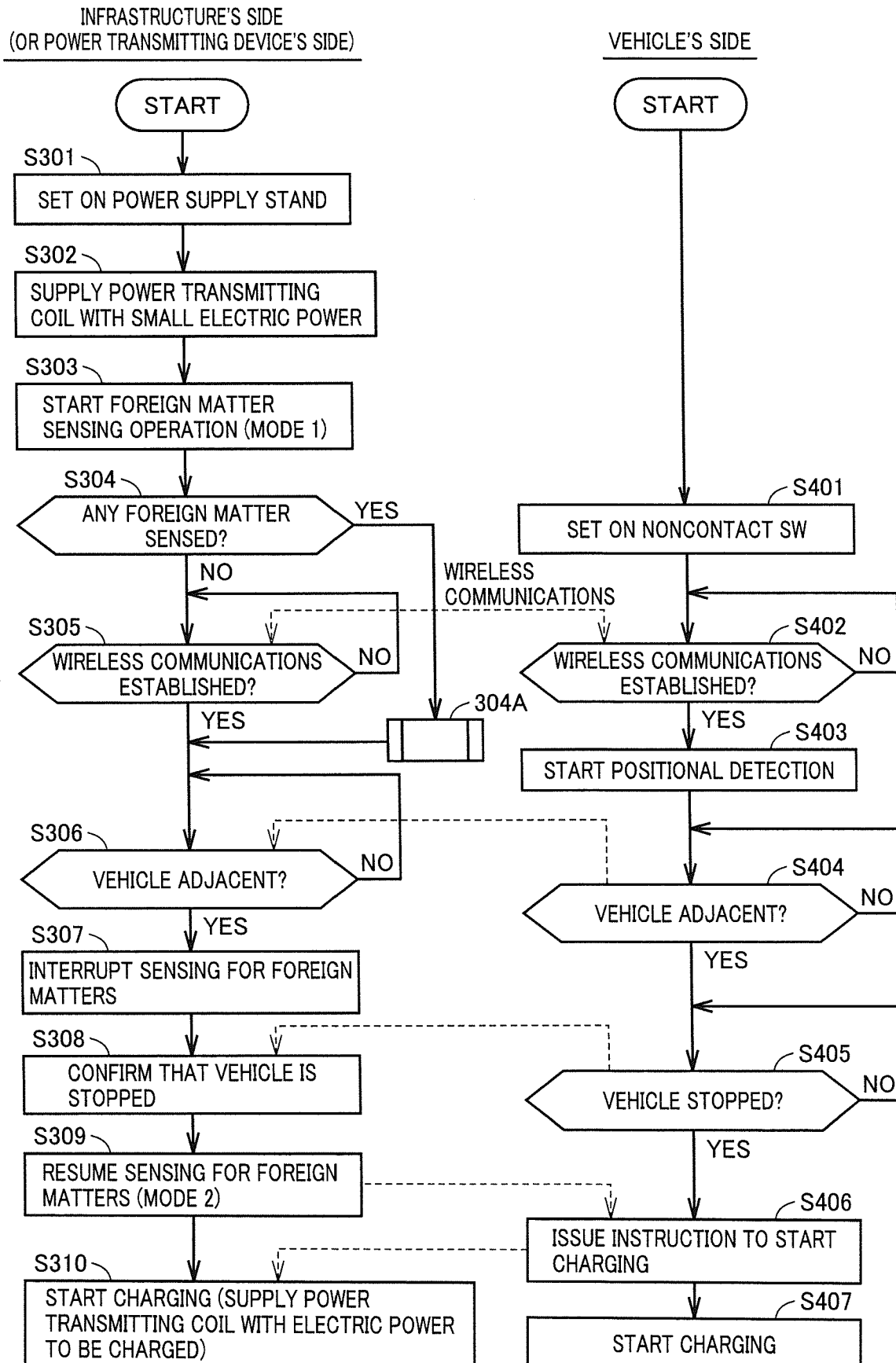
[Fig. 4]

FIG.4



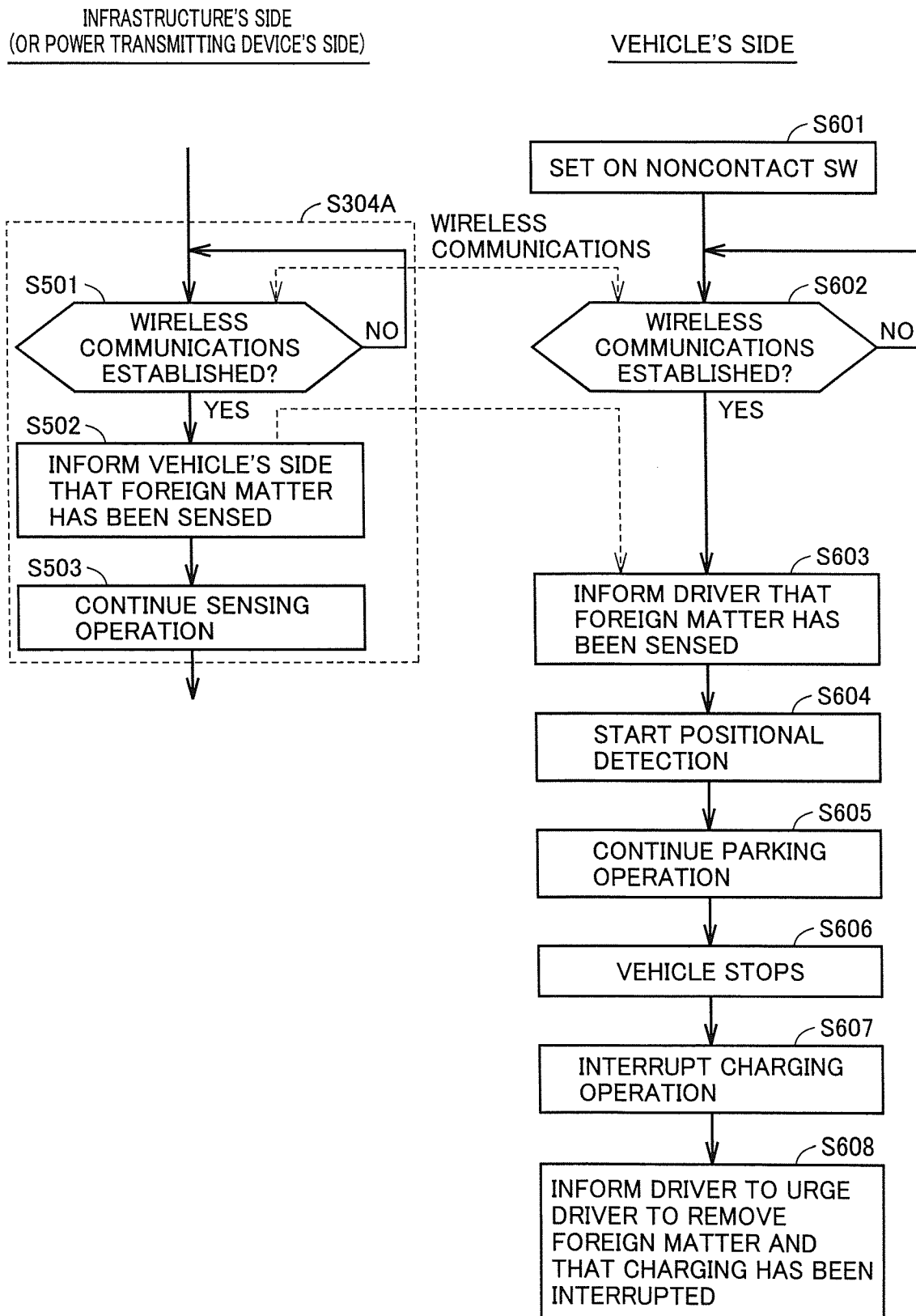
[Fig. 5]

FIG.5



[Fig. 6]

FIG.6

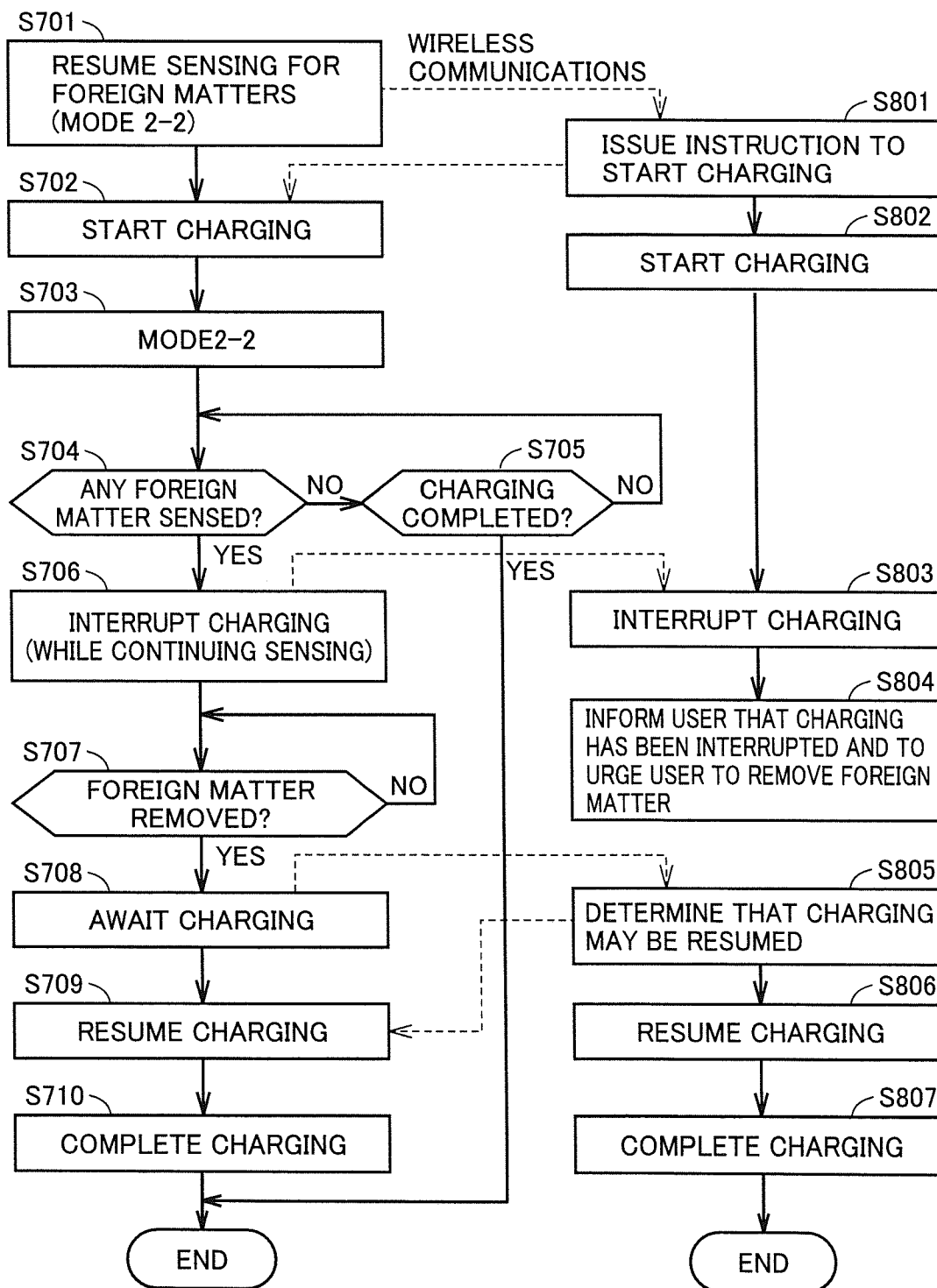


[Fig. 7]

FIG. 7

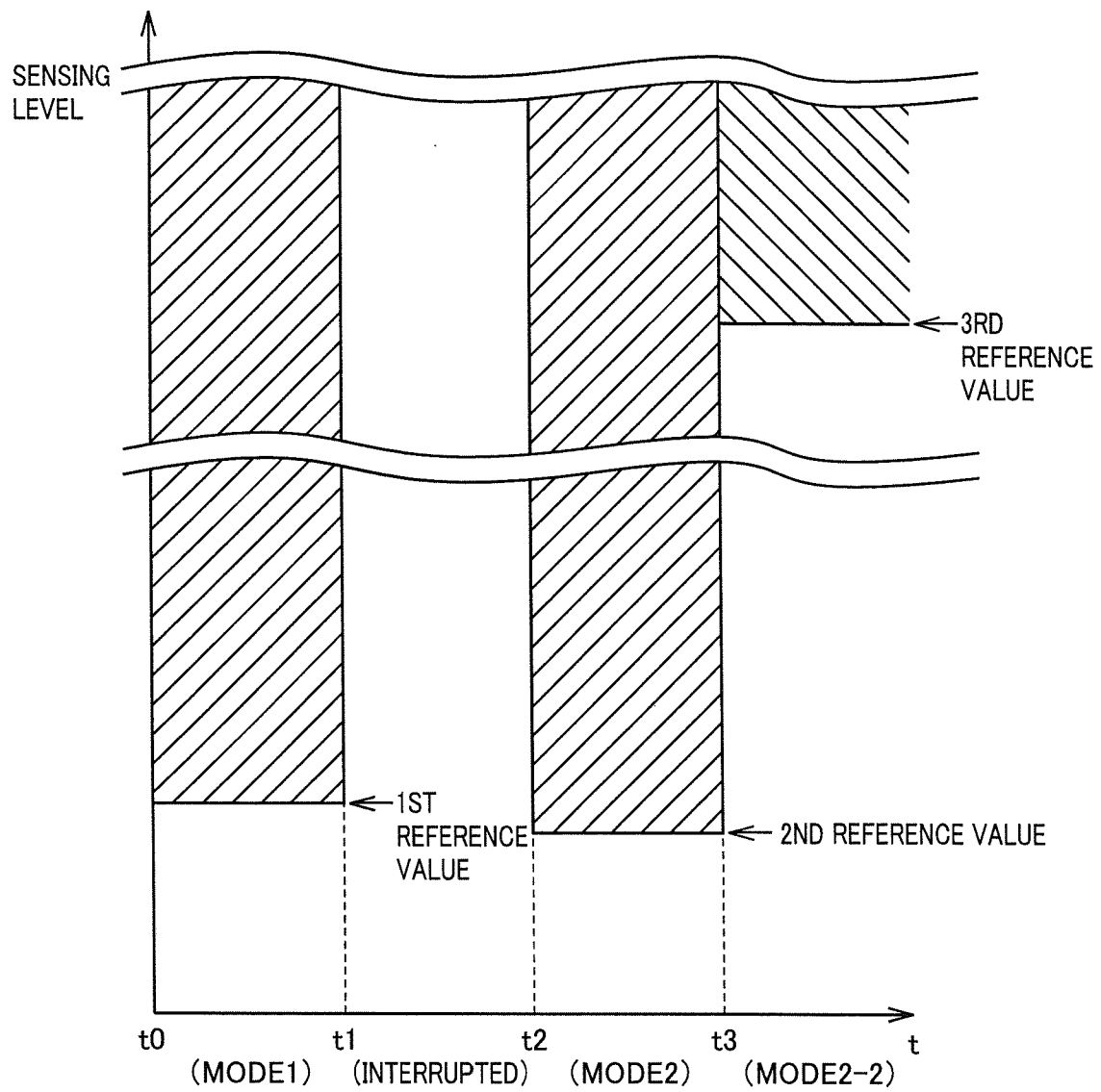
INFRASTRUCTURE'S SIDE
(OR POWER TRANSMITTING DEVICE'S SIDE)

VEHICLE'S SIDE



[Fig. 8]

FIG.8



INTERNATIONAL SEARCH REPORT

International application No

PCT/JP2014/004993

A. CLASSIFICATION OF SUBJECT MATTER
 INV. B60L11/18 H02J5/00 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)
 H02J B60L

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

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

EPO-Internal, WPI Data

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A	US 2013/263596 A1 (ARISAWA SHIGERU [JP]) 10 October 2013 (2013-10-10) abstract; figures 1,11 -----	1-6
	-/--	



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

13 March 2015

Date of mailing of the international search report

20/03/2015

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Authorized officer

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INTERNATIONAL SEARCH REPORT

International application No

PCT/JP2014/004993

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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International application No

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