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(54) **FEED UNIT, FEED SYSTEM, AND ELECTRONIC DEVICE FOR INCREASING POWER SUPPLIED TO A BATTERY BASED ON A DEVICE STATE AND/OR A CONTROL OF A CHARGING CURRENT**

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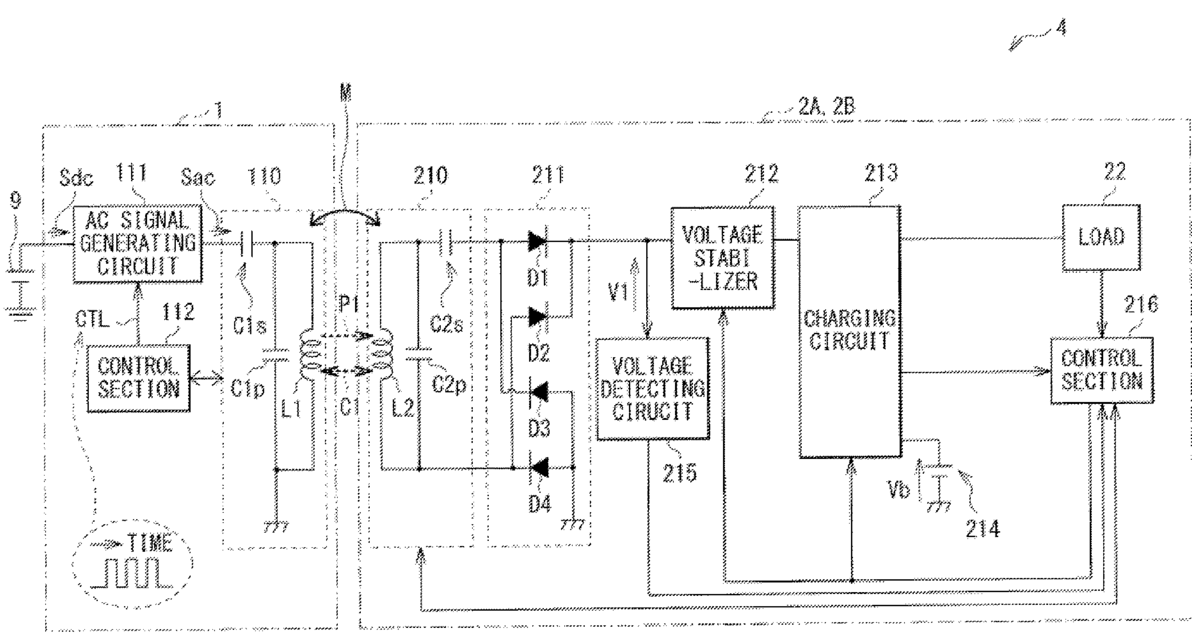
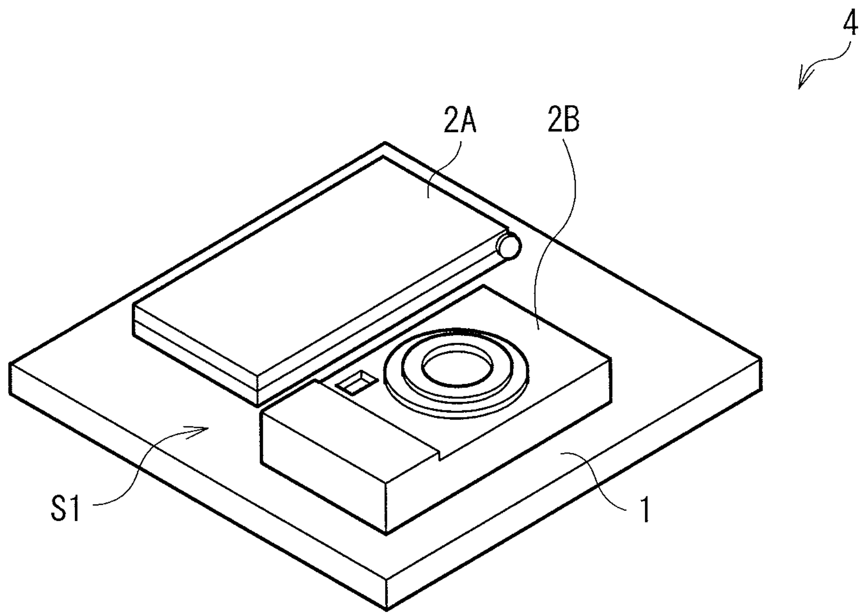
CPC ***H02J 50/12*** (2016.02); ***H02J 50/80*** (2016.02); ***H02J 7/0068*** (2013.01); *H02J 7/04* (2013.01); ***H02J 7/00714*** (2020.01); ***H02J 7/00*** (2013.01); ***H02J 7/0029*** (2013.01); ***H01M 10/44*** (2013.01)

(57) **ABSTRACT**

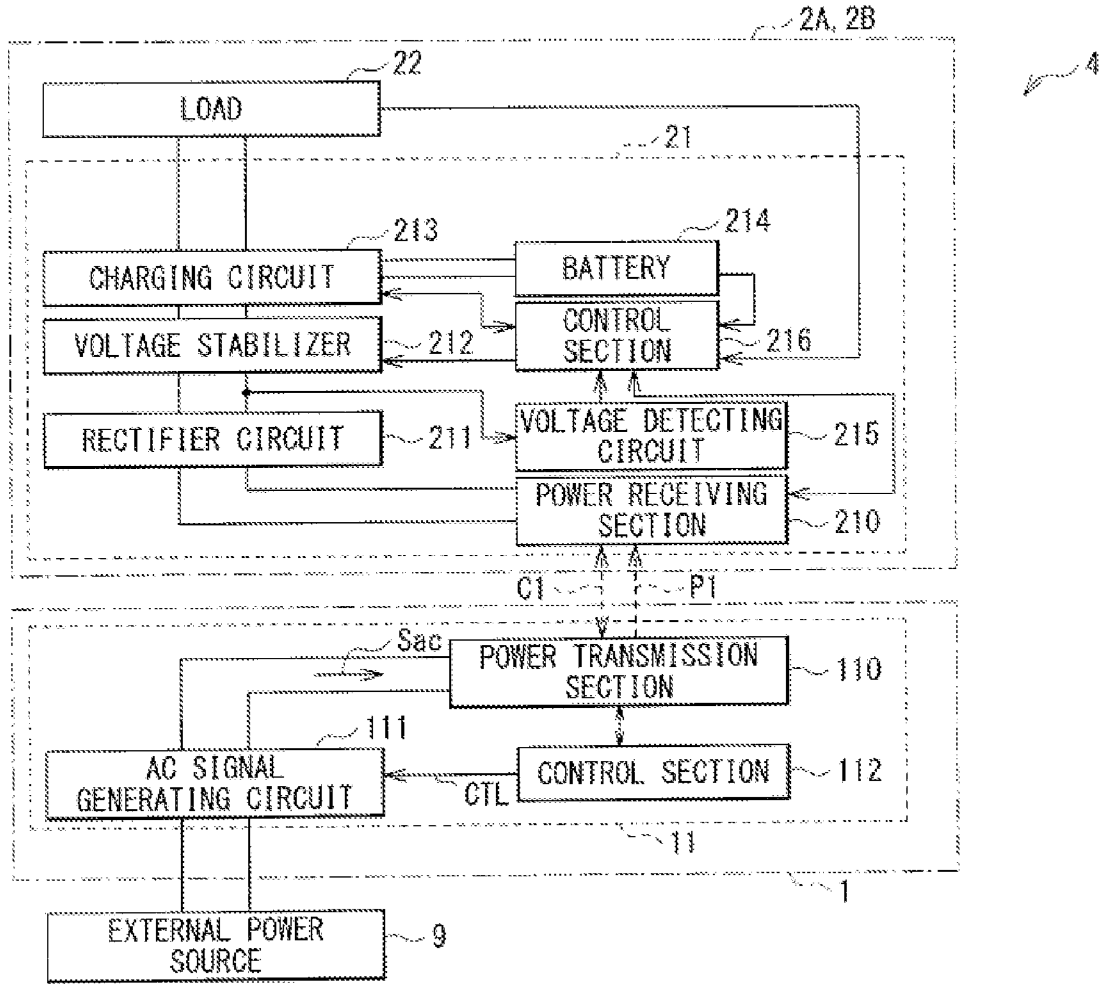
A feed unit includes: a power transmission section configured to perform power transmission using a magnetic field or an electric field, to a device to be fed including a secondary battery; and a power-transmission control section configured to control power transmission operation in the power transmission section. In a charging period in which charging to the secondary battery is performed based on transmitted power in the power transmission, when the device to be fed including the secondary battery is activated, the power-transmission control section controls the power transmission operation, to increase the transmitted power.



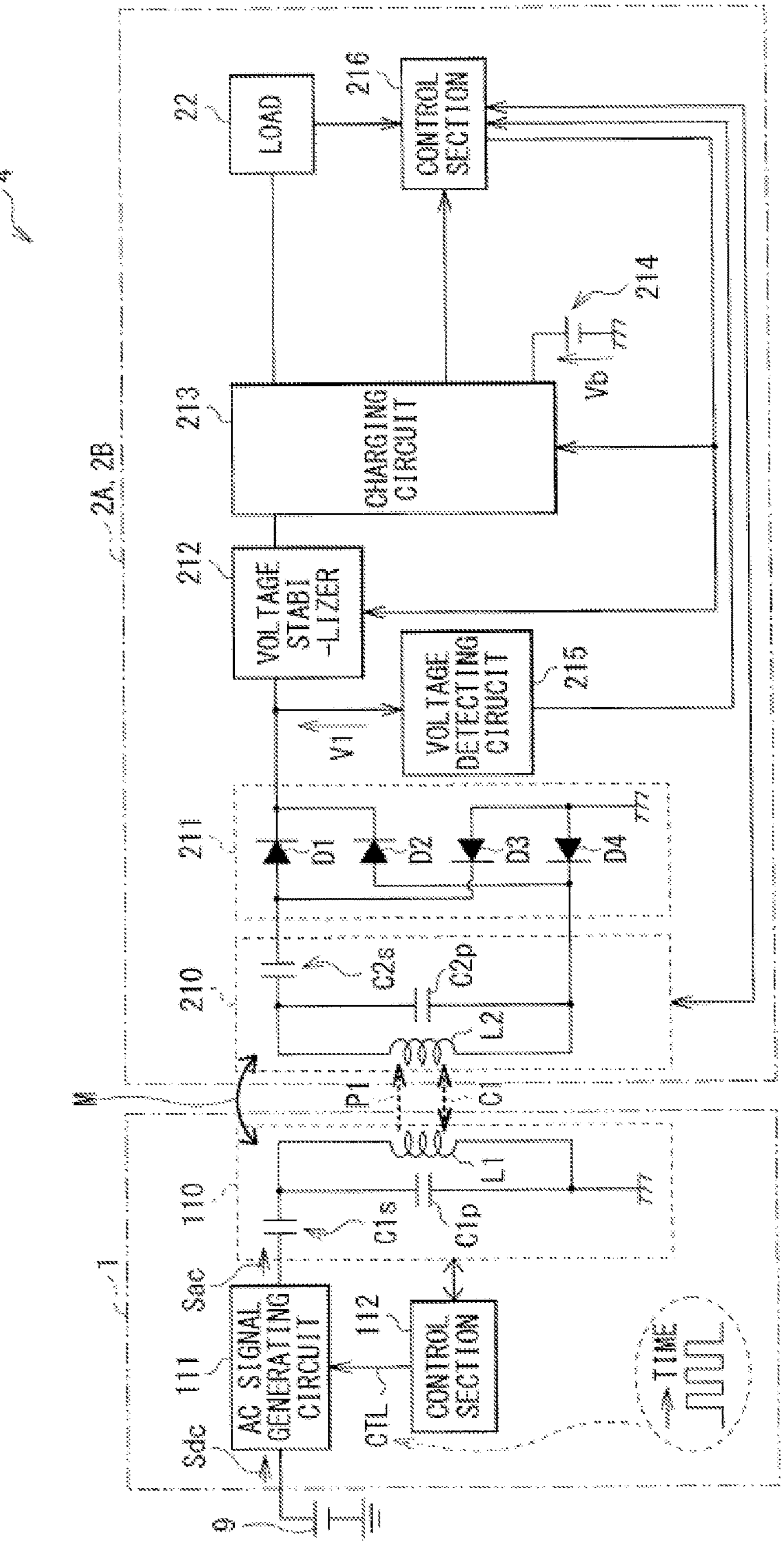
[FIG. 1]



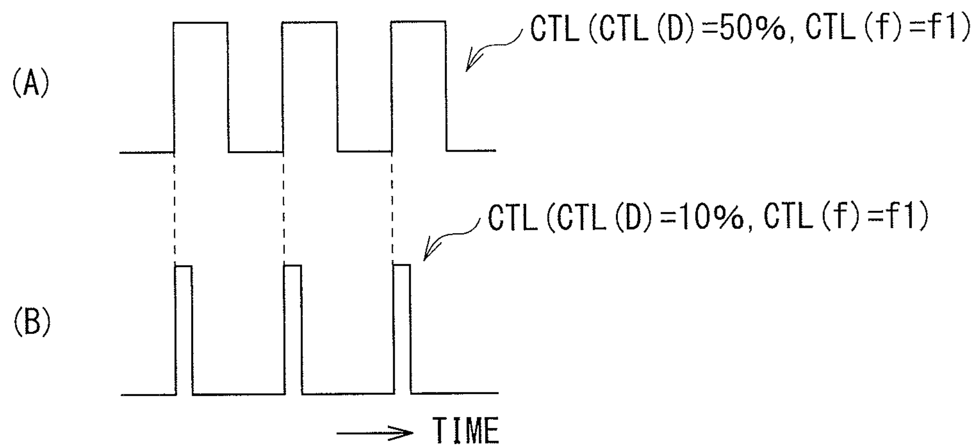
[FIG. 2]


2A, 2B
4
22
LOAD
21
213
214
CHARGING CIRCUIT
BATTERY
CONTROL SECTION
VOLTAGE STABILIZER
212
216
RECTIFIER CIRCUIT
211
VOLTAGE DETECTING CIRCUIT
215
POWER RECEIVING SECTION
210
C1
P1
Sac
POWER TRANSMISSION SECTION
110
111
AC SIGNAL GENERATING CIRCUIT
CTL
CONTROL SECTION
112
11
1
EXTERNAL POWER SOURCE
9

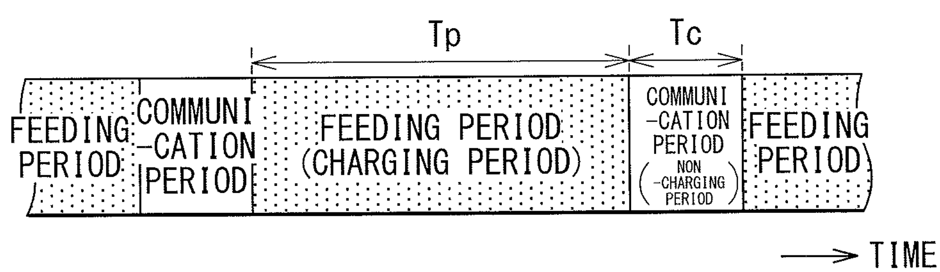
[FIG. 3]


4
2A, 2B
22
LOAD
216
CONTROL SECTION
213
CHARGING CIRCUIT
214
Vb
212
VOLTAGE STABI -LIZER
215
VOLTAGE DETECTING CIRCUIT
V1
211
D1
D2
D3
D4
210
C2s
C2p
L2
M
P1
C1
110
L1
C1s
C1p
1
Sac
111
AC SIGNAL GENERATING CIRCUIT
112
CONTROL SECTION
CTL
Sdc
TIME
9

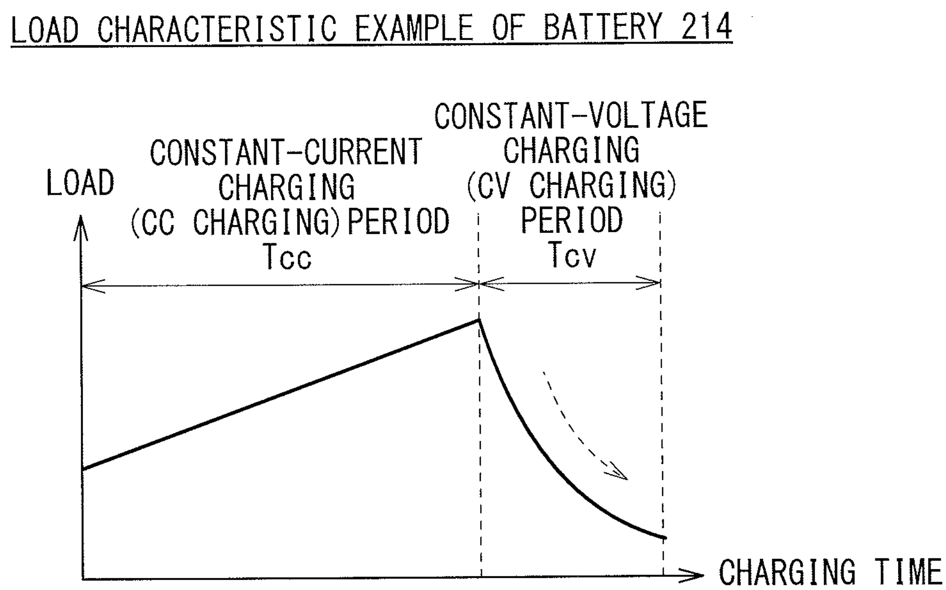
[FIG. 4]


(A)
CTL (CTL (D) =50%, CTL (f) =f1)
(B)
CTL (CTL (D) =10%, CTL (f) =f1)
TIME

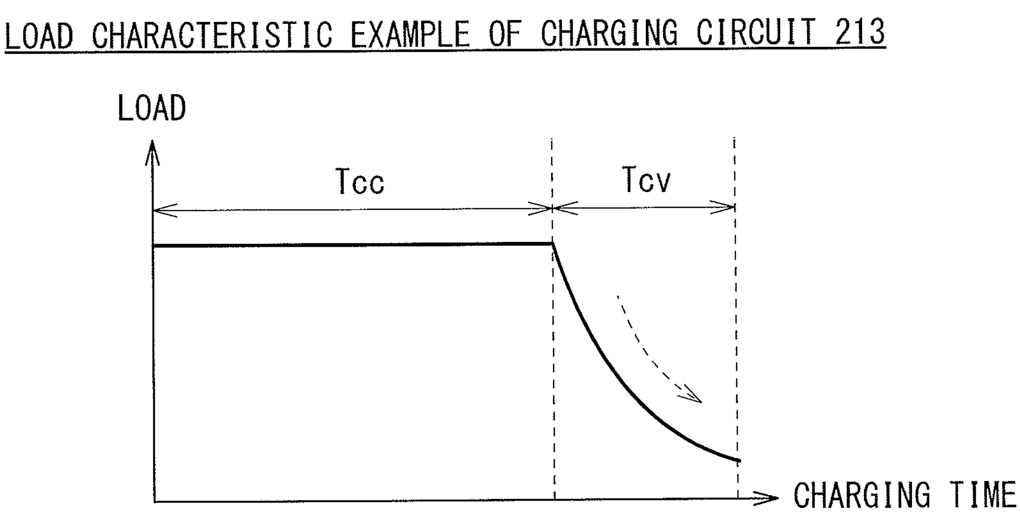
[FIG. 5]


Tp
Tc
FEEDING PERIOD
COMMUNI-CATION PERIOD
FEEDING PERIOD (CHARGING PERIOD)
COMMUNI-CATION PERIOD (NON-CHARGING PERIOD)
FEEDING PERIOD
TIME

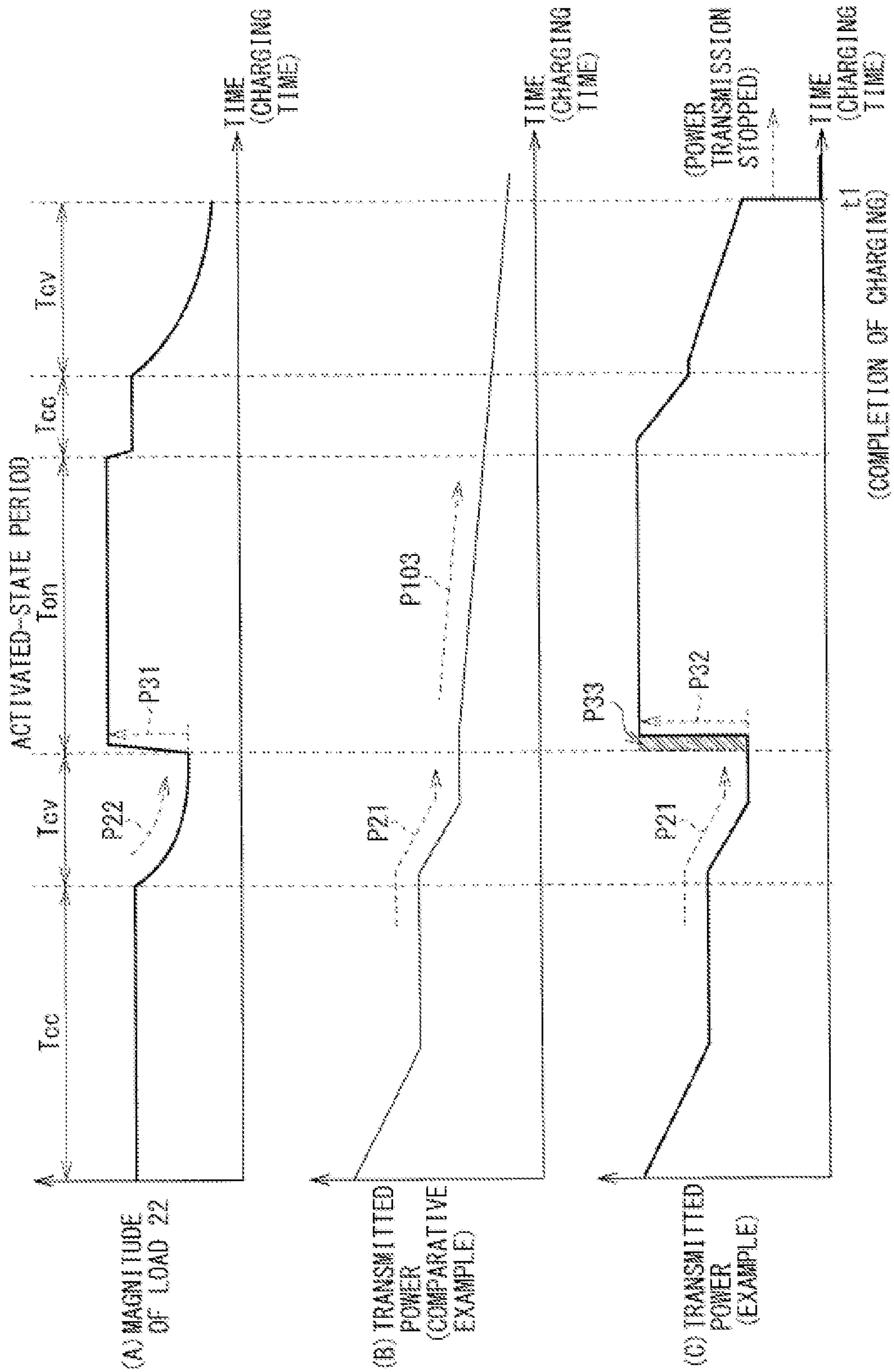
[FIG. 6]


LOAD CHARACTERISTIC EXAMPLE OF BATTERY 214
LOAD
CONSTANT-CURRENT CHARGING (CC CHARGING) PERIOD
Tcc
CONSTANT-VOLTAGE CHARGING (CV CHARGING) PERIOD
Tcv
CHARGING TIME

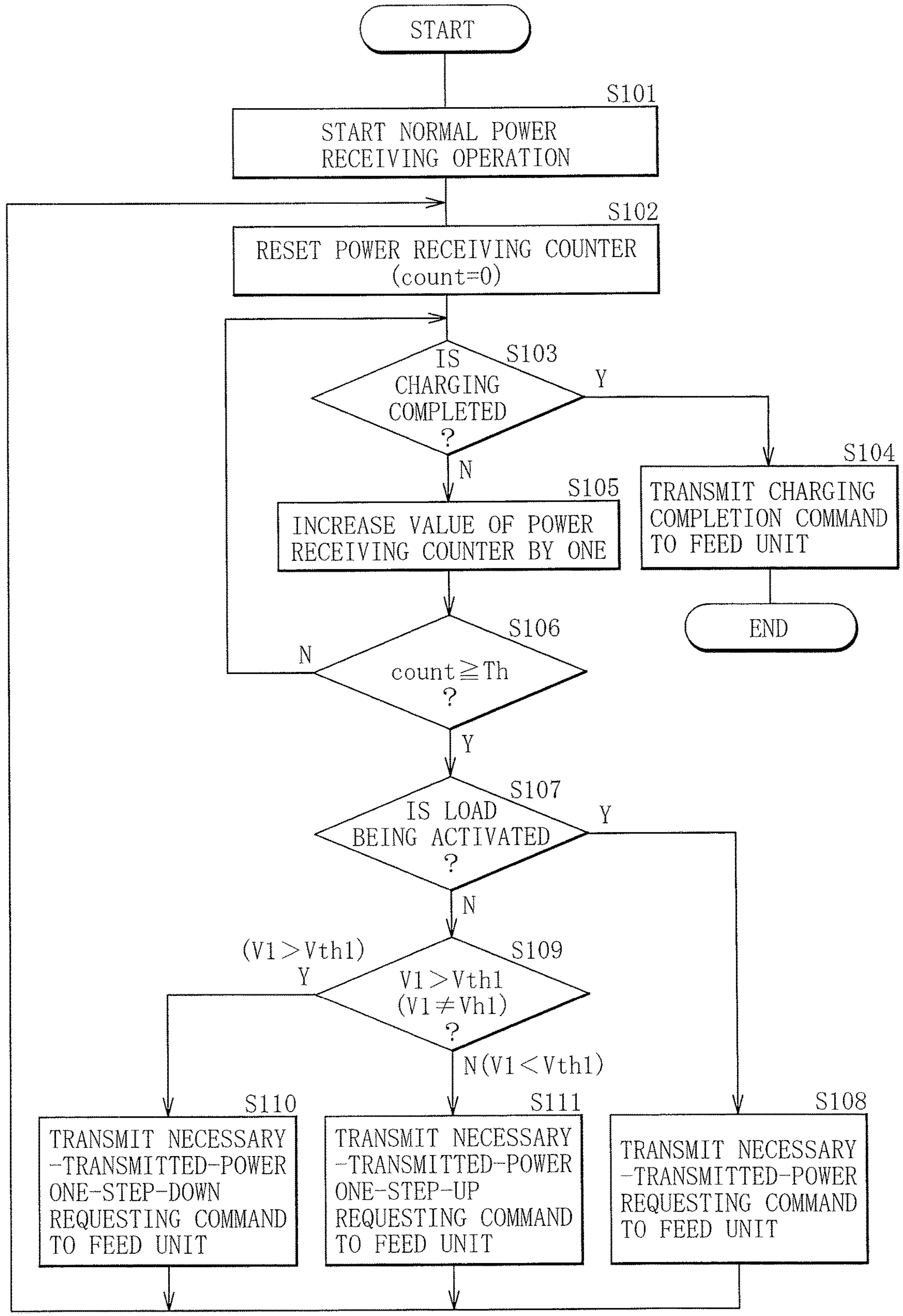
[FIG. 7]


LOAD CHARACTERISTIC EXAMPLE OF CHARGING CIRCUIT 213
LOAD
Tcc
Tcv
CHARGING TIME

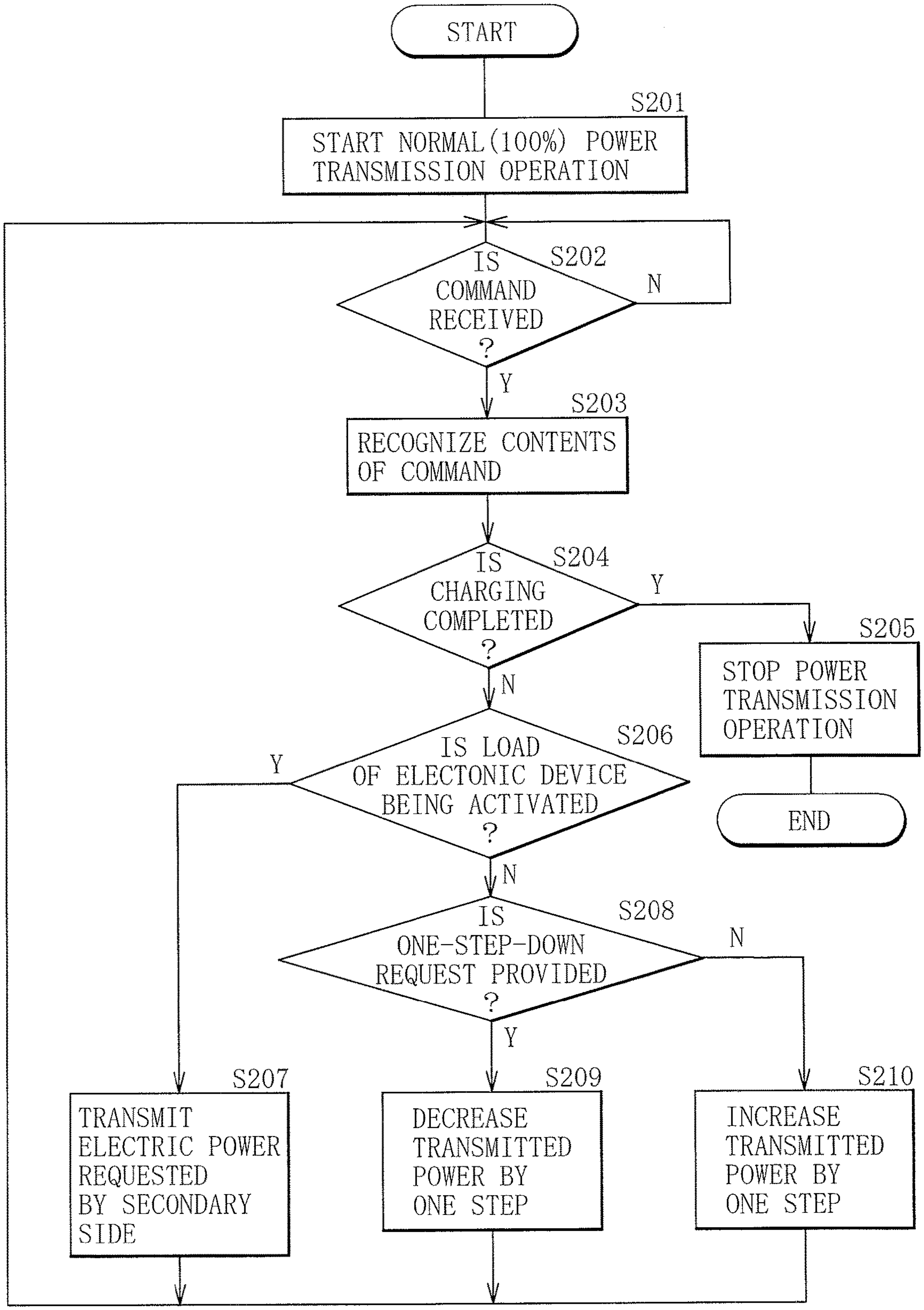
6/9


(A) MAGNITUDE OF LOAD 22
(B) TRANSMITTED POWER (COMPARATIVE EXAMPLE)
(C) TRANSMITTED POWER (EXAMPLE)
Tcc
Tcv
ACTIVATED-STATE PERIOD Ton
Tcc
Tcv
P22
P31
P21
P103
P21
P33
P32
TIME (CHARGING TIME)
TIME (CHARGING TIME)
TIME (CHARGING TIME)
(POWER TRANSMISSION STOPPED)
t1 (COMPLETION OF CHARGING)

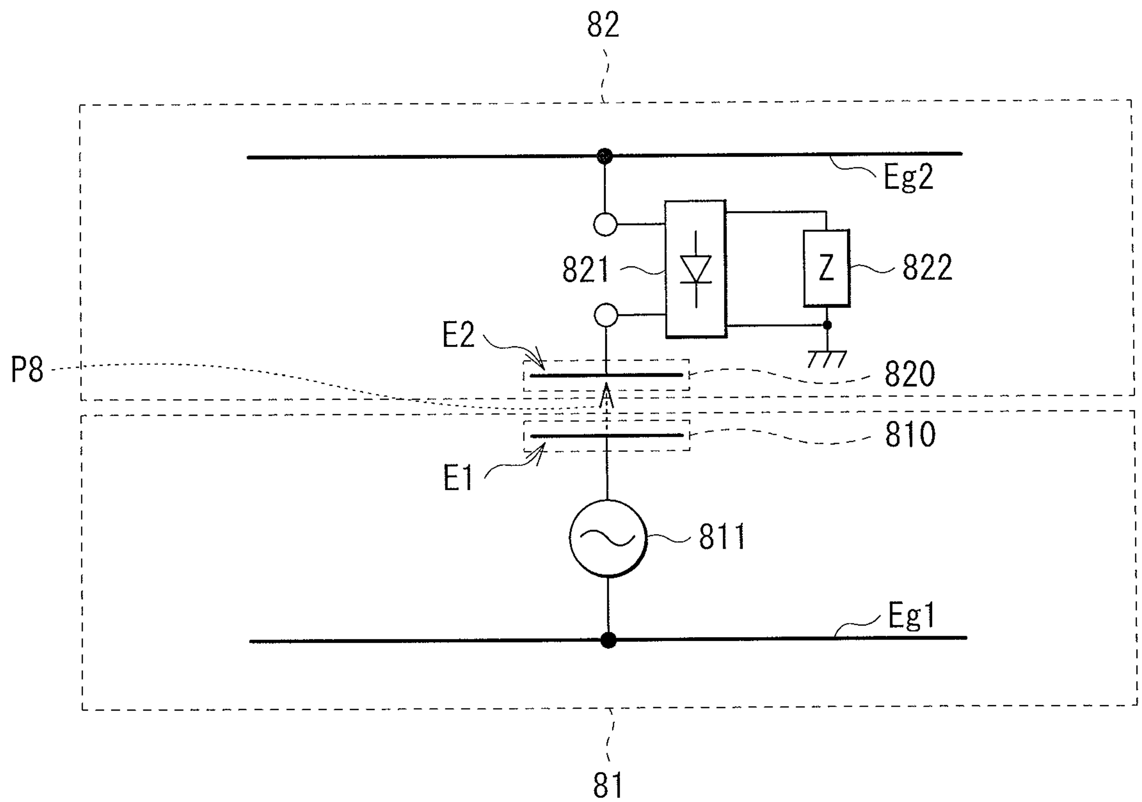
[FIG. 9]


START
S101
START NORMAL POWER RECEIVING OPERATION
S102
RESET POWER RECEIVING COUNTER (count=0)
S103
IS CHARGING COMPLETED ?
Y
N
S104
TRANSMIT CHARGING COMPLETION COMMAND TO FEED UNIT
END
S105
INCREASE VALUE OF POWER RECEIVING COUNTER BY ONE
S106
count≧Th ?
N
Y
S107
IS LOAD BEING ACTIVATED ?
Y
N
S109
V1＞Vth1 (V1≠Vh1) ?
(V1＞Vth1) Y
N(V1＜Vth1)
S110
TRANSMIT NECESSARY -TRANSMITTED-POWER ONE-STEP-DOWN REQUESTING COMMAND TO FEED UNIT
S111
TRANSMIT NECESSARY -TRANSMITTED-POWER ONE-STEP-UP REQUESTING COMMAND TO FEED UNIT
S108
TRANSMIT NECESSARY -TRANSMITTED-POWER REQUESTING COMMAND TO FEED UNIT

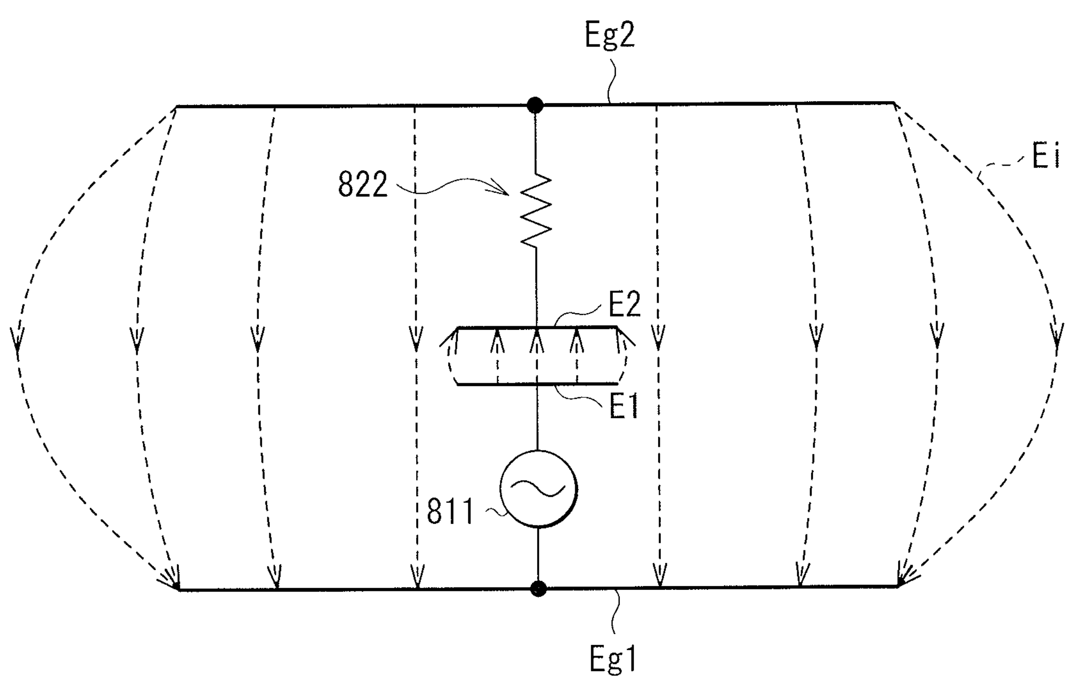
[FIG. 10]


START
S201
START NORMAL(100%) POWER TRANSMISSION OPERATION
S202
IS COMMAND RECEIVED ?
N
Y
S203
RECOGNIZE CONTENTS OF COMMAND
S204
IS CHARGING COMPLETED ?
Y
S205
STOP POWER TRANSMISSION OPERATION
END
N
S206
IS LOAD OF ELECTONIC DEVICE BEING ACTIVATED ?
Y
N
S208
IS ONE-STEP-DOWN REQUEST PROVIDED ?
N
Y
S207
TRANSMIT ELECTRIC POWER REQUESTED BY SECONDARY SIDE
S209
DECREASE TRANSMITTED POWER BY ONE STEP
S210
INCREASE TRANSMITTED POWER BY ONE STEP

[FIG. 11]


82
Eg2
821
822
Z
E2
P8
820
810
E1
811
Eg1
81

[FIG. 12]


Eg2
Ei
822
E2
E1
811
Eg1

FEED UNIT, FEED SYSTEM, AND ELECTRONIC DEVICE FOR INCREASING POWER SUPPLIED TO A BATTERY BASED ON A DEVICE STATE AND/OR A CONTROL OF A CHARGING CURRENT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of and claims priority to U.S. application Ser. No. 16/295,466, filed Mar. 7, 2019, which is a continuation of U.S. application Ser. No. 15/972,669, filed May 7, 2018, now U.S. Pat. No. 10,270, 278, which is a continuation of U.S. application Ser. No. 15/428,938, filed Feb. 9, 201, now U.S. Pat. No. 9,991,733, which is a continuation of U.S. application Ser. No. 14/357, 915, filed May 13, 2014, which is now U.S. Pat. No. 9,960,627, the entire contents of each of which is hereby incorporated herein by reference. U.S. application Ser. No. 14/357,915 is a National Stage application of International Application No. PCT/JP2012/082009, filed Dec. 11, 2012, which claims the benefit of priority from Japanese Patent Application Nos. 2012-094334, filed Apr. 18, 2012, and 2011-279239, filed Dec. 21, 2011. The benefit of priority is claimed to each of the foregoing.

TECHNICAL FIELD

[0002] The present disclosure relates to a feed system that performs non-contact electric power supply (power transmission, electric power transmission) to a device to be fed such as an electronic device, as well as a feed unit and an electronic device applied to such a feed system.

BACKGROUND ART

[0003] In recent years, attention has been given to a feed system (a non-contact feed system, a wireless charging system) that performs non-contact electric power supply (power transmission, electric power transmission) to a CE device (Consumer Electronics Device) such as a mobile phone and a mobile music player. This makes it possible to start charging merely by placing an electronic device (a secondary-side device) on a charging tray (a primary-side device), instead of starting charging by inserting (connecting) a connector of a power-supply unit such as an AC adapter into the device. In other words, terminal connection between the electronic device and the charging tray becomes unnecessary.

[0004] As a method of thus performing non-contact electric power supply, an electromagnetic induction method is well known. In addition, in recent years, a non-contact feed system using a method called a magnetic resonance method utilizing an electromagnetic resonance phenomenon has also been receiving attention. Such non-contact feed systems are disclosed in, for example, Patent Literatures 1 to 6.

CITATION LIST

Patent Literature

[0005] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2001-102974

[0006] Patent Literature 2: WO 00/27531

[0007] Patent Literature 3: Japanese Unexamined Patent Application Publication No. 2008-206233

[0008] Patent Literature 4: Japanese Unexamined Patent Application Publication No. 2002-34169

[0009] Patent Literature 5: Japanese Unexamined Patent Application Publication No. 2005-110399

[0010] Patent Literature 6: Japanese Unexamined Patent Application Publication No. 2010-63245

SUMMARY OF THE INVENTION

[0011] Incidentally, in a non-contact feed system like those described above, in general, it is expected to improve convenience of a user, by appropriately controlling charging to a battery (a secondary battery) in a device to be fed such as an electronic device.

[0012] Accordingly, it is desirable to provide a feed unit, a feed system, and an electronic device that are capable of improving convenience of a user, when performing electric power transmission (power transmission) using a magnetic field or an electric field.

[0013] A feed unit according to an embodiment of the present disclosure includes: a power transmission section configured to perform power transmission using a magnetic field or an electric field, to a device to be fed including a secondary battery; and a power-transmission control section configured to control power transmission operation in this power transmission section. In a charging period in which charging to the secondary battery is performed based on transmitted power in the power transmission, when the device to be fed including the secondary battery is activated, the power-transmission control section controls the power transmission operation, to increase the transmitted power

[0014] A first feed system according to an embodiment of the present disclosure includes: one or a plurality of electronic devices (devices to be fed) including a secondary battery; and the feed unit according to the above-described embodiment of the present disclosure. The feed unit is configured to perform electric power transmission using a magnetic field or an electric field, to this electronic device.

[0015] In the feed unit and the first feed system according to the above-described embodiments of the present disclosure, in the charging period in which the charging to the secondary battery in the device to be fed is performed based on the transmitted power in the power transmission using the magnetic field or the electric field, when the device to be fed including the secondary battery is activated, the power transmission operation is controlled to increase the transmitted power. Therefore, for example, even if the transmitted power is reduced and suppressed to be low in the charging period, the device to be fed may be allowed to secure electric power necessary for activation of its own, easily from the transmitted power.

[0016] An electronic device according to an embodiment of the present disclosure includes: a power receiving section configured to receive transmitted power in power transmission using a magnetic field or an electric field, from a feed unit; a secondary battery configured to be charged based on the transmitted power received by this power receiving section; and a control section configured to perform predetermined control. In a charging period in which charging to the secondary battery is performed, when the electronic device is activated, the control section notifies the feed unit side of a request for an increase of the transmitted power.

[0017] A second feed system according to an embodiment of the present disclosure includes: one or a plurality of the electronic devices (devices to be fed) according to the above-described embodiment; and a feed unit configured to perform power transmission using a magnetic field or an electric field, to this electronic device.

[0018] In the electronic device and the second feed system according to the above-described embodiments of the present disclosure, in the charging period in which the charging to the secondary battery is performed based on the transmitted power in the power transmission using the magnetic field or the electric field, when the electronic device is activated, the feed unit side is notified of the request for the increase of the transmitted power. Therefore, for example, even if the transmitted power is reduced and suppressed to be below in the charging period, the feed unit side is caused to increase the transmitted power, which may allow the electronic device to secure electric power necessary for activation of its own, easily from the transmitted power.

[0019] According to the electronic device and the first feed system according to the above-described embodiments of the present disclosure, in the charging period in which the charging to the secondary battery in the device to be fed is performed based on the transmitted power in the power transmission using the magnetic field or the electric field, the transmitted power is increased when the device to be fed including the secondary battery is activated. Therefore, even if the transmitted power is reduced and suppressed to be low in the charging period, the device to be fed may be allowed to secure the electric power necessary for the activation of its own, easily from the transmitted power. Hence, when the electric power transmission is performed using the magnetic field or the electric field, convenience of a user is allowed to be improved.

[0020] According to the electronic device and the second feed system according to the above-described embodiments of the present disclosure, in the charging period in which the charging to the secondary battery is performed based on the transmitted power in the power transmission using the magnetic field or the electric field, the feed unit side is notified of the request for the increase of the transmitted power, when the electronic device is activated. Therefore, even if the transmitted power is reduced and suppressed to be below in the charging period, the electronic device is allowed to secure the electric power necessary for the activation of its own, easily from the transmitted power. Hence, when the electric power transmission is performed using the magnetic field or the electric field, convenience of a user is allowed to be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0021] FIG. **1** is a perspective view illustrating an appearance configuration example of a feed system according to an embodiment of the present disclosure.

[0022] FIG. **2** is a block diagram illustrating a detailed configuration example of the feed system illustrated in FIG. **1**.

[0023] FIG. **3** is a circuit diagram illustrating a detailed configuration example of each block illustrated in FIG. **2**.

[0024] FIG. **4** is a timing waveform diagram illustrating an example of a control signal for an alternating-current signal generating circuit.

[0025] FIG. **5** is a timing chart illustrating an example of each of a feeding period and a communication period.

[0026] FIG. **6** is a schematic diagram illustrating a load characteristic example of a battery in the feed system illustrated in FIG. **3**.

[0027] FIG. **7** is a schematic diagram illustrating a load characteristic example of a charging circuit in the feed system illustrated in FIG. **3**.

[0028] FIG. **8** is a timing chart illustrating an operation example in a feed system according to each of an example and a comparative example.

[0029] FIG. **9** is a flowchart illustrating a control example in an electronic device according to the example.

[0030] FIG. **10** is a flowchart illustrating a power transmission control example in a feed unit according to the example.

[0031] FIG. **11** is a block diagram illustrating a schematic configuration example of a feed system according to a modification.

[0032] FIG. **12** is a schematic diagram illustrating a propagation mode example of an electric field in the feed system illustrated in FIG. **11**.

MODES FOR CARRYING OUT THE INVENTION

[0033] An embodiment of the present disclosure will be described below in detail with reference to the drawings. It is to be noted that the description will be provided in the following order.

1. Embodiment (an example in which transmitted power is increased when a device to be fed is activated in a charging period)
2. Modifications (such as an example of a feed system performing non-contact electric power transmission by using an electric field)

Embodiment

[Overall Configuration of Feed System **4**]

[0034] FIG. **1** illustrates an appearance configuration example of a feed system (a feed system **4**) according to an embodiment of the present disclosure, and FIG. **2** illustrates a block configuration example of this feed system **4**. The feed system **4** is a system (a non-contact type feed system) that performs electric power transmission (power supply, feeding, power transmission) in a non-contact manner by using a magnetic field (by utilizing magnetic resonance, electromagnetic induction, or the like; likewise hereinafter). This feed system **4** includes a feed unit **1** (a primary-side device) and one or a plurality of electronic devices (here, two electronic devices **2**A and **2**B; secondary-side devices) each serving as a device to be fed.

[0035] In this feed system **4**, electric power transmission from the feed unit **1** to the electronic devices **2**A and **2**B may be performed by placing the electronic devices **2**A and **2**B on (or, in proximity to) a feeding surface (a power transmission surface) Si in the feed unit **1**, as illustrated in FIG. **1**, for example. Here, in consideration of a case in which the electric power transmission to the electronic devices **2**A and **2**B is performed simultaneously or time-divisionally (sequentially), the feed unit **1** is shaped like a mat (a tray) in which the area of the feeding surface Si is larger than the electronic devices **2**A and **2**B to be fed and the like.

[0036] (Feed Unit **1**)

[0037] The feed unit **1** is a unit (a charging tray) that performs the electric power transmission (power transmission) to the electronic devices **2**A and **2**B by using a magnetic field as described above. This feed unit **1** may include, for example, a power transmission unit **11** that includes a power transmission section **110**, an alternating-current (AC) signal generating circuit (a high-frequency power generating circuit) **111**, and a control section (a power-transmission control section) **112**, as illustrated in FIG. **2**.

[0038] The power transmission section **110** is configured to include a power transmission coil (a primary-side coil) L**1** as well as capacitors (resonance capacitors) C**1***p* and C**1***s*, which will be described later, and the like. The power transmission section **110** performs electric power transmission (power transmission) using an alternating field to each of the electronic devices **2**A and **2**B (specifically, a power receiving section **210** to be described later), by utilizing the power transmission coil L**1** as well as the capacitors C**1***p* and C**1***s* (see an arrow P**1** in FIG. **2**). Specifically, the power transmission section **110** has a function of emitting a magnetic field (a magnetic flux) from the feeding surface Si towards the electronic devices **2**A and **2**B. This power transmission section **110** also has a function of performing predetermined mutual communication operation with the power receiving section **210** to be described later (see an arrow C**1** in FIG. **2**).

[0039] The AC signal generating circuit **111** may be, for example, a circuit that generates a predetermined AC signal Sac (high-frequency electric power) intended to perform power transmission, by using electric power supplied from an external power source **9** (a host power source) of the feed unit **1**. The AC signal generating circuit **111** as described above may be configured using, for example, a switching amplifier to be described later. It is to be noted that examples of the external power source **9** may include a USB (Universal Serial Bus) **2.0** power source (power supply ability: 500 mA, and power supply voltage: about 5 V) provided in a PC (Personal Computer) etc.

[0040] The control section **112** performs various kinds of control operation in the entire feed unit **1** (the entire feed system **4**). Specifically, other than controlling the power transmission (power transmission operation) and the communication (communication operation) performed by the power transmission section **110**, the control section **112** may have, for example, a function of controlling optimization of transmitted power and authenticating the secondary-side device. The control section **112** may further have a function of determining that the secondary-side device is on the primary-side device, and a function of detecting a mixture such as dissimilar metal. Here, when the above-described power transmission control is performed, operation of the AC signal generating circuit **111** is controlled using a predetermined control signal CTL to be described later. In addition, this control section **112** also has a function of performing modulation processing based on pulse width modulation (PWM) to be described later, by using the control signal CTL.

[0041] Further, the control section **112** has a function of performing a stepwise reduction of the transmitted power to a minimum power value necessary in charging, in a period in which each of the electronic devices **2**A and **2**B is not being activated, during a charging period in which a battery **214** to be described later in each of the electronic devices **2**A and **2**B is charged based on the transmitted power using a magnetic field. In addition, in such a charging period, the power transmission operation of the power transmission section **110** is controlled to increase the transmitted power, when the electronic devices **2**A and **2**B are activated. It is to be noted that, by utilizing communication to be described later with the electronic devices **2**A and **2**B, the control section **112** detects whether each of the electronic devices **2**A and **2**B is in the above-described charging period for the battery **214**, and whether each of the electronic devices **2**A and **2**B is being activated. Such power transmission control (feeding control) by the control section **112** will be described in detail later (FIGS. **8** and **10**).

[0042] (Electronic Devices **2**A and **2**B)

[0043] The electronic devices **2**A and **2**B each may be, for example, any of stationary electronic devices represented by television receivers, mobile electronic devices containing a rechargeable battery (a battery) represented by mobile phones and digital cameras, and the like. As illustrated in, for example, FIG. **2**, the electronic devices **2**A and **2**B may each include a power receiving unit **21**, and a load **22** that performs predetermined operation (operation that allows functions of serving as the electronic device to be performed) based on electric power supplied from this power receiving unit **21**. Further, the power receiving unit **21** includes the power receiving section **210**, a rectifier circuit **211**, a voltage stabilizer **212**, a charging circuit **213** (a charging section), a battery **214** (a secondary battery), a voltage detecting circuit **215**, and a control section **216**.

[0044] The power receiving section **210** is configured to include a power receiving coil (a secondary-side coil) L**2** and capacitors C**2***p* and C**2***s* (resonance capacitors), which will be described later, and the like. The power receiving section **210** has a function of receiving electric power (transmitted power) transmitted from the power transmission section **110** in the feed unit **1**, by utilizing the power receiving coil L**2** as well as the resonance capacitors C**2***p* and C**2***s*, and the like. This power receiving section **210** also has a function of performing the above-described predetermined mutual communication operation with the power transmission section **110** (see the arrow C**1** in FIG. **2**).

[0045] The rectifier circuit **211** is a circuit that rectifies the transmitted power (AC power) supplied from the power receiving section **210**, and generates DC power.

[0046] The voltage stabilizer **212** is a circuit that performs predetermined voltage stabilization operation, based on the DC power supplied from the rectifier circuit **211**. Specifically, an input voltage (an input voltage V**1** to be described later) obtained based on the transmitted power is stabilized, and an output voltage after the stabilization is supplied to the charging circuit **213**.

[0047] The charging circuit **213** is a circuit used to perform charging to the battery **214**, based on the DC power (the above-described output voltage) supplied from the voltage stabilizer **212** after the voltage stabilization.

[0048] The battery **214** stores electric power according to the charging by the charging circuit **213**, and may be configured using, for example, a rechargeable battery (a secondary battery) such as a lithium ion battery.

[0049] The voltage detecting circuit **215** is a circuit that detects the DC voltage (the input voltage V**1** to the voltage stabilizer **212**) outputted from the rectifier circuit **215**, and outputs a result of the detection to the control section **216**. Such a voltage detecting circuit **215** may be configured using, for example, a resistor and the like.

[0050] The control section **216** performs various kinds of control operation in each of the entire electronic devices **2**A and **2**B (the entire feed system **4**). Specifically, for example, the control section **216** may have a function of controlling the power receiving operation and the communication operation by the power receiving section **110**, and also have a function of controlling operation of each of the voltage stabilizer **212**, the charging circuit **213**, and the like. It is to be noted that the functions of this control section **216** will be described in detail later.

[0051] [Detailed Configuration of Feed Unit **1** as well as Electronic devices **2**A and **2**B]

[0052] FIG. **3** illustrates a detailed configuration example of each block in the feed unit **1** as well as the electronic devices **2**A and **2**B illustrated in FIG. **2**, in a circuit diagram.

[0053] (Power Transmission Section **110**)

[0054] The power transmission section **110** includes the power transmission coil L**1** provided to perform electric power transmission using a magnetic field (to generate a magnetic flux), and the capacitors C**1***p* and C**1***s* that form, together with this power transmission coil L**1**, an LC resonance circuit. The capacitor C**1***s* is electrically connected to the power transmission coil L**1** in series. In other words, one end of the capacitor C**1***s* and one end of the power transmission coil L**1** are connected to each other. Further, the other end of the capacitor C**1***s* and the other end of the power transmission coil L**1** are connected to the capacitor C**1***p* in parallel. A connection end between the power transmission coil L**1** and the capacitor C**1***p* is grounded.

[0055] The LC resonance circuit configured of the power transmission coil L**1** as well as the capacitors C**1***p* and C**1***s*, and an LC resonance circuit that will be described later and configured of the power receiving coil L**2** as well as the capacitors C**2***s* and C**2***p*, are magnetically coupled to each other. As a result, LC resonance operation is performed based on a resonance frequency that is substantially the same as the high-frequency electric power (the AC signal Sac) generated by the AC signal generating circuit **111** to be described below.

[0056] (AC Signal Generating Circuit **111**)

[0057] The AC signal generating circuit **111** is configured using a switching amplifier (a so-called class E amplifier) including one transistor (not illustrated) serving as a switching element. The control signal CTL for power transmission is supplied from the control section **112** to the AC signal generating circuit **111**. This control signal CTL is a pulse signal having a predetermined duty ratio, as illustrated in FIG. **3**. Further, for example, as illustrated in Parts (A) and (B) of FIG. **4**, the pulse width modulation to be described later may be performed, by controlling this duty ratio in the control signal CTL.

[0058] In the AC signal generating circuit **11**, with such a configuration, the above-described transistor performs ON/OFF operation (switching operation based on a predetermined frequency and duty ratio), according to the control signal CTL for power transmission. In other words, the ON/OFF operation of the transistor serving as the switching element is controlled using the control signal CTL supplied from the control section **112**. As a result, for example, the AC signal Sac (AC power) may be generated based on a DC signal Sdc inputted from the external power source **9** side, and the generated AC signal Sac may be supplied to the power transmission section **110**.

[0059] (Power Receiving Section **210**)

[0060] The power receiving section **210** includes the power receiving coil L**2** provided to receive electric power (from a magnetic flux) transmitted from the power transmission section **110**, and also includes the capacitors C**2***p* and C**2***s* that form, together with this power receiving coil L**2**, the LC resonance circuit. The capacitor C**2***p* is electrically connected to the power receiving coil L**2** in parallel, and the capacitor C**2***s* is electrically connected to the power receiving coil L**2** in series. In other words, one end of the capacitor C**2***s* is connected to one end of the capacitor C**2***p* and one end of the power receiving coil L**2**. Further, the other end of the capacitor C**2***s* is connected to one input terminal in the rectifier circuit **211**, and the other end of the power receiving coil L**2** as well as the other end of the capacitor C**2***p* are connected to the other input terminal in the rectifier circuit **211**.

[0061] The LC resonance circuit configured of the power receiving coil L**2** as well as the capacitors C**2***p* and C**2***s*, and the above-described LC resonance circuit configured of the power transmission coil L**1** as well as the capacitors C**1***p* and C**1***s* are magnetically coupled to each other. As a result, the LC resonance operation is performed based on a resonance frequency that is substantially the same as the high-frequency electric power (the AC signal Sac) generated by the AC signal generating circuit **111**.

[0062] (Rectifier Circuit **211**)

[0063] Here, the rectifier circuit **211** is configured using four rectifier elements (diodes) D**1** to D**4**. Specifically, an anode of the rectifier element D**1** and a cathode of the rectifier element D**3** are connected to the one input terminal in the rectifier circuit **211**, and a cathode of the rectifier element D**1** and a cathode of the rectifier element D**2** are connected to an output terminal in the rectifier circuit **211**. Further, an anode of the rectifier element D**2** and a cathode of the rectifier element D**4** are connected to the other input terminal in the rectifier circuit **211**, and an anode of the rectifier element D**3** and an anode of the rectifier element D**4** are grounded. In the rectifier circuit **211**, with such a configuration, the AC power supplied from the power receiving section **210** is rectified, and received electric power that is the DC power is supplied to the voltage stabilizer **212**.

[0064] (Voltage Stabilizer **212**)

[0065] The voltage stabilizer **212** is, as described above, a circuit that stabilizes the DC power (the input voltage V**1**) supplied from the rectifier circuit **211**, and may be configured using, for example, a power circuit such as a switching regulator.

[0066] (Charging Circuit **213**)

[0067] The charging circuit **213** is, as described above, a circuit that performs charging to the battery **214** based on the output voltage (the DC power) from the voltage stabilizer **212**. Here, the charging circuit **213** is disposed between the voltage stabilizer **212** and the load **22**.

[0068] (Voltage Detecting Circuit **215**)

[0069] The voltage detecting circuit **215** is, as described above, a circuit that detects the input voltage V**1** to the voltage stabilizer **212**, and thereby detects to what extent unnecessary electric power (electric power that exceeds the minimum power value necessary in charging to the battery **214**) to be described later has been received.

[0070] (Control Section **216**)

[0071] The control section **216** performs various kinds of control operation in each of the entire electronic devices **2**A and **2**B (the entire feed system **4**) as described above, and also has the following functions in the present embodiment in particular. Specifically, there is provided a function of first obtaining and grasping various pieces of device information in the device (the electronic device **2**A or the electronic device **2**B) of its own whenever necessary. Specifically, information (activation status information) indicating an activation status of the device (the load **22**) of its own (itself) is obtained from the load **22**. Further, information (input voltage information) indicating a magnitude of the above-described input voltage V**1** is obtained from the voltage detecting circuit **215**. Information (power-remaining-amount information: for example, a battery voltage Vb illustrated in FIG. **3**) indicating a power remaining amount in the battery **214** is also obtained from the charging circuit **213**.

[0072] The control section **216** has functions such as a function of notifying the feed unit **1** side (the control section **112**) of a request for an increase of the transmitted power, upon determining that the device of its own is activated in the charging period for the battery **214**, by utilizing these obtained pieces of device information. It is to be noted that such notifying the feed unit **1** side is performed utilizing communication using the power receiving section **210**. Such control (power-transmission request control) by the control section **216** will be described in detail later (FIGS. **8** and **9**).

[0073] [Functions and Effects of Feed System **4**]

1. Summary of Overall Operation

[0074] In this feed system **4**, based on the electric power supplied from the external power source **9**, the predetermined high-frequency electric power (the AC signal Sac) used to perform the electric power transmission is supplied from the high-frequency power generating circuit **111** in the feed unit **1**, to the power transmission coil L**1** as well as the capacitors C**1***p* and C**1***s* (the LC resonance circuit) in the power transmission section **110**. This causes the magnetic field (the magnetic flux) in the power transmission coil L**1** in the power transmission section **110**. At this moment, when the electronic devices **2**A and **2**B each serving as a device to be fed (a device to be charged) are placed on (or, in proximity to) the top surface (the feeding surface Si) of the feed unit **1**, the power transmission coil L**1** in the feed unit **1** and the power receiving coil L**2** in each of the electronic devices **2**A and **2**B are in proximity to each other in the vicinity of the feeding surface Si.

[0075] In this way, when the power receiving coil L**2** is placed in proximity to the power transmission coil L**1** generating the magnetic field (the magnetic flux), an electromotive force is generated in the power receiving coil L**2** by being induced by the magnetic flux generated by the power transmission coil L**1**. In other words, due to electromagnetic induction or magnetic resonance, the magnetic field is generated by forming interlinkage with each of the power transmission coil L**1** and the power receiving coil L**2**. As a result, electric power transmission from the power transmission coil L**1** side (a primary side, the feed unit **1** side, or the power transmission section **110** side) to the power receiving coil L**2** side (a secondary side, the electronic devices **2**A and **2**B side, or the power receiving section **210** side) is performed (see the arrow P**1** in FIGS. **2** and **3**). At this moment, the power transmission coil L**1** on the feed unit **1** side and the power receiving coil L**2** on the electronic devices **2**A and **2**B side are magnetically coupled to each other by the electromagnetic induction or the like, so that the LC resonance operation is performed in the above-described LC resonance circuits.

[0076] Then, in each of the electronic devices **2**A and **2**B, the AC power received by the power receiving coil L**2** is supplied to the rectifier circuit **211**, the voltage stabilizer **212**, and the charging circuit **213**, and the following charging operation is performed. Specifically, after this AC power is converted into predetermined DC power by the rectifier circuit **211**, and the voltage stabilization operation is performed by the voltage stabilizer **212**, the charging to the battery **214** based on this DC power is performed by the charging circuit **213**. In this way, in each of the electronic devices **2**A and **2**B, the charging operation based on the electric power received by the power receiving section **210** is performed.

[0077] In other words, in the present embodiment, at the time of charging the electronic devices **2**A and **2**B, terminal connection to an AC adapter or the like, for example, may be unnecessary, and it is possible to start the charging easily by merely placing the electronic devices **2**A and **2**B on (or in proximity to) the feeding surface Si of the feed unit **1** (non-contact feeding is performed). This reduces burden on a user.

[0078] Further, as illustrated in, for example, FIG. **5**, at the time of such feeding operation, a feeding period Tp (a charging period for the battery **214**) and a communication period Tc (a non-charging period) are time-divisionally periodic (or aperiodic). In other words, the control section **112** and the control section **216** perform the control so that the feeding period Tp and the communication period Tc are set to be time-divisionally periodic (or aperiodic). Here, this communication period Tc is a period in which the predetermined mutual communication operation (communication operation for authentication between devices, feeding efficiency control, and the like) using the power transmission coil L**1** and the power receiving coil L**2** is performed between the primary-side device (the feed unit **1**) and the secondary-side device (the electronic devices **2**A and **2**B) (see the arrow C**1** in FIGS. **2** and **3**). It is to be noted that a time ratio between the feeding period Tp and the communication period Tc at this moment may be, for example, about 9:1.

[0079] Here, in this communication period Tc, the communication operation using the pulse width modulation in the AC signal generating circuit **111** may be performed, for example. Specifically, the duty ratio of the control signal CTL in the communication period Tc is set based on predetermined modulation data, so that the communication based on the pulse width modulation is performed. It is to be noted that, it is theoretically difficult to perform frequency modulation at the time of resonance operation in the power transmission section **110** and the power receiving section **210** described above. Therefore, such pulse width modulation is used to achieve communication operation easily.

2. About Transmitted Power in Charging Period

[0080] Further, in the feed system **4** of the present embodiment, in the period in which the charging to the battery **214** in each of the electronic devices **2**A and **2**B is performed (in the charging period, or a period before completion of charging) based on the transmitted power in the power transmission using the magnetic field in the manner described above, the transmitted power is reduced and suppressed to be low. In other words, in such a charging period, the control section **112** in the feed unit **1** controls the power transmission operation performed by the power transmission section **110**, so that the transmitted power is reduced and suppressed to be low. One reason for this is as follows.

[0081] Specifically, at first, for example, as illustrated in FIGS. **6** and **7**, when the battery **214** is configured of a secondary battery such as a lithium ion battery, charging to the secondary battery may be performed usually based on so-called “CC-CV charging”. In other words, charging control is performed so that a constant-voltage charging (CV charging) period Tcv is set to follow a constant-current charging (CC charge) period Tcc. At the time of such CC-CV charging, a load characteristic (a relationship between charging time and a magnitude of a load) of the battery **214** may be, for example, as illustrated in FIG. **6**, and a load characteristic of the charging circuit **213** may be, for example, as illustrated in FIG. **7**. In other words, as indicated by an arrow of a broken line in each of FIGS. **6** and **7**, as the charging to the battery **214** proceeds, a gap occurs between the transmitted power and the electric power necessary in charging, and an amount corresponding to the gap becomes “surplus power ((excessive (unnecessary) transmitted power)” if the gap is left as it is. Such surplus power eventually becomes “heat”, which heats the feed unit **1** as well as the electronic devices **2**A and **2**B, and therefore is a problem.

[0082] For this reason, in the present embodiment, in the period in which each of the electronic devices **2**A and **2**B is not activated during the charging period for the battery **214**, the control section **112** performs control for a stepwise reduction of the transmitted power to the minimum power value necessary in charging. Further, the control section **216** in each of the electronic devices **2**A and **2**B side notifies the feed unit **1** (the control section **112**) side of a request for a stepwise reduction of the transmitted power to the minimum power value necessary in charging, in the period in which the device of its own is not activated during the charging period.

[0083] FIG. **8** illustrates an operation example in the charging period, in a timing chart, in which Part (A) illustrates the magnitude of the load **22**, Part (B) illustrates transmitted power in a feed system according to a comparative example, and Part (C) illustrates transmitted power according to an example of the present embodiment.

[0084] In this operation example, as indicated by an arrow P**21** in this figure, the control section **112** reduces the transmitted power stepwise, by decreasing (or increasing) the transmitted power one step at a time, in response to a request from each of the electronic devices **2**A and **2**B (the control section **216**). One reason for this is as follows. Specifically, first, for example, when the load **22** is lightened as indicated by an arrow P**22** in this figure, a voltage such as the above-described input voltage V**1** to the voltage stabilizer **212** may rise. Therefore, a minimum voltage value (a threshold voltage Vth**1** to be described later; a magnitude of the input voltage V**1**, which ensures operation of the voltage stabilizer **212** (for example, the switching regulator)) in this input voltage V**1** is defined, and the transmitted power is gradually reduced (one step at a time) to the extent not to fall below this minimum voltage value.

[0085] Specifically, as will be described in detail later, when the transmitted power is larger than the minimum power value necessary in charging (corresponding to the above-described threshold voltage Vth**1**), the control section **216** notifies a request for a decrease of the transmitted power by one step. On the other hand, when the transmitted power is smaller than the minimum power value (the threshold voltage Vth**1**), the control section **216** notifies a request for an increase of the transmitted power by one step. Subsequently, in response to such a request for the increase or decrease of the transmitted power, the control section **112** actually increases or decreases the transmitted power, one step a time. Such control of the transmitted power prevents useless (unnecessary) power transmission (charging) to the electronic devices **2**A and **2**B, and avoids heat and the like due to the above-described surplus transmitted power. It is to be noted that the above-described “minimum power value necessary in charging” may be preferably defined by not only the magnitude of the input voltage V**1** in the voltage stabilizer **212**, but also a magnitude of the output voltage from this voltage stabilizer **212**. This is to allow more reliable determination as to whether functions of the voltage stabilizer **212** are not stopped as will be described later.

2-1. Comparative Example

[0086] However, in a case in which the transmitted power is thus reduced while a light state of the load **22** continues, the following issue arises in a comparative example, when each of the electronic devices **2**A and **2**B (the load **22**) is activated as indicated by an arrow P**31** in this figure (such as automatic activation by a timer or the like, and manual activation by a user).

[0087] Specifically, first, the transmitted power at that time may be significantly below maximum power necessary for the load **22**. At the time of such an overload, although electric power is necessary for the charging circuit **213**, the voltage stabilizer **212** (for example, the switching regulator) with the reduced transmitted power is not allowed to supply the charging circuit **213** with the electric power. Therefore, the charging circuit **213** supplies the load **22** with electric power, by utilizing a part of the charging power accumulated in the battery **214**. In such a state, the input voltage V**1** to the voltage stabilizer **212** suddenly drops, and the voltage stabilizer **212** enters a so-called UVLO (Under Voltage Lock Out) mode. In other words, the voltage stabilizer **212** configured of the switching regulator or the like stops the functions thereof, and does not supply the electric power to the charging circuit **213**.

[0088] In such a UVLO mode, the load **22** being activated is supplied with the part of the charging power from the charging circuit **213** as described above, and therefore operates smoothly. On the other hand, the voltage stabilizer **212** in the UVLO mode is an electrically very light load. As a result, in an activated period (an activated-state period Ton) of the load **22**, as indicated by an arrow P**103** in the figure, the transmitted power is steadily reduced, because the voltage stabilizer **212** is a very light load even though the load **22** is in a heavy state.

[0089] In this way, in the comparative example illustrated in Part (B) of FIG. **8**, although it is necessary to increase the transmitted power and there is sufficient transfer capability, the transmitted power is steadily reduced, and as a result, the amount of remaining power in the battery **214** continuously decreases, which impairs convenience of a user.

2-2. Present Embodiment

[0090] Therefore, in the feed system **4** of the present embodiment, when each of the electronic devices **2**A and **2**B is activated in the charging period for the battery **214**, the control section **112** in the feed unit **1** controls the power transmission operation of the power transmission section **110** to increase the transmitted power (see an arrow P**32** in Part (C) of FIG. **8**). Further, the control section **216** in each of the electronic devices **2**A and **2**B side notifies the feed unit **1** side (the control section **112**) of a request for an increase of the transmitted power, upon determining that the device (the load **22**) of its own is activated in such a charging period.

[0091] At this moment, by utilizing the communication with the electronic devices **2**A and **2**B, the control section **112** detects whether each of the electronic devices **2**A and **2**B is in the charging period for the battery **214**, and whether each of the electronic devices **2**A and **2**B (the load **22**) is being activated. Further, the control section **216** notifies the feed unit **1** (the control section **112**) side, by utilizing the communication with the feed unit **1**. In the present embodiment, such control of the transmitted power results in the following, unlike the comparative example. Specifically, as described above, even if the transmitted power is reduced and suppressed to be low in the charging period, each of the electronic devices **2**A and **2**B readily secures electric power necessary for activation of its own, from the transmitted power.

[0092] It is to be noted that, in this process, as indicated by an arrow P**33** and a diagonally shaded portion in Part (C) of FIG. **8**, the control section **216** performs control so that activation operation of the load **22** is performed using a part of the charging power accumulated in the battery **214**, in a period before the transmitted power actually increases in response to the request for the increase of the transmitted power. This is because this period corresponds to a time lag in the communication from the electronic devices **2**A and **2**B side to the feed unit **1** side, and in this period, it is necessary to perform the activation operation by receiving support from the charging power.

[0093] (Control Example in Electronic Devices **2**A and **2**B)

[0094] Here, FIG. **9** illustrates a specific control example of the control section **216** in each of the electronic devices **2**A and **2**B (a control example in the charging period), in a flowchart. In this control example, first, normal power receiving operation (operation of receiving 100% of the transmitted power) is performed in the power receiving section **210** (step S**101**).

[0095] Next, the control section **216** resets (initializes) a predetermined power receiving counter (Count=0: step S**102**). Subsequently, the control section **216** determines, by using the power-remaining-amount information serving as the above-described device information, whether a power remaining amount in the battery **214** is equal to or larger than a predetermined threshold, i.e., whether charging to the battery **214** is completed (step S**103**). Specifically, here, whether the battery voltage Vb is equal to or larger than a predetermined threshold voltage Vth is determined.

[0096] Here, upon determining that the battery voltage Vb is equal to or larger than the threshold voltage Vth (step S**103**: Y), the control section **216** determines that the charging to the battery **214** is completed, and notifies this result (transmits a charging completion command) to the feed unit **1** (the control section **112**) side (step S**104**). This ends the control by the control section **216** in the charging period illustrated in FIG. **9**. It is to be noted that this notification (the charging completion command) is performed utilizing the communication with the feed unit **1**.

[0097] On the other hand, upon determining that the battery voltage Vb is smaller than the threshold voltage Vth (step S**103**: N), the control section **216** determines that the charging to the battery **214** is not yet completed), and increases the value of the power receiving counter by one (Count=Count+1: step S**105**). The control section **216** then determines whether this value of the power receiving counter is equal to or larger than a predetermined threshold Th (whether Count≥Th is satisfied) (step S**106**).

[0098] Here, when it is determined that the value of the power receiving counter is smaller than the threshold Th (Count<Th) (step S**106**: N), the flow returns to step S**103** described above. On the other hand, upon determining that the value of the power receiving counter is equal to or larger than the threshold Th (Count≥Th) (step S**106**: Y), the control section **216** then determines, by using the above-described activation status information serving as the device information, whether the device (the load **22**) of its own is being activated (step S**107**).

[0099] Here, upon determining that the load **22** is being activated (step S**107**: Y), the control section **216** notifies a request for an increase of the transmitted power (transmits a necessary-transmitted-power requesting command) to the feed unit **1** side (the control section **112**) as described above (step S**108**). In other words, the control section **216** notifies the feed unit **1** side of a request, to bring the transmitted power to the power value necessary in activation. This notification (the necessary-transmitted-power requesting command) is also performed utilizing the communication with the feed unit **1**. It is to be noted that the flow subsequently returns to step S**102** described above.

[0100] On the other hand, upon determining that the load **22** is not being activated (step S**107**: N), the control section **216** then determines whether the input voltage V**1** to the voltage stabilizer **212** is larger than or smaller than the threshold voltage Vth**1** corresponding to the minimum power value necessary in charging (step S**109**). It is to be noted that, as described above, this threshold voltage Vth**1** corresponds to the magnitude of the input voltage V**1**, the magnitude ensuring the operation of the voltage stabilizer **212** (for example, the switching regulator).

[0101] Here, when the input voltage V**1** is larger than the threshold voltage Vth**1** (V**1**>Vth**1**, step S**109**: Y), the control section **216** determines that the transmitted power is larger than the minimum power value necessary in charging, and notifies the feed unit **1** (the control section **112**) side of a request for a decrease of the transmitted power by one step. In other words, the control section **216** transmits a necessary-transmitted-power one-step-down requesting command to the feed unit **1** side (step S**110**). This notification (the necessary-transmitted-power one-step-down requesting command) is also performed utilizing the communication with the feed unit **1**. It is to be noted that the flow subsequently returns to step S**102** described above.

[0102] On the other hand, when the input voltage V**1** is smaller than the threshold voltage Vth**1** (V**1**<Vth**1**, step S**109**: N), the control section **216** determines that the transmitted power is smaller than the minimum power value necessary in charging, and notifies the feed unit **1** (the control section **112**) side of a request for an increase of the transmitted power by one step. In other words, the control section **216** transmits a necessary-transmitted-power one-step-up requesting command to the feed unit **1** side (step S**111**). This notification (the necessary-transmitted-power

one-step-up requesting command) is also performed utilizing the communication with the feed unit **1**. It is to be noted that the flow subsequently returns to step S**102** described above.

[0103] In this way, in the charging period in which the charging to the battery **214** is performed based on the transmitted power, the request for an increase of the transmitted power is notified from each of the electronic devices **2**A and **2**B to the feed unit **1** side, when the device itself (the electronic device **2**A or the electronic device **2**B) is activated. This causes the feed unit **1** side to increase the transmitted power even if the transmitted power is reduced and suppressed to be below in the charging period as described above. Therefore, in each of the electronic devices **2**A and **2**B, this makes it easy to secure the electric power necessary for the activation of its own, from the transmitted power.

[0104] (Power Transmission Control Example in Feed Unit **1**)

[0105] On the other hand, FIG. **10** illustrates a specific power transmission control example (a power transmission control example in the charging period) of the control section **112** in the feed unit **1**, in a flowchart. In this power transmission control example, first, normal power transmission operation (operation of transmitting 100% of the transmitted power) is performed in the power transmission section **110** (step S**201**).

[0106] Next, the control section **112** determines whether a predetermined command from each of the electronic devices **2**A and **2**B (the control section **216**) side is received (whether notification is provided for a predetermined request) (step S**202**). Here, when it is determined that the command is not received (step S**202**: N), step S**202** is repeated.

[0107] On the other hand, upon determining that the command is received (step S**202**: Y), the control section **112** then recognizes contents of the command by decoding the contents (step S**203**). Subsequently, the control section **112** determines whether charging to the battery **214** is completed (whether the above-described charging completion command is received) (step S**204**).

[0108] Here, upon determining that the charging is completed (step S**204**: Y), the control section **112** then performs the power transmission control, to stop the power transmission operation by the power transmission section **110** (step S**205**). This prevents useless (unnecessary) power transmission (charging) to the electronic devices **2**A and **2**B, thereby avoiding heat and the like due to surplus transmitted power. The power transmission control by the control section **112** in the charging period illustrated in FIG. **10** is then completed.

[0109] On the other hand, upon determining that the charging is not yet completed (step S**204**: N), the control section **112** then determines, based on the contents (the above-described start status information) of the command, whether the electronic device (the load **22** in the electronic device **2**A or the electronic device **2**B) is being activated (step S**206**).

[0110] Here, upon determining that the electronic device (the load **22**) is being activated (step S**206**: Y), the control section **112** then controls the transmitted power to bring the transmitted power to a power value necessary in activation, requested by the device side (requested in the necessary-transmitted-power requesting command described above). As a result, power transmission based on such a necessary power value is performed by the power transmission section **110** (step S**207**). It is to be noted that the flow subsequently returns to step S**202** described above.

[0111] On the other hand, upon determining that the electronic device (the load **22**) is not being activated (step S**206**: N), the control section **112** then determines, based on the contents of the command, whether a transmitted-power one-step-down request is provided (step S**208**). In other words, it is determined whether the necessary-transmitted-power one-step-down requesting command described above is received, or whether the necessary-transmitted-power one-step-up requesting command described above is received.

[0112] Here, upon determining that the transmitted-power one-step-down request is provided (the necessary-transmitted-power one-step-down requesting command is received) (step S**208**: Y), the control section **112** then controls the transmitted power to decrease the transmitted power by one step. As a result, power transmission based on the transmitted power decreased by one step is performed by the power transmission section **110** (step S**209**). It is to be noted that the flow subsequently returns to step S**202** described above.

[0113] On the other hand, upon determining that the transmitted-power one-step-down request is not provided (the necessary-transmitted-power one-step-up requesting command is received) (step S**208**: N), the control section **112** controls the transmitted power to increase the transmitted power by one step. As a result, power transmission based on the transmitted power increased by one step is performed by the power transmission section **110** (step S**210**). It is to be noted that the flow subsequently returns to step S**202** described above.

[0114] In this way, when the electronic device (the electronic device **2**A or the electronic device **2**B) having the battery **214** is activated in the charging period in which the charging to the battery **214** is performed based on the transmitted power, the power transmission operation is controlled to increase the transmitted power. This makes it easy in each of the electronic devices **2**A and **2**B to secure the electric power necessary for activation of its own from the transmitted power, even if the transmitted power is reduced and suppressed to be low in the charging period as described above.

[0115] As described above, in the present embodiment, when the electronic device (the electronic device **2**A or the electronic device **2**B) having the battery **214** is activated in the charging period in which the charging to the battery **214** is performed based on the transmitted power, the control section **112** controls the power transmission operation to increase the transmitted power. Further, the control section **216** notifies the feed unit **1** side of the request for the increase of the transmitted power, when the device (the electronic device **2**A or the electronic device **2**B) of its own is activated in such a charging period. This causes the feed unit **1** side to increase the transmitted power, even if the transmitted power is reduced and suppressed to be below in the charging period. Therefore, this makes it easy in each of the electronic devices **2**A and **2**B, to secure the electric power necessary for activation of its own from the transmitted power. Hence, it is possible to improve convenience of a user, when the electric power transmission using a magnetic field is performed.

[0116] It is to be noted that the transmitted power (including a combination with the charging power in the battery

214) exceeding maximum electric power necessary in activation of the load 22 is a condition for the control by each of the control sections 112 and 216 in the present embodiment. Therefore, when such an electric power balance is not satisfied, part of the functions in the load 22 may be preferably limited (invalidated) at the time of activating the load 22, and the like, according to the amount of remaining power in the battery 214. This is because, without such a limit (invalidation), the charging power in the battery 214 gradually decreases.

Modifications

[0117] Technology of the present disclosure has been described above with reference to the embodiment, but the present technology is not limited to this embodiment and may be variously modified.

[0118] For example, the description has been provided using various coils (the power transmission coil, and the power receiving coil) in the above-described embodiment, but various kinds of configurations may be used as the configurations (the shapes) of these coils. In other words, each coil may have, for example, a shape such as a spiral shape, a loop shape, a bar shape using a magnetic substance, an a-winding shape in which a spiral coil is folded to be in two layers, a spiral shape having more multiple layers, a helical shape in which a winding is wound in a thickness direction, etc. In addition, each coil may be not only a winding coil configured using a wire rod having conductivity, but also a pattern coil having conductivity and configured using, for example, a printed circuit board, a flexible printed circuit board, etc.

[0119] Further, in the above-described embodiment, an electronic device has been described as an example of the device to be fed, but the device to be fed is not limited thereto and may be any type of device to be fed other than electronic devices (for example a vehicle such as an electric car).

[0120] Furthermore, in the above-described embodiment, each component of the feed unit and the electronic device has been specifically described. However, it is not necessary to provide all the components, or other component may be further provided. For example, a communication function, a function of performing some kind of control, a display function, a function of authenticating a secondary-side device, a function of detecting a mixture such as dissimilar metal, and/or the like may be provided in the feed unit and/or the electronic device. Moreover, the power transmission control (the control of increasing the transmitted power, when the electronic device that is the device to be fed is activated in the charging period) in the above-described embodiment may be performed only under a predetermined condition, without being uniformly executed at the time of activating the electronic device. For example, in a case in which a predetermined sequence (operation) defined beforehand is performed, execution of the above-described power transmission control may be disabled, even when the electronic device is activated. In other words, the above-described power transmission control may be executed, for example, when the electronic device is activated in anything other than the above-described predetermined sequence, such as when a user activates the electronic device by pushing a power button of the electronic device.

[0121] In addition, the embodiment has been described above by taking mainly the case in which the plurality of (two or more) electronic devices are provided in the feed system, as an example. However, without being limited to this case, only one electronic device may be provided in the feed system.

[0122] Moreover, the embodiment has been described above by taking the charging tray for the small electronic device (the CE device) such as a mobile phone, as an example of the feed unit. However, the feed unit is not limited to such a home charging tray, and may be applicable to battery chargers of various kinds of electronic devices. In addition, it is not necessary for the feed unit to be a tray, and may be, for example, a stand for an electronic device such as a so-called cradle.

[0123] (Example of Feed System Performing Non-contact Electric Power Transmission Using Electric Field)

[0124] Further, the above-described embodiment has been provided by taking, as an example, the case of the non-contact feed system that performs the non-contact electric power transmission (feeding) using a magnetic field, from the feed unit serving as the primary-side device to the electronic device serving as the secondary-side device, but this is not limitative. In other words, contents of the present disclosure are applicable also to a feed system that performs non-contact electric power transmission using an electric field (electric field coupling), from a feed unit serving as a primary-side device to an electronic device serving as a secondary-side device. In this case, it is possible to obtain effects similar to those of the above-described embodiment.

[0125] Specifically, for example, a feed system illustrated in FIG. 11 may include one feed unit 81 (a primary-side device) and one electronic device 82 (a secondary-side device). The feed unit 81 mainly includes a power transmission section 810, an AC signal source 811 (an oscillator), and an earth electrode Eg1. The power transmission section 810 includes a power transmission electrode E1 (a primary-side electrode). The electronic device 82 mainly includes a power receiving section 820, a rectifier circuit 821, a load 822, and an earth electrode Eg2. The power receiving section 820 includes a power receiving electrode E2 (a secondary-side electrode). To be more specific, this feed system includes two sets of electrodes, i.e., the power transmission electrode E1 and the power receiving electrode E2, as well as the earth electrode Eg1 and the earth electrode Eg2. In other words, the feed unit 81 (the primary-side device) and the electronic device 82 (the secondary-side device) each include, inside thereof, an antenna having a structure of an asymmetric pair of electrodes such as a monopole antenna.

[0126] In the feed system having such a configuration, when the power transmission electrode E1 and the power receiving electrode E2 face each other, the above-described non-contact antennas are coupled to each other (electric field coupling with respect to each other occurs along a vertical direction of the electrodes). Then, an induction field is generated therebetween, and electric power transmission using the electric field is performed (see electric power P8 illustrated in FIG. 11). Specifically, for example, as schematically illustrated in FIG. 12, the generated electric field (an induction field Ei) may propagate from the power transmission electrode E1 side towards the power receiving electrode E2 side, and the generated induction field Ei may propagate from the earth electrode Eg2 side towards the earth electrode Eg1 side. In other words, between the primary-side device and the secondary-side device, a loop path of the generated induction field Ei is formed. In such a non-contact electric power supply system using an electric field, by applying a technique similar to that of the above-described embodiment, it is possible to obtain similar effects.

[0127] It is to be noted that the present technology may also have the following configurations.

(1)

[0128] A feed unit including:

[0129] a power transmission section configured to perform power transmission using a magnetic field or an electric field, to a device to be fed including a secondary battery; and

[0130] a power-transmission control section configured to control power transmission operation in the power transmission section,

[0131] wherein, in a charging period in which charging to the secondary battery is performed based on transmitted power in the power transmission, when the device to be fed including the secondary battery is activated,

[0132] the power-transmission control section controls the power transmission operation, to increase the transmitted power.

(2)

[0133] The feed unit according to (1), wherein the power-transmission control section controls the transmitted power, to achieve a power value necessary in activation, requested by the device to be fed.

(3)

[0134] The feed unit according to (1) or (2), wherein

[0135] in a period in which the device to be fed is not activated during the charging period,

[0136] the power-transmission control section reduces the transmitted power stepwise, to a minimum power value necessary in the charging.

(4)

[0137] The feed unit according to (3), wherein, when reducing the transmitted power stepwise, the power-transmission control section decreases or increases the transmitted power one step at a time, in response to a request from the device to be fed.

(5)

[0138] The feed unit according to any one of (1) to (4), wherein the power-transmission control section stops the power transmission operation, upon completion of charging to the secondary battery.

(6)

[0139] The feed unit according to any one of (1) to (5), wherein the power-transmission control section detects, by utilizing communication with the device to be fed, whether the device to be fed is in the charging period, and whether the device to be fed is activated.

(7)

[0140] A feed system including:

[0141] one or a plurality of electronic devices including a secondary battery; and

[0142] a feed unit configured to perform power transmission using a magnetic field or an electric field, to the electronic device,

[0143] wherein the feed unit includes

[0144] a power transmission section configured to perform the power transmission, and

[0145] a power-transmission control section configured to control power transmission operation in the power transmission section, and

[0146] in a charging period in which charging to the secondary battery is performed based on transmitted power in the power transmission, when the electronic device including the secondary battery is activated,

[0147] the power-transmission control section controls the power transmission operation, to increase the transmitted power.

(8)

[0148] An electronic device including:

[0149] a power receiving section configured to receive transmitted power in power transmission using a magnetic field or an electric field, from a feed unit;

[0150] a secondary battery configured to be charged based on the transmitted power received by the power receiving section; and

[0151] a control section configured to perform predetermined control,

[0152] wherein, in a charging period in which charging to the secondary battery is performed, when the electronic device is activated,

[0153] the control section notifies the feed unit side of a request for an increase of the transmitted power.

(9)

[0154] The electronic device according to (8), wherein

[0155] in a period before the transmitted power actually increases in response to the request for the increase of the transmitted power,

[0156] the control section performs control to allow activation operation by using a part of charging power accumulated in the secondary battery.

(10)

[0157] The electronic device according to (8) or (9), wherein,

[0158] in a period in which the electronic device is not activated during the charging period,

[0159] the control section notifies the feed unit side of a request for a stepwise reduction of the transmitted power to a minimum power value necessary in the charging.

(11)

[0160] The electronic device according to (10), wherein,

[0161] the control section notifies a request for a decrease of the transmitted power by one step, when the transmitted power is larger than the minimum power value, and

[0162] the control section notifies a request for an increase of the transmitted power by one step, when the transmitted power is smaller than the minimum power value.

(12)

[0163] The electronic device according to (10) or (11), further including:

[0164] a charging section configured to perform charging to the secondary battery; and

[0165] a voltage stabilizer configured to perform stabilization of an input voltage obtained based on the transmitted power, and to supply the charging section with an output voltage after the stabilization,

[0166] wherein the minimum power value is defined using a magnitude of each of the input voltage and the output voltage in the voltage stabilizer.

(13)

[0167] The electronic device according to (12), wherein

[0168] the voltage stabilizer is configured using a switching regulator, and

[0169] the minimum power value corresponds to a magnitude of the input voltage, the magnitude ensuring operation of the switching regulator.

(14)

[0170] The electronic device according to any one of (8) to (13), wherein the control section notifies the feed unit side of a request to bring the transmitted power to a power value necessary in activation.

(15)

[0171] The electronic device according to any one of (8) to (14), wherein, upon completion of charging to the secondary battery, the control section notifies the feed unit side of the completion.

(16)

[0172] The electronic device according to any one of (8) to (15), wherein the control section notifies the feed unit side, by utilizing communication with the feed unit.

(17)

[0173] A feed system including:

[0174] one or a plurality of electronic devices; and

[0175] a feed unit configured to perform power transmission using a magnetic field or an electric field, to the electronic device,

[0176] wherein the electronic device includes

[0177] a power receiving section configured to receive transmitted power in the power transmission,

[0178] a secondary battery configured to be charged based on the transmitted power received by the power receiving section, and

[0179] a control section configured to perform predetermined control, and

[0180] when the electronic device is activated, in a charging period in which charging to the secondary battery is performed,

[0181] the control section notifies the feed unit side of a request for an increase of the transmitted power.

[0182] The present application claims priority based on Japanese Patent Application No. 2011-279239 filed in the Japan Patent Office on Dec. 21, 2011, and Japanese Patent Application No. 2012-94334 filed in the Japan Patent Office on Apr. 18, 2012, the entire contents of each of which is hereby incorporated by reference.

[0183] It should be understood by those skilled in the art that various modifications, combinations, sub-combinations, and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

1. An electronic device, comprising:
- a power receiving coil configured to receive wireless power transmitted from a feed device;
- a voltage converting circuit configured to generate a predetermined voltage based on the transmitted power;
- a battery configured to receive the power from the voltage converting circuit; and
- a control circuit configured to transmit a request to the feed device to:
  - (i) decrease the transmitted power by one step in response to the transmitted power being larger than a minimum power value, and
  - (ii) increase the transmitted power by one step in response to the transmitted power being smaller than the minimum power value.

2. The electronic device according to claim **1**, wherein the request transmitted by the control circuit indicates to increase the transmitted power in response to changing from a first state to a second state of the electronic device by pushing a button of the electronic device, and
- wherein during the first state, the power receiving coil is configured to:
  - receive a first power, which indicates a first power level, in response to storage of a first charge of the battery,
  - receive a second power, which indicates a second power level that is less than the first power level, in response to storage of a second charge of battery that is greater than the first change, and
  - receive a third power, which indicates a third power level that is less than the second power level, in response to a completion of a charging of the battery.

3. The electronic device according to claim **2**, wherein in response to the first charge being greater than a predetermined threshold, the request transmitted by the control circuit indicates to decrease the transmitted power.

4. The electronic device according to claim **3**, in response to the first charge being greater than the predetermined threshold, the feed device is configured to stepwise reduce the power wirelessly transmitted to the power receiving coil from the first power level to the second power level and then to the third power level.

5. The electronic device according to claim **2**, wherein the first state has a first load state and the second state has a second load state which is larger than the first load state.

6. The electronic device according to claim **2**, wherein the control circuit is configured to control the electronic device to enter the second state in a period before the power received by the power receiving coil is increased in response to the request transmitted to the feed device.

7. The electronic device according to claim **2**, wherein the second state includes a power-on state in which the electronic device is activated in response to a power button of the electronic device being activated, and the first state includes a power-off state in which the electronic device is not activated by the power button.

8. A feed device, comprising:
- a power transmission coil configured to wirelessly supply power to an electronic device including a battery; and
- a control circuit configured to:
  - receive a request transmitted from the electronic device, and
  - determine whether to control the power transmission coil to increase or decrease the power wirelessly supplied to the electric device based on the request,
- wherein in response to receiving the request from the electronic device, the control circuit is configured to:
  - (i) decrease the power wirelessly supplied to the electric device by one step in response to the power wirelessly supplied to the electric device being larger than a minimum power value, and
  - (ii) increase the power wirelessly supplied to the electric device by one step in response to the power wirelessly supplied to the electric device being smaller than the minimum power value.

9. The feed device according to claim **8**, wherein
- the control circuit controls the power transmission coil to increase the power in response to changing a first state of the electronic device into a second state of the electronic device, and

during the first state of the electronic device, the control circuit controls the power transmission coil to:

transmit a first power, which indicates a first power level, in response to storage of a first charge of the battery,

transmit a second power, which indicates a second power level that is less than the first power level, in response to storage of a second charge of battery that is greater than the first change, and

transmit a third power, which indicates a third power level that is less than the second power level, in response to a completion of a charging of the battery.

10. The feed device according to claim **9**, wherein in response to the first charge being greater than a predetermined threshold, the request transmitted by the electronic device indicates to decrease the transmitted power.

11. The feed device according to claim **10**, wherein in response to the first charge being greater than the predetermined threshold, the control circuit is configured to stepwise reduce the power wirelessly supplied to the electronic device from the first power level to the second power level and then to the third power level.

12. The feed device according to claim **9**, wherein the first state has a first load state and the second state has a second load state which is larger than the first load state.

13. The feed device according to claim **9**, wherein the electronic device is configured to enter the second state in a period before the power received by the power wirelessly supplied to the electronic device is increased in response to the request transmitted to the feed device.

14. An electronic device, comprising:

a power receiving coil configured to receive wireless power transmitted from a feed device;

a voltage converting circuit configured to generate a predetermined voltage based on the transmitted power;

a battery configured to receive the power from the voltage converting circuit; and

a control circuit configured to transmit a request to the feed device to:

(i) decrease the transmitted power by one step in response to the transmitted power being larger than the minimum power value, and

(ii) increase the transmitted power by one step in response to the transmitted power being smaller than the minimum power value.

15. The electronic device according to claim **14**, wherein the request transmitted by the control circuit indicates to increase the transmitted power in response to changing a first state, in which a display of the electronic device is blank during the first state, into a second state in which information is shown on the display of the electronic device, and

during the first state, the power receiving coil is configured to:

receive a first power, which indicates a first power level, in response to storage of a first charge of the battery,

receive a second power, which indicates a second power level that is less than the first power level, in response to storage of a second charge of battery that is greater than the first change, and

receive a third power, which indicates a third power level that is less than the second power level, in response to a completion of a charging of the battery.

16. The electronic device according to claim **15**, wherein in response to the first charge being greater than a predetermined threshold, the request transmitted by the control circuit indicates to decrease the transmitted power.

17. The electronic device according to claim **16**, in response to the first charge being greater than the predetermined threshold, the feed device is configured to stepwise reduce the power wirelessly transmitted to the power receiving coil from the first power level to the second power level and then to the third power level.

18. The electronic device according to claim **15**, wherein the first state has a first load state and the second state has a second load state which is larger than the first load state.

19. The electronic device according to claim **15**, wherein the control circuit is configured to control the electronic device to enter the second state in a period before the power received by the power receiving coil is increased in response to the request transmitted to the feed device.

20. The electronic device according to claim **15**, wherein the second state includes a power-on state in which the electronic device is activated in response to a power button of the electronic device being activated, and the first state includes a power-off state in which the electronic device is not activated by the power button.

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