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(71) Applicant (for all designated States except US): **JOSUYA TECHNOLOGY CORP.** [KR/KR]; Seoul Building 309, 1532-7 Seocho 3-dong, Seocho-gu, Seoul 137-871 (KR).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **CHO, Gyu, Hyeong** [KR/KR]; Kaist Apt. 15-401, 237 Gajeong-dong, Yuseong-gu, Daejeon 305-350 (KR). **JEON, Seong, Jeub** [KR/KR]; Gyeongnam Apt. 103-502, 1375 Jwa-dong, Haeundae-gu, Busan 612-030 (KR).

(74) Agent: **JANG, Seong, Ku**; 17th Fl., Kec Building, 275-7, Yangjae-dong, Seocho-ku, Seoul 137-130 (KR).

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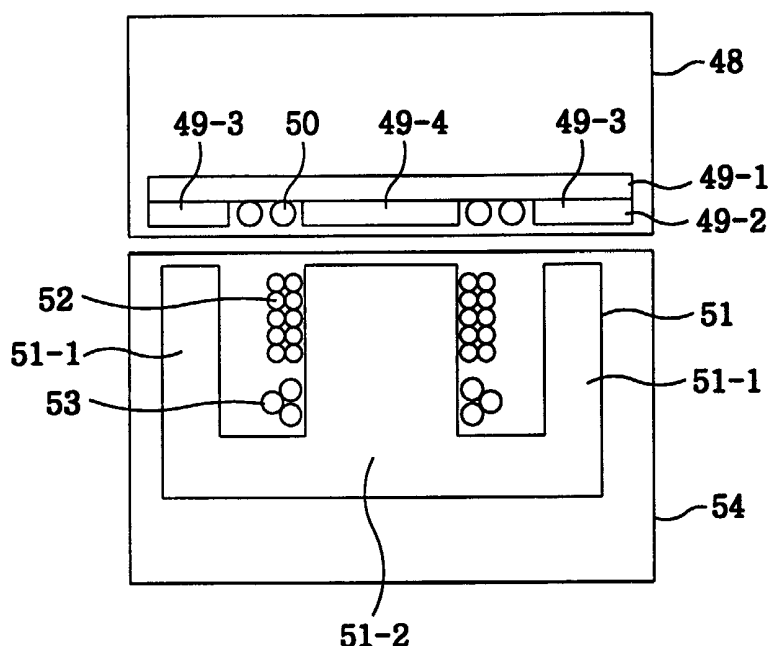
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(54) Title: NONCONTACT CHARGER FOR A PORTABLE DEVICE



(57) Abstract: In a noncontact charger, a primary circuit receives a low frequency AC signal and converts the received low frequency AC signal into a high frequency AC signal, a first core has a main winding for generating a magnetic field and is connected to the primary circuit, a second core has an auxiliary winding for inducing an AC signal from the magnetic field generated by the main winding and a secondary circuit converts the AC signal induced from the main winding into a direct current (DC) signal to provide the DC to a rechargeable battery.

NONCONTACT CHARGER FOR A PORTABLE DEVICEFIELD OF THE INVENTION

5 The present invention relates to a charging device for a portable device; and, more particularly, to a noncontact charging device for charging a rechargeable battery of a portable device by the induction coupling between a charger and the rechargeable battery.

BACKGROUND OF THE INVENTION

10 In general, a portable device such as a mobile phone and a notebook computer is provided with a rechargeable battery which enables a user to use the device even on the move. Required to charge such a rechargeable battery is a charger connected to a general power source to supply a charging current to the rechargeable battery.

15 The charger and the rechargeable battery respectively have contact terminals, and by connecting the contact terminals of the rechargeable battery and the charger, the rechargeable battery can be charged.

20 However, since such contact terminals are exposed to the outside of the charger and the rechargeable battery, the contact terminals may be easily contaminated, resulting in a loose contact between the charger and the rechargeable battery.

25 Further, in the conventional charging method as described above, the user's carelessness may cause a short-circuit of the rechargeable battery, which in turn makes the rechargeable battery to be completely discharged. In addition, if the rechargeable battery is charged for an excessively long time, the charger and the rechargeable battery may be heated or short-circuited.

30 As a solution to the above-described drawbacks of the conventional charging method, there has been developed a

noncontact charging method capable of charging the rechargeable battery without the need of the contact terminals prepared in the rechargeable battery and the charger. In the noncontact charging method, a primary
5 circuit of a transformer which operates at a high frequency is installed in the charger while a secondary circuit thereof is formed in the portable device. In such configuration, the current, i.e., energy, of the charger can be provided to the rechargeable battery of the portable
10 device by magnetic coupling. This noncontact scheme using the magnetic coupling has been applied in certain areas (e.g., an electrically powered tooth brush, an electric shaver, etc.). Conventionally, a ferrite core is used in the first and the second circuit of the transformer.

15 Meanwhile, the portable devices such as a mobile phone, a MP3 player, a MD player, a portable cassette player, a notebook computer have been continuously scaled down in size and weight. The noncontact charging scheme can be employed in these portable devices to resolve the problems of the
20 conventional charging method. However, in case the conventional noncontact charging method is applied to the portable devices without appropriate modifications, the weight and the volume of the secondary circuit in the portable device may increase, so that a further
25 miniaturization of the portable device may not be achieved. Thus, the volume and the weight of the secondary circuitry should be reduced.

Further, it is required to monitor a charged state of the rechargeable battery in order to automatically control
30 and protect the charging device.

SUMMARY OF THE INVENTION

It is, therefore, a primary object of the present
35 invention to provide a small-sized and light-weighted charging device of a noncontact type.

It is another object of the present invention to provide a noncontact type charging device suitable for checking a charging-discharging state of a rechargeable battery and automatically controlling a charging operation in real time.

In accordance with a preferred embodiment of the present invention, there is provided a noncontact charger for a portable device, including: a primary circuit for receiving a low frequency alternative current (AC) signal and converting the received low frequency AC signal into a high frequency AC signal; a first core having a main winding wound therearound and connected to the primary circuit, wherein the main winding generates a magnetic field caused by the high frequency AC signal; a second core, disconnected to the first core and composed of film or sheet shape materials, for having an auxiliary winding wound therearound, wherein an auxiliary winding induces an AC signal from the magnetic field generated by the main winding; and a secondary circuit, connected to the second core, for converting the AC signal induced from the main winding into a direct current (DC) signal to provide the DC to a rechargeable battery.

In accordance with another preferred embodiment of the present invention, there is provided a noncontact charger using a separable type transformer for charging a rechargeable battery by magnetically transferring energy of a primary circuit installed within a charger to a portable device, including: a detection and communication unit for detecting state information of the rechargeable battery and wirelessly or optically outputting the detected information; and a control circuit unit for receiving the detected information provided from the detection and communication unit to operate and protect the primary circuit.

BRIEF DESCRIPTION OF THE INVENTION

The above and other objects and features of the present invention will become apparent from the following description of preferred embodiments given in conjunction with the accompanying drawings, in which:

Fig. 1 shows a block diagram illustrating a noncontact type charging device in accordance with a first preferred embodiment of the present invention;

Fig. 2 depicts a circuit diagram of the noncontact charging device shown in Fig. 1;

Fig. 3 shows a block diagram illustrating a noncontact charging device in accordance with a second preferred embodiment of the present invention;

Fig. 4 depicts a circuit diagram of the noncontact charging device shown in Fig. 3;

Fig. 5 represents a circuit diagram illustrating a flyback converter which can be used as a DC-DC converter shown in Fig. 3;

Fig. 6 shows a block diagram illustrating a noncontact charging device in accordance with a third preferred embodiment of the present invention;

Fig. 7 depicts a circuit diagram of the noncontact charging device shown in Fig. 6;

Fig. 8 is a structure diagram of a first transformer in accordance with the first and the third preferred embodiment of the present invention;

Fig. 9 is a structure diagram of a second transformer in accordance with the first and the third preferred embodiment of the present invention;

Fig. 10 is a structure diagram of a third transformer in accordance with the first and the third preferred embodiment of the present invention;

Fig. 11 describes a structure diagram of a transformer in accordance with the second preferred embodiment of the present invention;

Fig. 12 provides a structure diagram of a ferrite sheet and a reactor configured to secondary circuitry of a transformer in accordance with the present invention;

Fig. 13 presents a block diagram of a detection and communication unit in accordance with the present invention; and

Fig. 14 offers a block diagram of a control and protection circuit unit in accordance with the present invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Preferred embodiments of the present invention will now be described hereinafter with reference to the accompanying drawings in detail.

Referring to Fig. 1, there is provided a charging device in accordance with the first embodiment of the present invention. The charging device includes a first rectifying unit 1, a series resonance-type inverter unit 2, a separable type transformer 3, a second rectifying unit 4, a rechargeable battery 5, a control and protection circuit unit 6, a detection and communication unit 7 and a power supply 8. The first rectifying unit 1, the series resonance-type inverter unit 2, a primary circuit of the separable type transformer 3 and the control and protection circuit unit 6 constitute a charger, while a secondary circuit of the separable type transformer 3, the second rectifying unit 4 and the detection and communication unit 7, which are installed within a portable device, are connected to the rechargeable battery 5.

The first rectifying unit 1 converts a low frequency alternating current (AC) provided from the power supply 8 into a direct current and provides the direct current (DC) to the series resonance-type inverter unit 2. Then, the series resonance-type inverter unit 2 converts the received DC into a high frequency AC under the control of the control

and protection circuit unit 6. The separable type transformer 3 magnetically transfers the high frequency AC obtained from the series resonance-type inverter unit 2 to the second rectifying unit 4. An auxiliary winding 26 in the primary circuit of the transformer 3 is connected to the control and protection circuit unit 6 so that operational state information of the transformer 3 can be transferred to the control and protection circuit unit 6.

The second rectifying unit 4 converts the high frequency AC provided from the transformer 3 to a DC suitable for the rechargeable battery 5. The control and protection circuit unit 6 protects the charging device by way of controlling the operations of the series resonance-type inverter unit 2 based on operational state information of the rechargeable battery 5 wirelessly or optically transferred from the detection and communication unit 7 and the operational state information of the transformer 3 delivered through the auxiliary winding 26. The detection and communication unit 7 detects, e.g., a current and a voltage of the rechargeable battery 5 and then wirelessly or optically transfers the detected information to the control and protection circuit unit 6.

Fig. 2 depicts a circuit diagram of a part of a charging device shown in Fig. 1. The first rectifying unit 1, the series resonance-type inverter unit 2, the separable type transformer 3 and the second rectifying unit 4 will be described hereinafter in further detail.

The first rectifying unit 1 includes four rectifier diodes D11, D12, D13 and D14 and two rectifier capacitors C_{DC1} and C_{DC2} . The diodes D11 and D12 turn on when a voltage of the power supply 8 is a (+) half-wave while turn off when the voltage of the power supply 8 is a (-) half-wave. The diodes D13 and D14 are, on the other hand, set on when the voltage of the power supply 8 is the (-) half-wave but set off when the voltage of the power supply 8 is the (+) half-wave. By such operations of the diodes D11, D12, D13 and

D14, the alternating current (AC) voltage of the power supply 8 is converted into a DC.

The series resonance-type inverter unit 2 includes two field effect transistors (hereinafter referred to as FETs) F1 and F2 and a L-C resonant circuit. Gates of the FETs F1 and F2 are connected to the control and protection unit 6. The drain and the source of the FET F1 are connected to the diode D1 and a capacitor C1, while the drain and the source of the FET F2 are coupled to the diode D2 and a capacitor C2. The FETs F1 and F2 are alternately turned on and off by the control of the control and protection circuit unit 6 to thereby provide a square wave voltage to nodes A and B. The L-C resonant circuit has a capacitor C3 and an inductor L1 and is connected to an output terminal of the FETs in series. The L-C resonant circuit serves to pass only the fundamental wave components of the square wave that is provided from the FETs F1 and F2. If the FETs F1 and F2 are operated faster than a resonance period of the resonant circuit by a zero-voltage-switching, a voltage at both ends of the FETs F1 and F2 slowly increases during a switching operation by the capacitors C1 and C2 and the diodes D1 and D2. Accordingly, energy loss that might be caused in the FETs F1 and F2 during the switching operation can be effectively reduced. At this time, the amount of energy delivered from the series resonance-type inverter unit 2 to the separable type transformer 3 is controlled by a switching period of the FETs F1 and F2, and the switching period of the FETs F1 and F2 is determined by the control and protection circuit unit 6.

The primary circuit of the separable type transformer 3 magnetically delivers the energy provided from the series resonance-type inverter unit 2 to the secondary circuit thereof. The secondary circuit of the separable type transformer 3 is connected to the second rectifying unit 4 and an intermediary tap branched from the secondary circuit of the transformer 3 is also coupled to the second

rectifying unit 4.

The auxiliary winding 26 is wound around a core of the primary circuit in the separable type transformer 3. The auxiliary winding 26 connected to the control and protection circuit unit 6 absorbs energy when the battery 5 is fully charged or when the primary and the secondary circuit of the transformer 3 are separated from each other and provide the absorbed energy to the control and protection circuit unit 6. That is, the operational state of the transformer 3 is transferred to the control and protection circuit unit 6 through the auxiliary winding 26.

The second rectifying unit 4 has two diodes Df1 and Df2 connected between two ends of the secondary circuit of the separable type transformer 3 and a filter composed of a capacitor Cp1 and an inductor Lf1. The second rectifying unit 4 is coupled to the intermediary tap of the secondary circuit of the transformer 3, so that the induced current flows through the diode Df1 during the (+) half-wave period but through the diode Df2 during the (-) half-wave. Since the current in the second rectifying unit 4 flows through only one diode at a time, the amount of energy consumed by the second rectifying unit can be reduced.

The diode rectification unit of diode Df1 and Df2 serves as an AC and DC constant current source for the filter (Lf1 and Cp1). The capacitor Cp1 cancels out most of the AC components from the constant current provided from the constant current source, thereby leaving DC component. Because an AC passing through the inductor Lf1 has a high frequency and a voltage at both ends of the inductor Lf1 is small, the AC can hardly pass through the inductor Lf1 though the inductance of the inductor Lf1 is very small. Accordingly, harmonic ripples can be effectively removed and a considerably clean direct current can be supplied to the rechargeable battery 5.

The detection and communication unit 7 is connected to the rechargeable battery 5 to detect the state of the

rechargeable battery 5, i.e., the charging/discharging state or a temperature thereof, etc. The detected information of the rechargeable battery 5 is wirelessly or optically transferred to the control and protection circuit unit 6.

5 The control and protection circuit unit 6 senses the operations state of the transformer 3 through the auxiliary winding 26 of the primary circuit in the transformer 3, as described above, and then, controls the series resonance-type inverter unit 2 on the basis of the respective
10 operational state information of the transformer 3 and the rechargeable battery 5.

 To be more specific, if the primary circuit and the secondary circuit of the transformer 3 are separated from each other, large amount of energy is induced to the primary
15 circuit of the transformer 3, and the auxiliary winding 26 transfers some portion of such large amount of energy to the control and protection circuit unit 6. The control and protection circuit unit 6 controls an on/off ratio of the FETs F1 and F2 based on the amount of the received energy.

20 Further, the control and protection circuit unit 6 analyzes the operational state information of the rechargeable battery 5 that is wirelessly or optically transferred from the detection and communication unit 7. Then, the control and protection circuit unit 6 turns off
25 the FETs F1 and F2 in case it is determined that the rechargeable battery 5 is completely charged but maintains the on-state of the FETs F1 and F2 if it is found that a charging is further required.

 Referring to Fig. 3, there is provided a charging
30 device in accordance with the second embodiment of the present invention. Like numerals represent the same parts in Figs. 1 and 3. The charging device includes the power supply 8, a first rectifying unit 9, a DC-to-DC converter unit 10, a self-excited resonance type inverter unit 11, a
35 separable type transformer 12, the second rectifying unit 4, the rechargeable battery 5, a control circuit unit 13 and

the detection and communication unit 7. As in the first preferred embodiment of the present invention given in connection with Fig. 1, the first rectifying unit 9, the DC-to-DC converter unit 10, the self-excited resonance type inverter unit 11, a primary circuit of the separable type transformer 12 and the control circuit unit 13 constitutes a charger and a secondary circuit of the separable type transformer 12, the second rectifying unit 4 and the detection and communication unit 7, which are installed within a portable device, are connected to the rechargeable battery 5.

The first rectifying unit 9 converts a low frequency alternating current provided from the power supply 8 into a direct current and provides the direct current to the DC-to-DC converter unit 10. Then, the DC-to-DC converter unit 10 converts the received direct current into a low voltage under the control of the control circuit unit 13. The self-excited resonance type inverter unit 11 converts the DC obtained from the DC-to-DC converter unit 10 into a high frequency AC and deliver the obtained high frequency AC to the separable type transformer 12. The separable type transformer 12 magnetically delivers the high frequency AC from the self-excited resonance type inverter unit 11 to the second rectifying unit 4. At this time, since a voltage of a signal inputted through an inductor L2 of the DC-to-DC converter 10 is not high, a voltage induced to the secondary circuit of the separable type transformer 12 is not high, either. For instance, the voltage at the primary circuit of the separable type transformer 12 varies within the range of several tens of V and the secondary circuit thereof exhibits an average voltage of about 3-4 V and a maximum instantaneous value of about 10 V.

The second rectifying unit 4 converts the high frequency AC induced by the separable type transformer 12 into a DC suitable for the rechargeable battery 5. The control circuit unit 13 controls operations of the DC-to-DC

converter unit 10 based on the operational information of the rechargeable battery provided wirelessly or optically from the detection and communication unit 7. The detection and communication unit 7 detects, e.g., a current and a voltage of the rechargeable battery 5 and, then, wirelessly or optically transfers the detected information to the control circuit unit 13.

Fig. 4 depicts a circuit diagram of a part of the charging device shown in Fig. 3. Hereinafter, the first rectifying unit 9, the DC-to-DC converter unit 10, the self-excited resonance type inverter unit 11, the separable type transformer 12 and the second rectifying unit 4 will be described in further detail.

The first rectifying unit 9 includes four rectifier diodes D11, D12, D13 and D14 and a rectifier capacitor C_{DC3} . This configuration and, further, the operation of the first rectifying unit 9 in Fig. 4 is identical to those of the first rectifying unit 1 in Fig. 2, excepting that the first rectifying unit includes only one capacitor C_{DC3} .

The DC-to-DC converter unit 10 is a buck type converter having a FET F3, a diode D3 and an inductor L2. The DC-to-DC converter lowers the DC voltage. The FET F3 is connected to the control unit 13 and also coupled to the primary circuit of the transformer 12 through the inductor L2. The amount of the DC converted in the DC-to-DC converter 10 is controlled by the control circuit unit 13 based on the on/off ratio of the FET F3. That is, if the FET F3 turns on, a voltage at both ends of the diode D3 becomes identical to a voltage V_{DC} at both ends of the capacitor C_{DC3} , so that the current amount of the inductor L2 is increased. On the contrary, if the FET F3 turns off, the current which has flown through the inductor L2 is set to pass through the diode D3, so that the voltage at both ends of the diode D3 becomes zero and the amount of the current flowing through the inductor L2 is decreased.

The self-excited resonance-type inverter unit 11

includes two transistors Tr1 and Tr2 and a L-C resonant circuit. The two transistors Tr1 and Tr2 are alternately turned on and off to provide a square wave current to the transformer 12. Since the bases of the transistors Tr1 and Tr2 are connected to each other via an auxiliary winding 36 of the primary circuit of the separable type transformer 12, the transistors Tr1 and Tr2 can be self-excitedly operated based on the amount of energy induced to the transformer 12. Since the L-C resonant circuit composed of a leakage inductance of the separable type transformer 12 and a capacitor C4 serves to pass only the fundamental wave components of the square wave, only a signal of fundamental wave components can appear at the primary circuit of the transformer 12. If the transistors Tr1 and Tr2 are turned on and off in coincidence with a resonance period of the L-C resonant circuit, energy loss that might be caused in the transistors Tr1 and Tr2 during the switching operation can be minimized and a switching frequency of the transistors Tr1 and Tr2 may be increased.

The separable type transformer 12 is connected to an inductor L2 of the DC-to-DC converter unit 10 by an intermediary tap branched from its primary circuit. An average voltage applied to the intermediary tap is the same as that applied to both ends of the diode D3. Therefore, if the amount of the current flowing through the inductor L2 can be controlled by the adjustment of the on/off ratio of the FET F3, the amount of the current provided into the transformer 12 can also be controlled, and, thus, the charging current induced by the secondary circuit of the transformer 12 can be adjusted as well.

Since the structure and the operation of the second rectifying unit 4 in Fig. 4 are identical to those of the second rectifying unit 4 in Fig. 2, the explanation of the second rectifying unit 4 will be omitted herein.

The detection and communication unit 7 is connected to the rechargeable battery 5 to detect the operational state

of the rechargeable battery 5, i.e., the charging/discharging state or a temperature thereof and, then, wirelessly or optically transfers the detected information to the control circuit unit 13.

5 Thereafter, the control circuit unit 13 analyzes the received operational state information of the rechargeable battery 5 and, then, turns off the FET F3 in case the rechargeable battery 5 is fully charged but maintains the on-state of the FET F3 in case the rechargeable battery
10 needs to be more charged.

 The DC-to-DC converter unit 10 can be replaced with a flyback transformer 41 shown in Fig. 5. A primary circuit of the flyback transformer 41 includes a transistor Tr3 and an inductor L3 while a secondary circuit thereof includes a
15 diode D4 and a capacitor C5 connected in parallel. The base of the transistor Tr3 is coupled to the control circuit unit 13 shown in Fig. 3, so that the transistor Tr3 is operated by the control of the control circuit unit 13. When the transistor Tr3 is turned on, the current amount increases at
20 the primary circuit of the flyback transformer 41 and the energy is stored in an exciting inductance. If the transistor Tr3 turns off, on the other hand, the current is induced to the secondary circuit of the flyback transformer 41 due to the energy stored in the exciting inductance.
25 Accordingly, the induced current flows through the diode D4 and a voltage of the capacitor C5 increases. As can be seen from the above description, the energy stored in the exciting inductance of the flyback transformer 41 is emitted to the secondary circuit thereof. The control circuit unit
30 13 analyzes the operational state information of the rechargeable battery 5 that is wirelessly or optically transferred from the detection and communication unit 7 and then turns off the transistor Tr3 in case the rechargeable battery 5 is fully charged while maintains the on-state of
35 the transistor Tr3 if the rechargeable battery 5 needs to be more charged.

Fig. 6 shows a block diagram of a noncontact charging device using a flyback circuit. The noncontact charging device includes the power supply 8, the first rectifying unit 9, a flyback converter unit 14, a separable type transformer 15, a second rectifying unit 16, the rechargeable battery 5, a control and protection circuit unit 17 and the detection and communication unit 7.

The first rectifying unit 9 converts a low frequency AC provided from the power supply 8 into DC and the flyback converter unit 14 converts the DC from the first rectifying unit 9 into a high frequency AC under the control of the control and protection circuit unit 17. The separable type transformer 15 provides the converted high frequency AC from the flyback converter unit 14 to the second rectifying unit 16. An auxiliary winding 46 provided at the primary circuit of the transformer 15 to the control and protection circuit unit 17, so that the operational information of the transformer 15 can be delivered to the control and protection circuit unit 17.

The second rectifying unit 16 converts the high frequency AC induced through the separable type transformer 15 into a DC suitable for the rechargeable battery 5. The control and protection circuit unit 17 protects the charging device by controlling operations of the flyback converter unit 14 based on both the operational information of the rechargeable battery 5 wirelessly or optically transferred from the detection and communication unit 7 and the operational information of the transformer 15 transferred through the auxiliary winding 46. The detection and communication unit 7 detects the operational state of the rechargeable battery 5 including a current and a voltage thereof and, then, wirelessly or optically transfers the detected information to the control and protection circuit unit 17.

Fig. 7 depicts a circuit diagram of a part of the charging device shown in Fig. 6. The first rectifying unit

1, the flyback converter unit 14, the separable type transformer 15 and the second rectifying unit 16 will be described hereinafter in further detail.

5 Since the structure and the function of the first rectifying unit 9 in Fig. 7 are identical to those of the first rectifying unit 9 in Fig. 4, the explanation of the first rectifying unit will be omitted.

10 The flyback converter unit 14 includes a FET F4 and a diode D5. The gate of the FET F4 is connected to the control and protection circuit unit 17, and the drain and the source of the FET F4 are connected to the diode D5.

15 If the FET F4 in the flyback converter is set on, the current amount in the primary circuit of the separable type transformer 15 increases and the energy is stored in an exciting inductance. If the FET F4 turns off, on the other hand, the current is induced to the secondary circuit of the transformer 15 by the energy stored in the exciting inductance, so that the current becomes to flow through a diode Df3 of the second rectifying unit and a voltage of a capacitor Cp2 becomes increased. In other words, the energy stored in the exciting inductance of the separable type transformer 15 is emitted to the secondary circuit thereof.

20 If the flyback converter unit 14 operates with the secondary circuit of the transformer 15 opened, a high voltage is induced to each winding of the separable type transformer 15 when the FET F4 turns off. That is, during a flyback operation, the secondary circuit of the separable type transformer 15 comes to have poor transient characteristics due to a great amount of leakage inductance. Therefore, the voltage of the separable type transformer 15 should be limited to a certain safety range.

25 To this end, the primary circuit of the separable type transformer 15 is coupled to the control and protection circuit unit 17 by the auxiliary winding 46 branched therefrom. The auxiliary winding 46 absorbs the energy induced to each winding of the transformer and delivers the

absorbed energy to the control and protection circuit unit 17. Then, the control and protection circuit unit 17 transfers a control signal to the flyback converter unit 14, so that a voltage of each winding falls within the safety range. The auxiliary winding 46 is connected to the control and protection circuit unit 17 via a rectifying unit (not shown), which is identical to the second rectifying unit 16.

The capacitor Cp2 in the second rectifying unit 16 cancels out most of AC components from the current rectified in a diode Df3, thereby leaving a DC component. Since the AC passing through the inductor Lf2 has a high frequency and a voltage at both ends thereof is small, the AC can hardly pass through the inductor Lf1 though the inductance of the inductor Lf1 is very small. Accordingly, harmonic ripples can be effectively removed and a considerably clean DC can be supplied to the rechargeable battery 5.

The detection and communication unit 7 is connected to the rechargeable battery 5 to detect the operational state of the rechargeable battery 5, i.e., the charging/discharging state or a temperature thereof, and, then, wirelessly or optically transfers the detected information to the control and protection circuit unit 6.

The control and protection circuit unit 17 operates similarly as the control and protection circuit unit 6 of Fig. 1. That is, the control and protection circuit unit 17 senses the states of the transformer 15 through the auxiliary winding 46 of the primary circuit of the transformer 15, and controls the flyback converter unit 14 according to the states information of the transformer 15 and the rechargeable battery 5.

In detail, if the flyback converter unit 14 operates in a state that the secondary circuit of the transformer 15 is opened and thus large energy is induced in the primary circuit of the transformer 15, the auxiliary winding 26 transfers a portion of such large energy to the control and protection circuit unit 17. The control and protection

circuit unit 17 controls an on/off ratio of the FET F4 according to an amount of the transferred energy.

Further, the control and protection circuit 17 analyzes the states information of the rechargeable battery 5 that is wirelessly or optically transferred from the detection and communication unit 7 and then turns off the FET F4 in case a charging of the rechargeable battery 5 is completed. If a continuous charging is required, an on state of the FET F4 is maintained.

Fig. 8A is a cross sectional view of showing a transformer in accordance with the first preferred embodiment of the present invention, which is divided into two parts implemented in a charger 54 and such portable device 48 as a mobile phone, a MP3 player, a MD player, a portable cassette player and a notebook computer. A primary circuit of a separable type transformer is installed in the charger 54, and a secondary circuit of the separable type transformer is installed in the portable device 48. Fig. 8B is a plan view of the secondary circuit of the separable type transformer installed in the portable device 48, and Fig. 8C is a plan view of the primary circuit of the separable type transformer installed in the charger 54. Hereinafter, a structure of the transformer in accordance with the first preferred embodiment of the present invention will be described in detail with reference to Figs. 8A to 8C.

The primary circuit of the transformer has a ferrite core 51 of a pot core type constituting a cylindrical part 51-1 having a closed bottom portion and a circular column 51-2 formed at a central part of the cylindrical part 51-1. A main winding 52 of the primary circuit of the transformer is wound around the circular column 51-2 of the ferrite core 51 to transfer energy to the secondary circuit of the transformer. Further, an auxiliary winding 53 being wound around the circular column 51-2 corresponds to the auxiliary winding 26 or 46 shown in Fig. 2 or 7.

The secondary circuit of the transformer includes two

layers of ferrite sheets 49-1 and 49-2. The first ferrite sheet 49-1 is constructed as a round shape with a diameter corresponding to the ferrite core 51, and the second ferrite sheet 49-2 is formed at a position facing the charger 54.

5 The second ferrite sheet 49-2, which is a ring shape, has a cylindrical part 49-3 whose circumference and thickness are similar to those of the cylindrical part 51-1 of the ferrite core 51, and a circular column 49-4 whose diameter is identical to that of the circular column 51-2 of the ferrite

10 core 51. A winding groove is constructed on the round shaped ferrite sheet 49-2, and a thin film shape winding 50 of the secondary circuit of the transformer is formed inside of the winding groove. Here, the winding 50 corresponds to the winding constituting the secondary circuit of the

15 transformer shown in Fig. 2 or 7.

A ferrite sheet is very soft and not easily breakable by an impact. Also, it can be easily shaped with scissors or a knife. Therefore, the ferrite sheets 49-1 and 49-2 and the winding 50 of the secondary circuit can be thinly

20 manufactured unlike the ferrite core 51. Accordingly, by tailoring a thickness of a desired ferrite and a thickness and a width of a wire, a charging device having a high charging efficiency can be obtained without increasing a volume and a weight of a portable device.

25 Further, a mass-production of wires and ferrite sheets can also be achieved to provide planar type thin films and thick ferrite films.

As described above, the primary and the secondary circuit of the transformer are respectively built in the

30 charger 54 and the portable device 48. When the portable device 48 and the charger 54 are individually used, any of magnetic couplings are not made between the primary and the second circuit of the transformer, since the primary and the secondary circuit of the transformer are separated from each

35 other. If, however, the ferrite sheets 49-1 and 49-2 are approached to the ferrite core 51 of the charger 54, a

magnetic coupling is made between the main winding 52 around the ferrite core 51 and the winding 50 of the ferrite sheets 49-1 and 49-2 of the secondary circuit, so that energy of the primary circuit of the transformer is transferred to the secondary circuit thereof. Accordingly, the energy is charged in the rechargeable battery 5 within the portable device 48.

The present embodiment uses the pot core 51 as a magnetic circuit of the primary circuit of the transformer within the charger 54 to facilitate a winding even if the main winding 52 and an auxiliary winding 53 have a large number of windings. Also, it uses the ferrite sheets 49-1 and 49-2 as a magnetic circuit in the secondary circuit within the portable device 48, which are manufactured as a thin film. Therefore, the volume and the weight of the portable device do not considerably increase due to the secondary circuit thereof even though the secondary circuit of the transformer is constructed within the portable device 48.

Fig. 9A is a cross sectional view showing a transformer in accordance with the second preferred embodiment of the present invention, which can be also divided into two parts implemented in a charger 54-1 and a portable device 48-1, similarly as in Fig. 8A. A primary circuit of a separable type transformer is installed in the charger 54-1, and a secondary circuit of the separable type transformer is installed in the portable device 48-1. Fig. 9B is a plan view of the secondary circuit of the transformer installed in the portable device 48-1, and Fig. 9C is a plan view of the primary circuit of the transformer installed in the charger 54-1. Hereinafter, a structure of the transformer in accordance with the second preferred embodiment of the present invention will be described in detail with reference to Figs. 9A to 9C.

The primary circuit of the transformer has an E-frame ferrite core 55 implemented by a central protrusion part 55-

1 and two outer protrusion parts 55-2. A main winding 52-1 of the primary circuit of the transformer is wound around the central protrusion part of the ferrite core 55 to transfer energy to a secondary circuit of the transformer. Also, an auxiliary winding 53-1 being wound around the central protrusion part 55-1 corresponds to the auxiliary windings 26 and 46 shown in Figs. 2 and 7.

The secondary circuit of the transformer corresponding to the primary circuit thereof includes two layers of ferrite sheets 49-5 and 49-6, similarly to the embodiment of Fig. 8. The second ferrite sheet 49-6 is attached to the first ferrite sheet 49-5 and formed at a position facing the charger 54-1. The second ferrite sheet 49-6 has an outer surrounding part 49-7 installed at a position corresponding to the outer protrusion parts 55-2 of the E-frame ferrite core 55 and a rectangular-shaped center part 49-8 installed at a position corresponding to the central protrusion part 55-1 of the E-frame ferrite core 55. A winding groove is constructed on the ferrite sheet 49-5, and a thin film shaped winding 50-1 of the secondary circuit of the transformer is formed inside of the winding groove. Here, the winding 50-1 corresponds to the winding constituting the secondary circuit of the transformer shown in Fig. 2 or 7.

It will be apparent to those skilled in the art that functions of the primary and the secondary circuit of the transformer being constituted as described above are identical to those of the primary and the secondary circuit of the transformer in Fig. 8. Further, although the protrusion parts 55-1 and 55-2 of the E-frame ferrite core 55 are illustrated as of a rectangular shape in the present embodiment, it will be apparent to those skilled in the art that the shape can be diversely constituted.

Fig. 10A is a cross sectional view showing a transformer in accordance with the third preferred embodiment of the present invention, which can be also divided into two parts in a charger 54-2 and a portable

device 48-2, similarly as in Figs. 8A and 9A. A primary circuit of a separable type transformer is installed in the charger 54-2, and a secondary circuit of the transformer is installed in the portable device 48-2. Fig. 10B is a plan view of the secondary circuit of the transformer installed in the portable device 48-2, and Fig. 10C is a plan view of the primary circuit of the transformer installed in the charger 54-2. Hereinafter, a structure of the transformer in accordance with the third preferred embodiment of the present invention will be described in detail with reference to Figs. 10A to 10C.

As shown therein, the primary circuit of the transformer includes a U-frame ferrite core 56. A main winding 52-2 and an auxiliary winding 53-2 are wound around two outer protrusion parts 56-1. Here, the auxiliary winding 53-2 corresponds to the auxiliary windings 26 or 46 shown in Fig. 2 or 7.

The secondary circuit of the transformer corresponding thereto has two ferrite sheets 49-9 and 49-10, similarly to the embodiments of Figs. 8 and 9. The second ferrite sheet 49-10, which includes two outer protrusion parts 56-1 whose bottom portions are connected to each other, is attached to the first ferrite sheet 49-9 and formed at a position facing the primary circuit of the transformer. The second ferrite sheets 49-10 are respectively formed at positions corresponding to two outer protrusion parts 56-1, and windings 50-2 of thin film state are wound around the ferrite sheet 49-10. Here, the winding 50-2 corresponds to the winding constituting the secondary circuit of the transformer shown in Fig. 2 or 7.

It will be apparent to those skilled in the art that functions of the primary and the secondary circuit of the transformer being constituted as described above are identical to those of the primary and the secondary circuit of the transformer of Figs. 8 and 9. Further, although the protrusion parts 56-1 of the U-frame ferrite core 56 are

illustrated as of a rectangular shape in the present embodiment, it will be apparent to those skilled in the art that the shape can be variously constituted.

Fig. 11 describes a cross sectional view of a transformer in accordance with the fourth preferred embodiment of the present invention, which can be used for the embodiment described in Figs. 3 and 4. A transformer can be divided into two parts installed in a charger 54-3 and a portable device 48-3, wherein a primary circuit of the separable type transformer is installed in the charger 54-3, and a secondary circuit of the transformer is installed in the portable device 48-3.

Since both voltages of the primary and the secondary circuit of the transformer of the present embodiment are low, the charging device can charge enough energy, even with a limited number of windings. Therefore, unlike the configurations of the primary circuit of the transformers using a ferrite core in Figs. 8 to 10, two ferrite sheets 60-1 and 60-2 are constituted as the planar type primary part of the transformer.

Two ferrite sheets 60-1 and 60-2 form the primary circuit of the transformer. The fourth ferrite sheet 60-2 is attached to the third ferrite sheet 60-1, and includes a central protrusion part 60-3 and outer protrusion part(s) 60-4. A main winding 52-3 and an auxiliary 53-3 are wound around the central protrusion part 60-3. Here, the auxiliary 53-3 corresponds to the auxiliary winding 36 shown in Fig. 4.

The secondary circuit of the transformer has two ferrite sheets 49-11 and 49-12, similarly as in Figs. 8 to 10. The ferrite sheet 49-12 at a position facing the primary circuit of the transformer includes a central and outer protrusion part(s) 49-13 and 49-14 that are formed at positions corresponding to a central protrusion part 60-3 and outer protrusion part(s) 60-4 of the transformer. A winding 50-3 of a thin film is wound around the protrusion

part 49-13. Here, the winding 50-3 corresponds to the winding constituting the second circuit of the transformer shown in Fig. 4.

5 When an operation frequency is set to be as high as a MHz range, a magnetic flux density of a core becomes large. Therefore, since enough energy can be transferred even with a small number of required windings and the thin ferrite core, the primary circuit of the transformer can be implemented in a planar shape as described above.

10 Further, it will be apparent those skilled in the art that a thin or thick ferrite film can be utilized, instead of the ferrite sheet, by using the thin or thick film processing described above.

15 Fig. 12 provides a schematic plan view of a magnetic circuit 57 and an inductor being constituted in a secondary circuit of a transformer. In the drawing, the magnetic circuit 57 is shown as a circular shape on a ferrite sheet corresponding to the first ferrite sheets 49-1, 49-5, 49-9 and 49-11 constituting the second circuit of the separable type transformer in Figs 8 to 11. Such first ferrite sheets 20 49-1, 49-5, 49-9 and 49-11 are connected to a rechargeable battery at each upper-side. At each lower-side, second ferrite sheets 49-2, 49-6, 49-10 and 49-12 are connected or formed.

25 An inductor whose weight and volume are smaller than a conventional inductor can be manufactured on a remaining portion 58 in the ferrite sheet left after being used for the magnetic circuit 57. In the drawing, positions indicated as 'X' are terminals of the manufactured inductor. 30 Further, the inductor can be provided on an opposite side of the ferrite sheet where the magnetic inductor 57 is not formed. Likewise, since an inductance of the inductor manufactured on the ferrite sheet falls within a range of several μH , and is able to be unsaturated even in a large 35 current of about several A, the inductor can be used as inductors Lf1 and Lf2 for a filter constituting the second

rectifying units 4 and 16 of Figs. 2, 4 and 7. Since an output voltage of a transformer is not high in most portable devices, an operation voltage of the second circuit of the transformer is low and an operation frequency thereof is high. Therefore, even an inductor manufactured in such small size can also function as a filter. If a conventional inductor is used therein, the weight and the volume thereof increase, so that it would difficult to achieve a miniaturization thereof.

Further, in accordance with the present invention, a thin or a thick ferrite film can be formed under the rechargeable battery by using the thin or thick film process described above, and the filter inductors Lf1 and Lf2 can be implemented on a region surrounding the central portion used as the transformer.

Fig. 13 presents a circuit diagram of the detection and communication unit 7, and includes a voltage sensor 71, a current sensor 72, a temperature sensor 73, a microprocessor 74, a modulator 78 and an antenna 79. The voltage, the current and the temperature sensor 71, 72 and 73 are connected to a rechargeable battery, and check charging-discharging states such as charging voltage, charging current and temperature of the rechargeable battery to transfer the information to the microprocessor 74. The microprocessor 74 has an A/D converter 75, a controller 76 and a parallel/series port 77. The A/D converter 75 converts information of the states, such as the charging voltage, the charging current and the temperature of the rechargeable battery provided from the voltage, the current, the temperature sensor 71, 72 and 73, into digital data signals to transfer same to the parallel/series port 76. The parallel/series port 77 arranges the transferred data signal for the information of the rechargeable battery into series signals and then transfers the arranged data signals to the modulator 78. The transferred data signal is modulated into a high frequency RF signal in the modulator

78. Then it is transferred wirelessly or optically to the control and protection circuit unit 6 or 17 of Figs. 1 or 7 or to the control circuit unit 13 of Fig. 3 through the antenna 79.

5 A charging process should be adapted to rechargeable batteries of various types. That is, a charging operations such as a charging time, the charging voltage and the charging current are differently carried out depending on varying materials or capacities of the rechargeable
10 batteries. Therefore, the control and protection circuit unit 6 and the control circuit unit 13 should know which kind of the rechargeable battery is charged and control the charging operation based thereon. The information of the type of the rechargeable battery can be separately inputted
15 by the user of the portable device.

For this, the controller 76 encodes data for the type of the rechargeable battery, and transfers the coded data to the parallel/series port 77. Then, the rechargeable battery type data are transferred to the control and protection
20 circuit unit 6 or 17 or the control circuit unit 13 through the modulator 78 and the antenna 79.

Fig. 14, which is a circuit diagram illustrating a part of the control and protection circuit unit 6 or 17, offers a receiving part for receiving information
25 transferred from the detection and communication unit 7. The receiving part includes a demodulator 61, a comparator 62, a series/parallel port 63, a controller 64 and an antenna 65.

A high frequency RF signal wirelessly or optically
30 transferred from the detection and communication unit 7 is received through the antenna 65, and transferred to the demodulator 61. The demodulator 61 demodulates the high frequency RF signal and obtains the rechargeable battery information signals such as the type of the rechargeable
35 battery, a charging current, a charging voltage, a temperature. The comparator 62 converts the information

signals into a stable series data by comparing the demodulated rechargeable battery information signals with reference voltages and then transfers the stable series data to the series/parallel port 63. The series/parallel port 63
5 arranges the transferred signal in parallel to compute the number of bits of the rechargeable battery information data converted in series, and transfers the arranged data to the controller 64.

The controller 64 performs a charging or a protection
10 operation in an optimal state according to the rechargeable information data from the series/parallel port 63 and transformer states information provided through the auxiliary windings 26 or 46 of the secondary circuit of the separable type transformer.

That is, the control and protection circuit unit 6 of
15 Fig. 1 disables the series resonance-type inverter unit 2 from operating when the energy being induced to the auxiliary winding 26 is excessively large, and drives the series resonance-type inverter 2 when the energy induced to
20 the auxiliary winding 26 is small. The control and protection circuit unit 17 of Fig. 7, based on a signal induced in the auxiliary winding 46 and then transferred thereto by passing through a rectifying unit (not shown) with an identical configuration of the second rectifying
25 unit 16, drives the flyback converter unit 14 if a level of the signal is small. If not, the flyback converter unit 14 is disabled from operating, to thereby perform the protection operation.

Further, the control and protection circuit unit 6
30 enables a corresponding rechargeable battery to be charged in a proper way by adjusting the charging time, a voltage or a current according to information of the type of the rechargeable battery that is wirelessly or optically transferred from the communication and detection unit 7.

35 The control circuit unit 13 shown in Fig. 3 is not separately illustrated in detail. However, it performs

identical functions to those of the control and protection circuit units 6 and 17 of Fig. 14, excepting that it does not carry out a protection operation.

5 While the invention has been shown and described with respect to the preferred embodiments, it will be understood by those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the following claims.

10

CLAIMS

1. A noncontact charger for a portable device,
comprising:
- 5 a primary circuit for receiving a low frequency
alternative current (AC) signal and converting the received
low frequency AC signal into a high frequency AC signal;
- a first core having a main winding wound therearound
and connected to the primary circuit, wherein the main
10 winding generates a magnetic field caused by the high
frequency AC signal;
- a second core, disconnected to the first core and
composed of film or sheet shape materials, for having an
auxiliary winding wound therearound, wherein an auxiliary
15 winding induces an AC signal from the magnetic field
generated by the main winding; and
- a secondary circuit, connected to the second core, for
converting the AC signal induced from the main winding into
a direct current (DC) signal to provide the DC to a
20 rechargeable battery.
2. The noncontact charger of claim 1, wherein the second
core is composed of two ferrite sheets.
- 25 3. The noncontact charger of claim 1, wherein the second
core is composed of a ferrite sheet and a ferrite thick film.
4. The noncontact charger of claim 1, wherein the second
core is composed of a ferrite sheet and a ferrite thin film.
- 30 5. The noncontact charger of claims 2 to 4, wherein a
thin film type winding is formed on the ferrite sheet or the
ferrite films to be used as an inductor constituting the
secondary circuit.

35

6. The noncontact charger of claim 5, wherein the thin film type winding is formed on the ferrite sheet or the ferrite film or an opposite side of the ferrite sheet or the ferrite film to be used as the inductor constituting the secondary circuit.

7. The noncontact charger of claim 6, wherein the inductor cancels out harmonic ripples of the DC signal.

8. The noncontact charger of claim 1, wherein the first core is a pot core type ferrite core constituted of a cylindrical part having a closed bottom portion and a protrusion part formed at a central place of the cylindrical part.

9. The noncontact charger of claim 1, wherein the first core is an E-frame ferrite core constituted of protrusion parts formed at an outer portion and a central portion.

10. The noncontact charger of claim 1, wherein the first core is a U-frame ferrite core constituted of two protrusion parts whose bottom portions are connected to each other.

11. The noncontact charger of claim 1, wherein the first core has a film or a sheet shape material and a protrusion part.

12. The noncontact charger of claim 1, wherein first core has a film or a sheet shape material and a thin film type winding formed on the film or the sheet shape material.

13. A noncontact charger using a separable type transformer for charging a rechargeable battery by magnetically transferring energy of a primary circuit installed within a charger to a portable device, comprising:
a detection and communication unit for detecting state

information of the rechargeable battery and wirelessly or optically outputting the detected information; and

5 a control circuit unit for receiving the detected information provided from the detection and communication unit to operate and protect the primary circuit.

FIG. 1

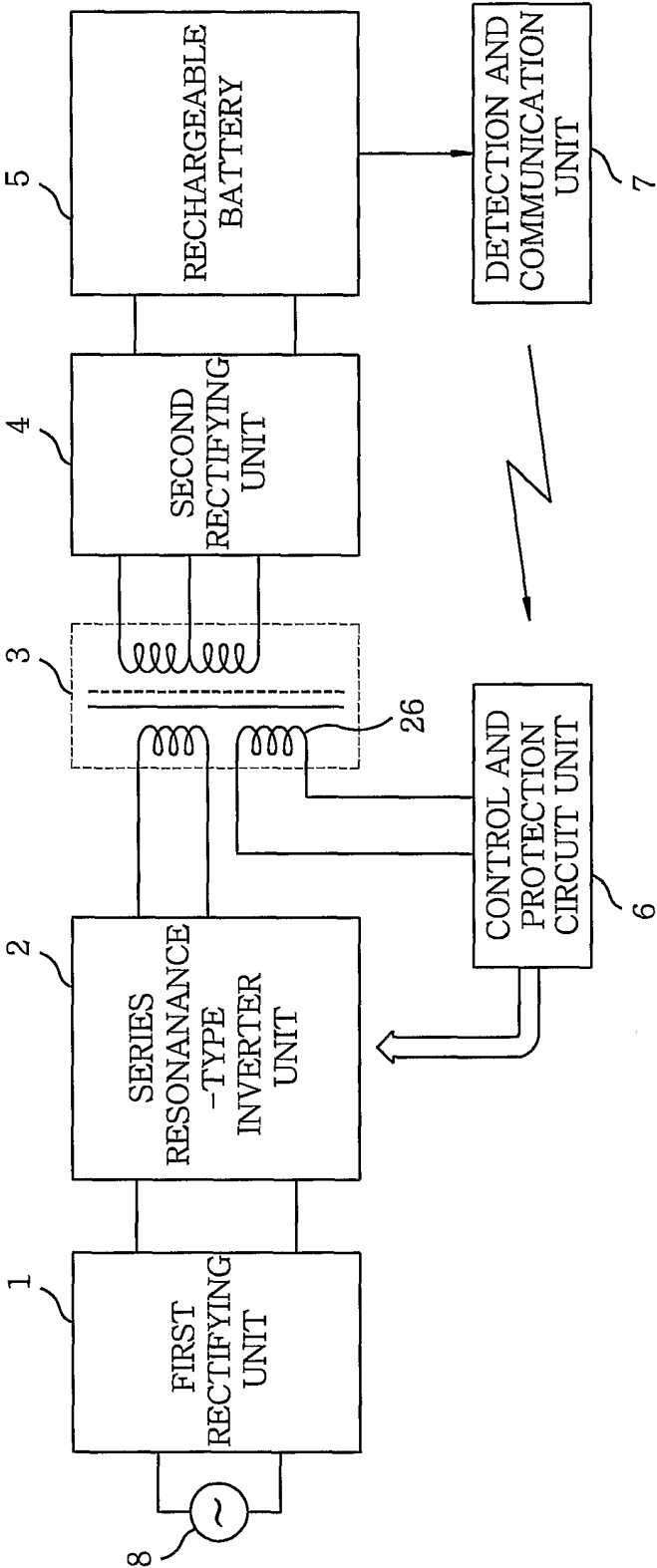


FIG.2

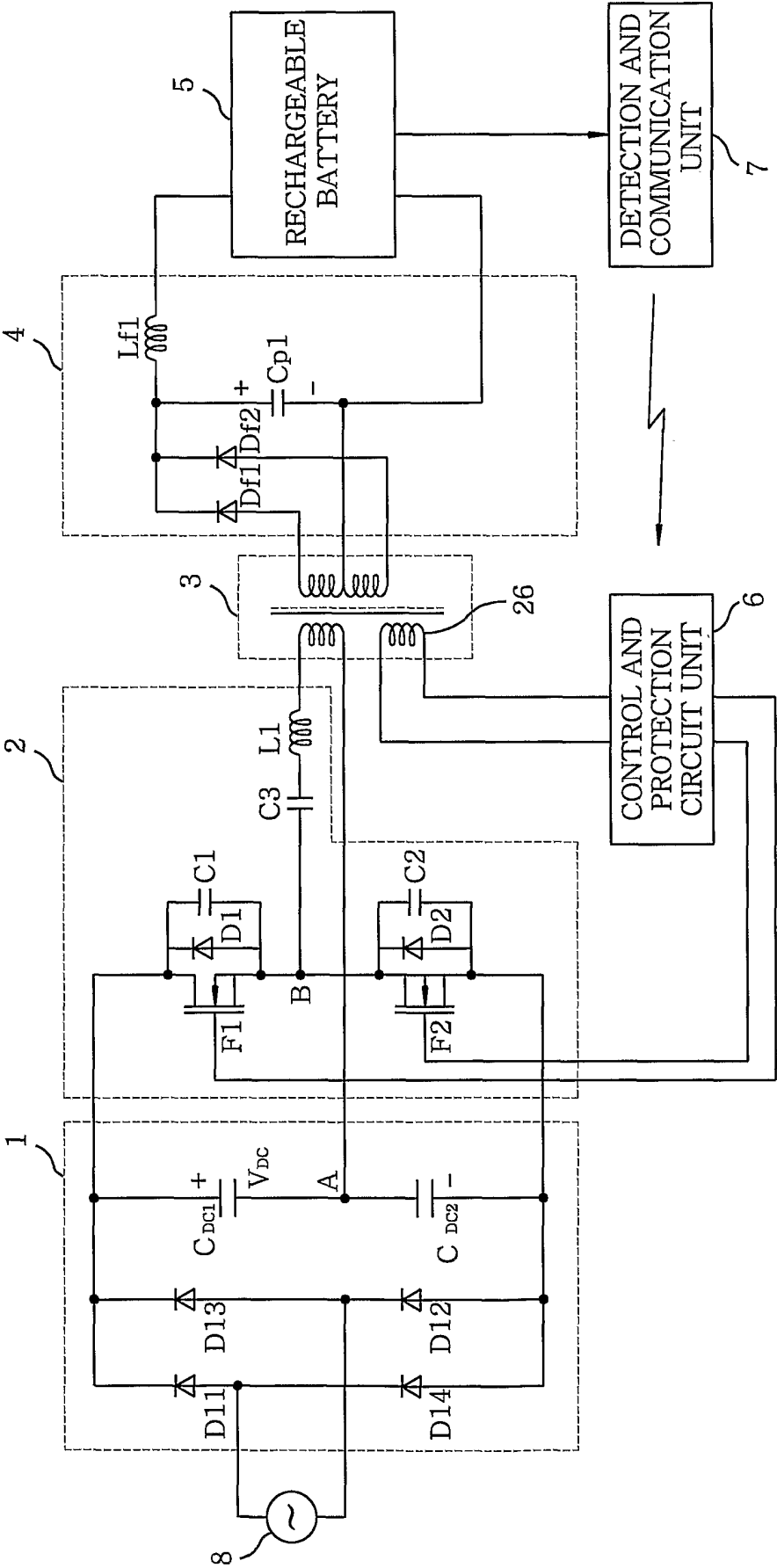


FIG. 3

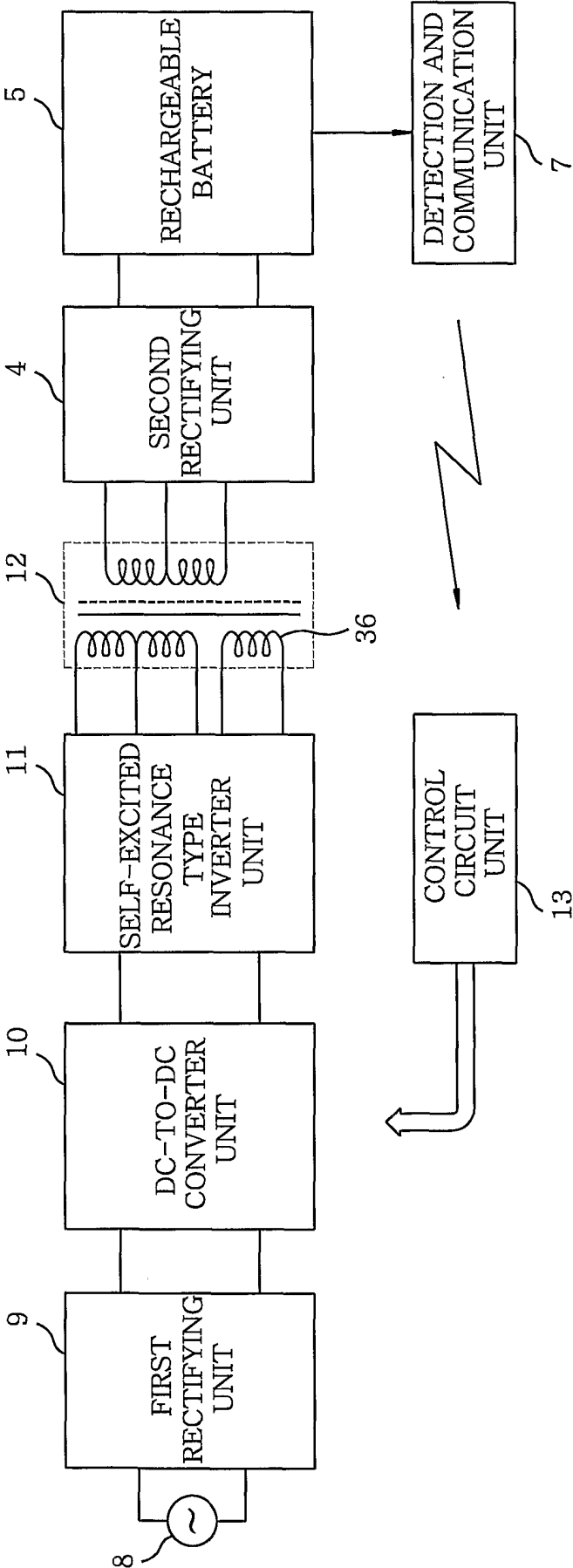
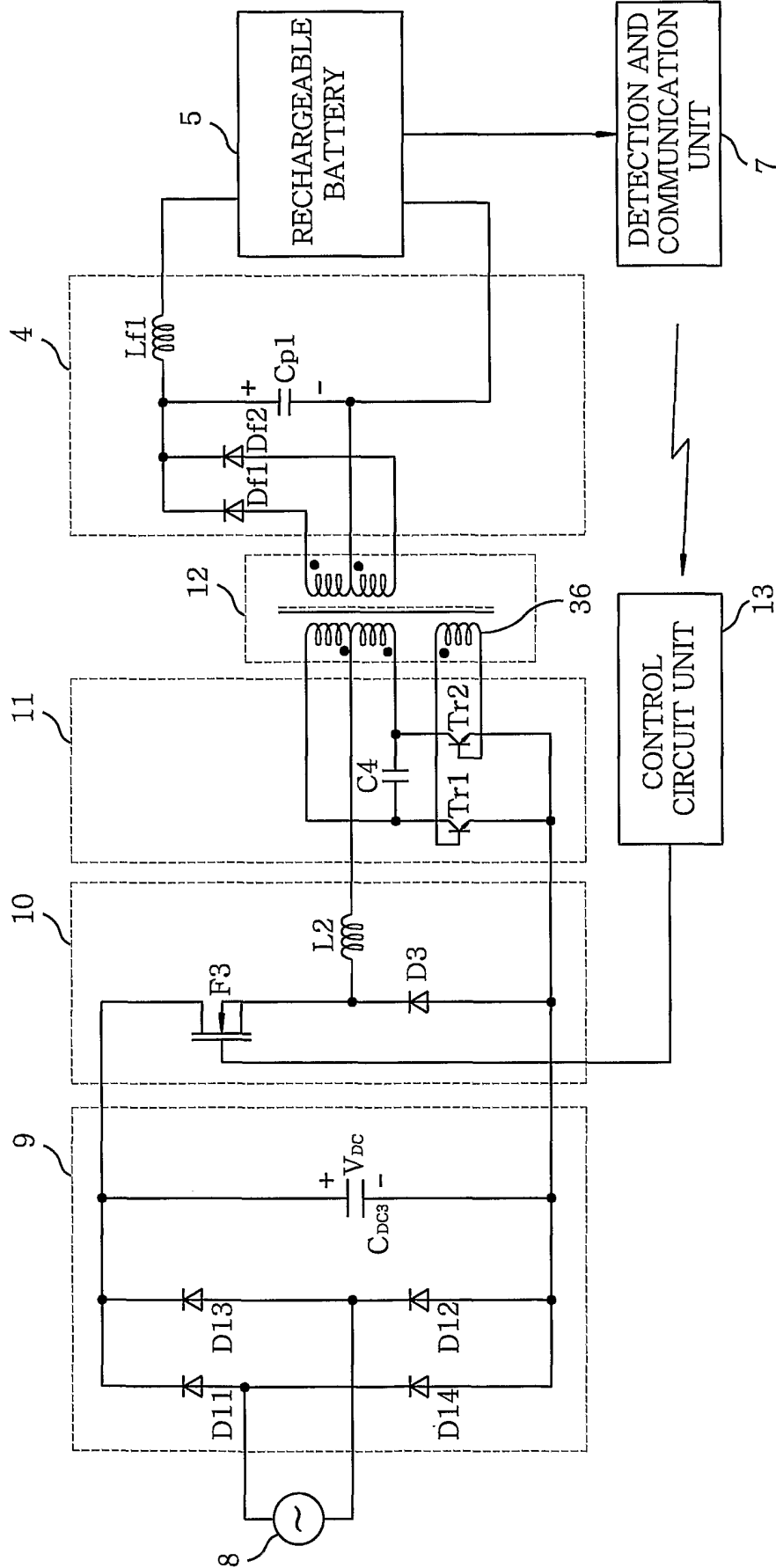
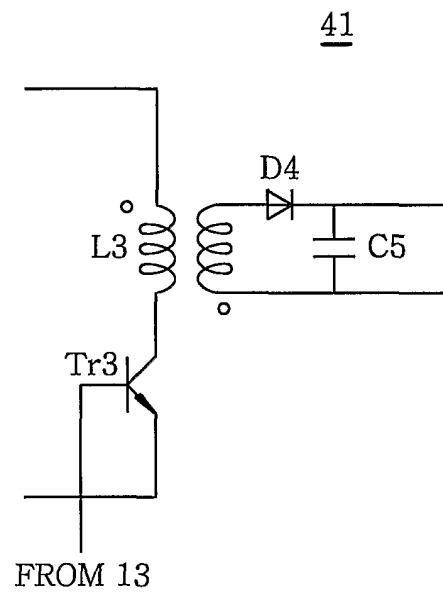


FIG.4

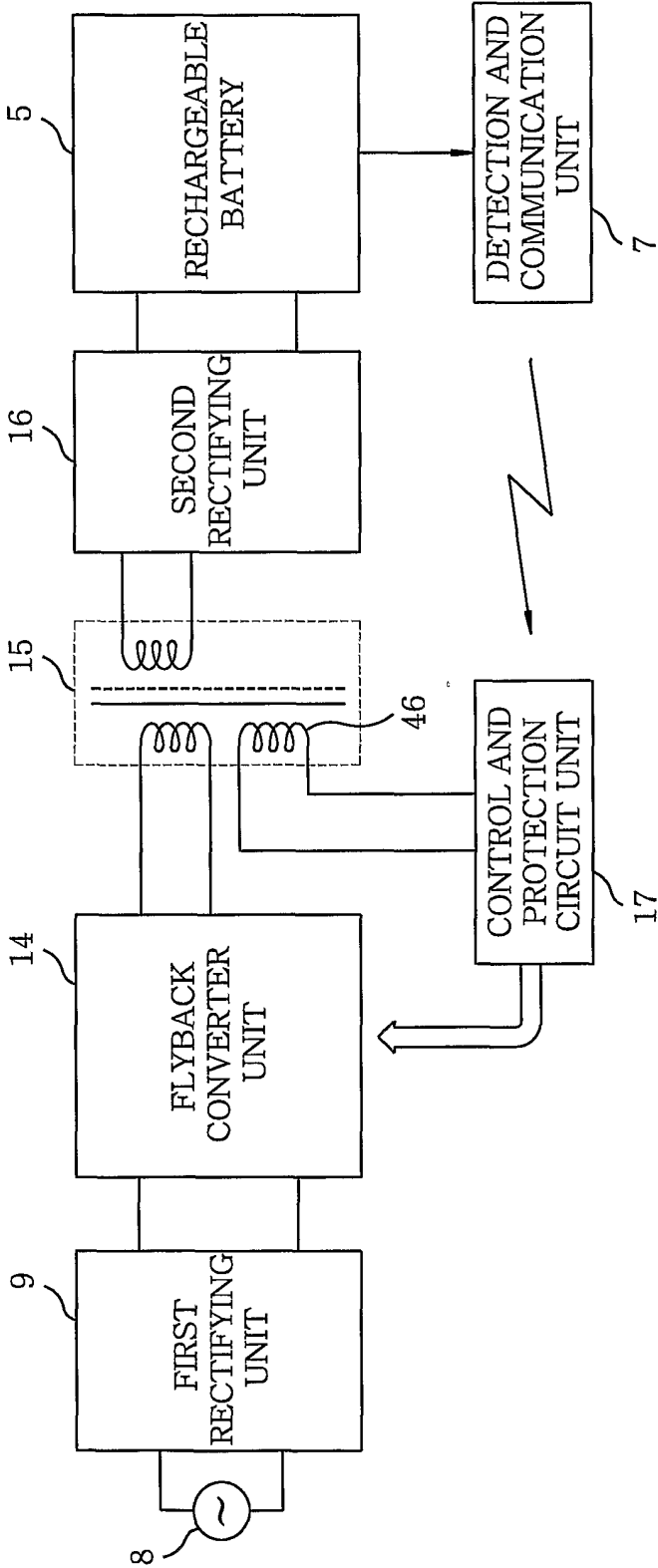


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FIG. 5

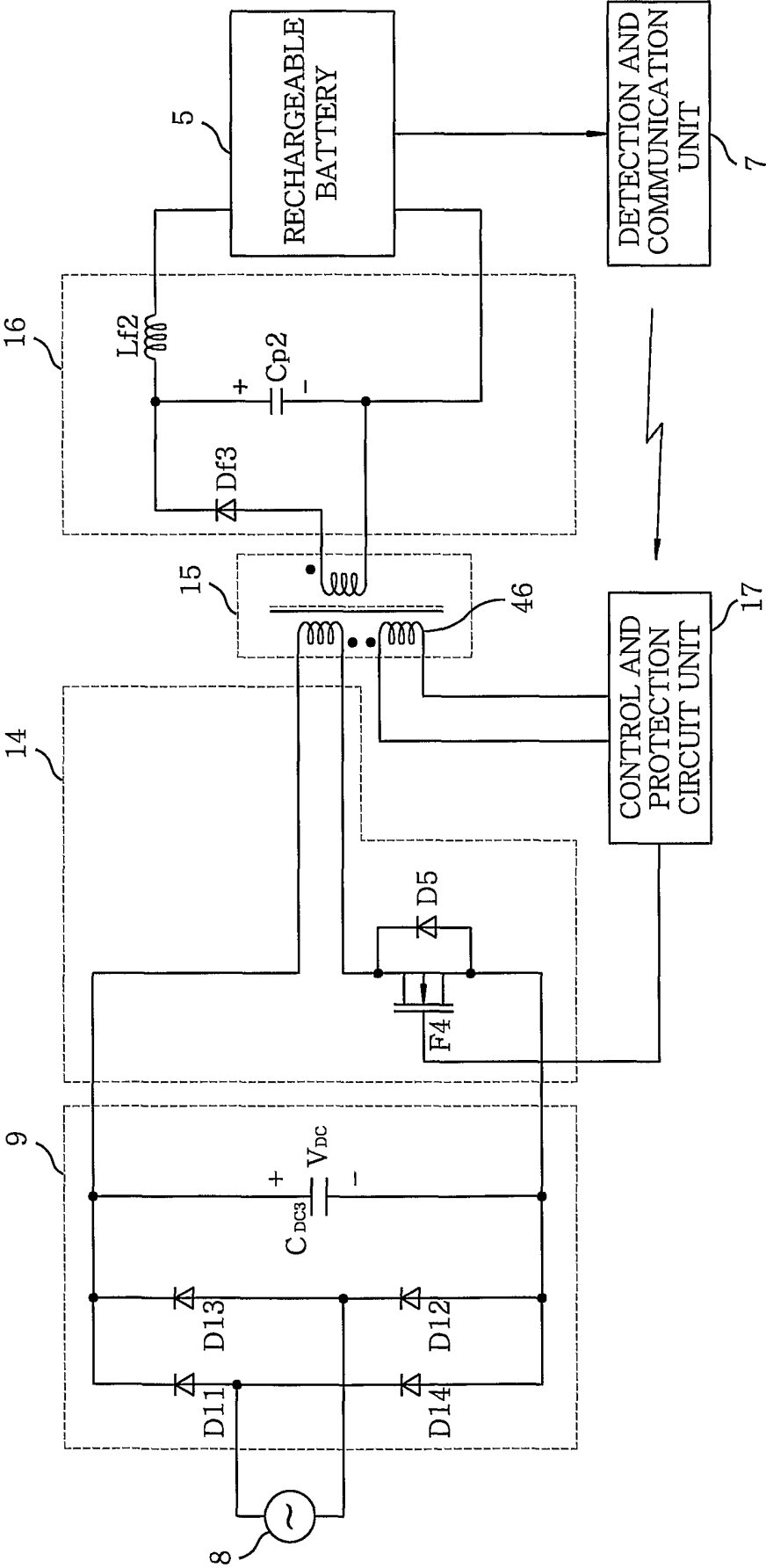
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FIG. 6



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FIG. 7



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FIG.8A

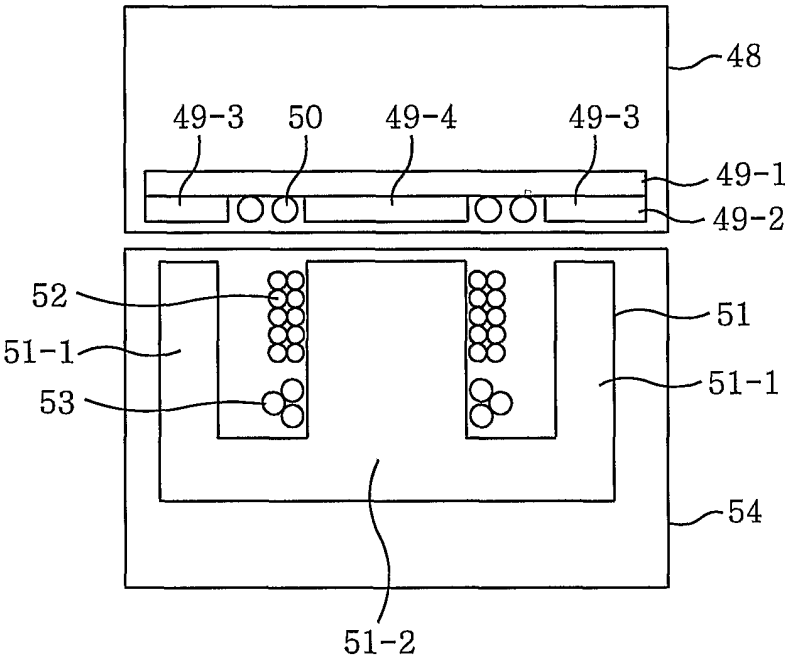


FIG.8B

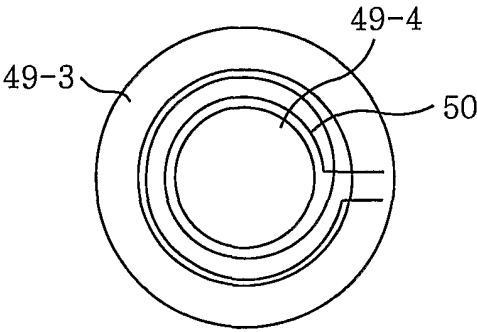
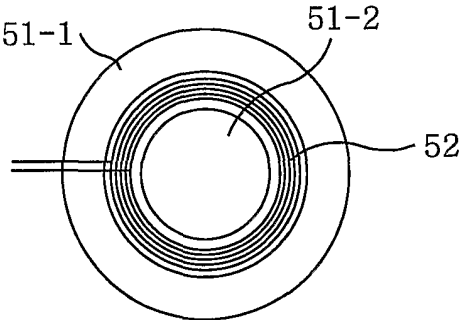


FIG.8C



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FIG. 9A

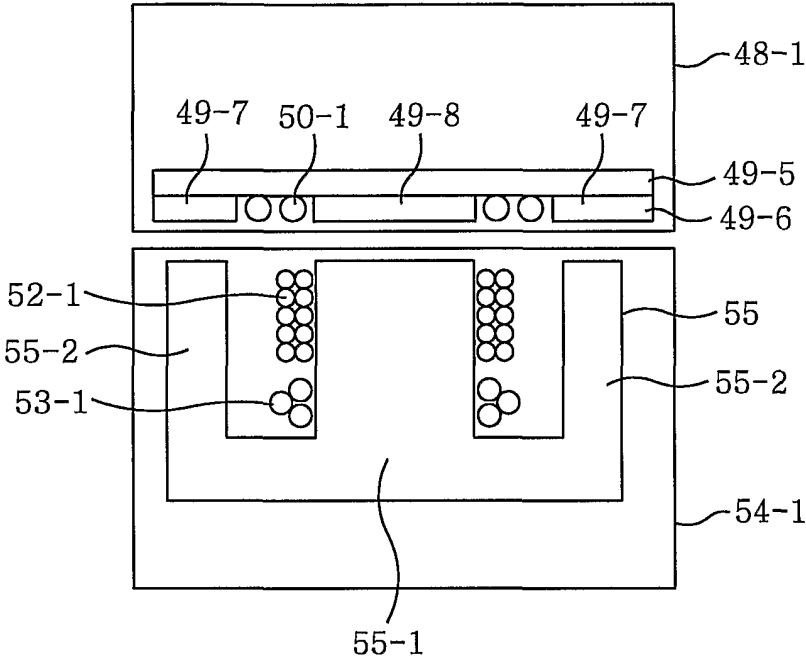


FIG. 9B

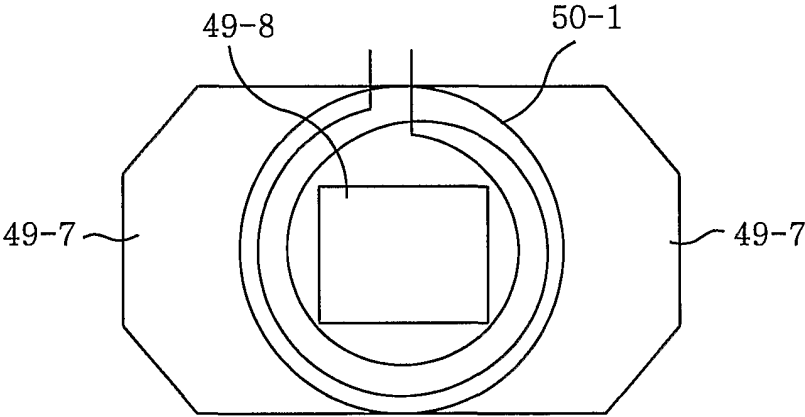


FIG. 9C

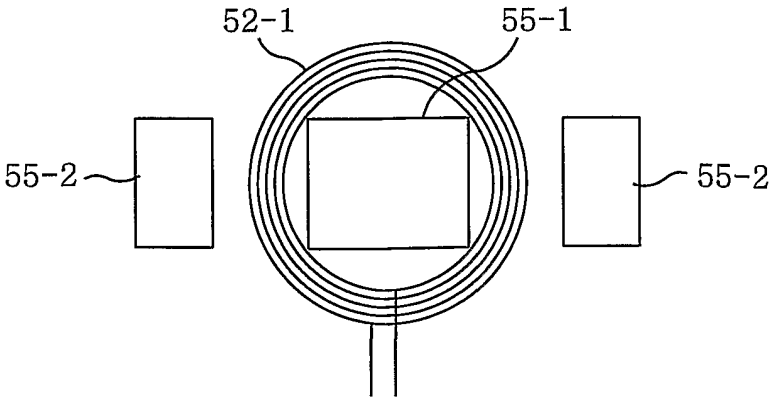


FIG. 10A

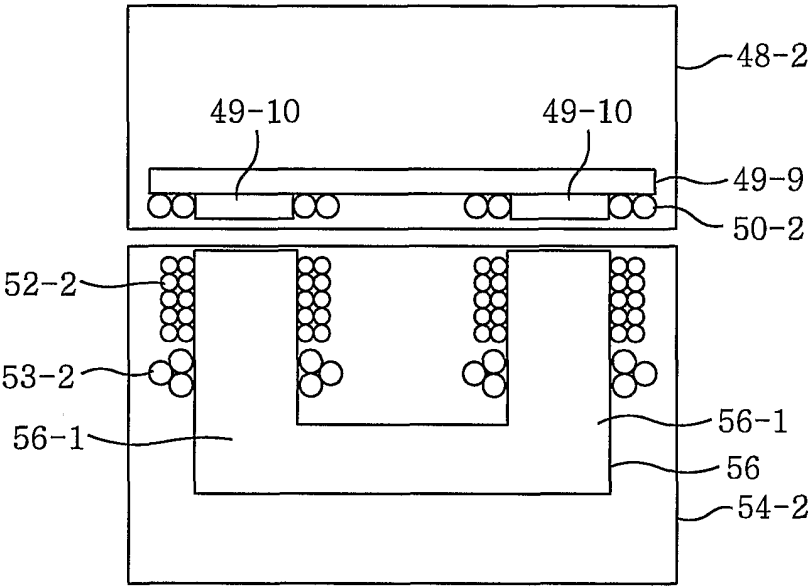


FIG. 10B

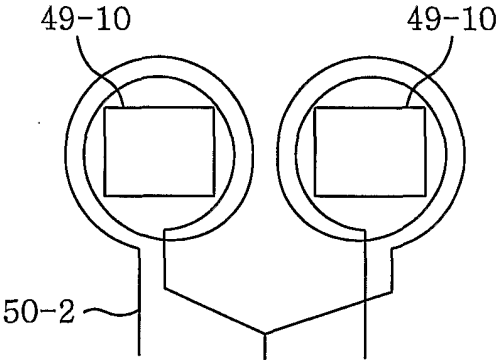


FIG. 10C

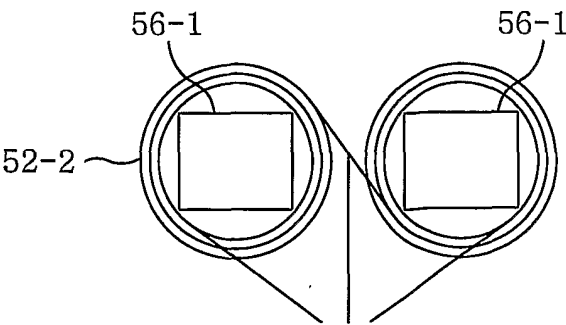


FIG. 11

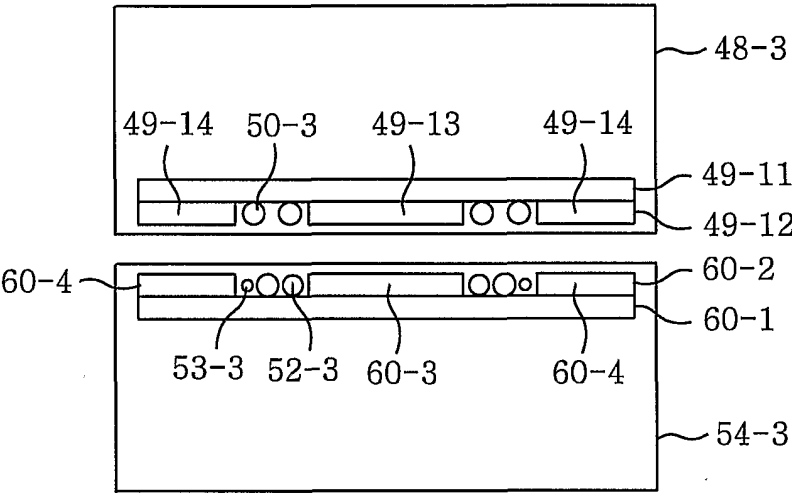


FIG. 12

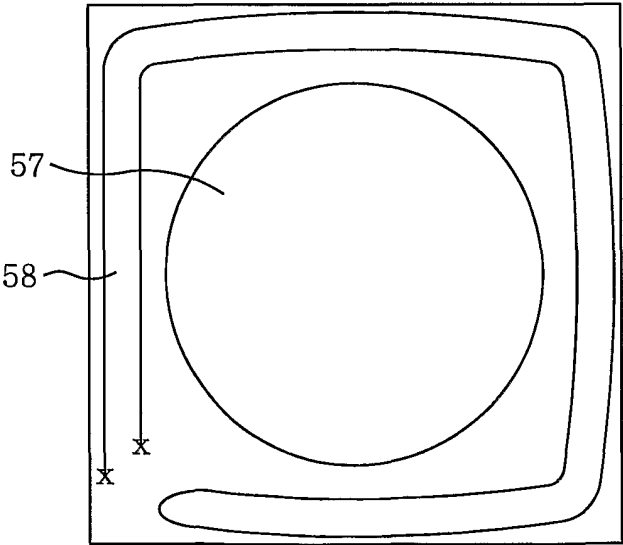


FIG. 13

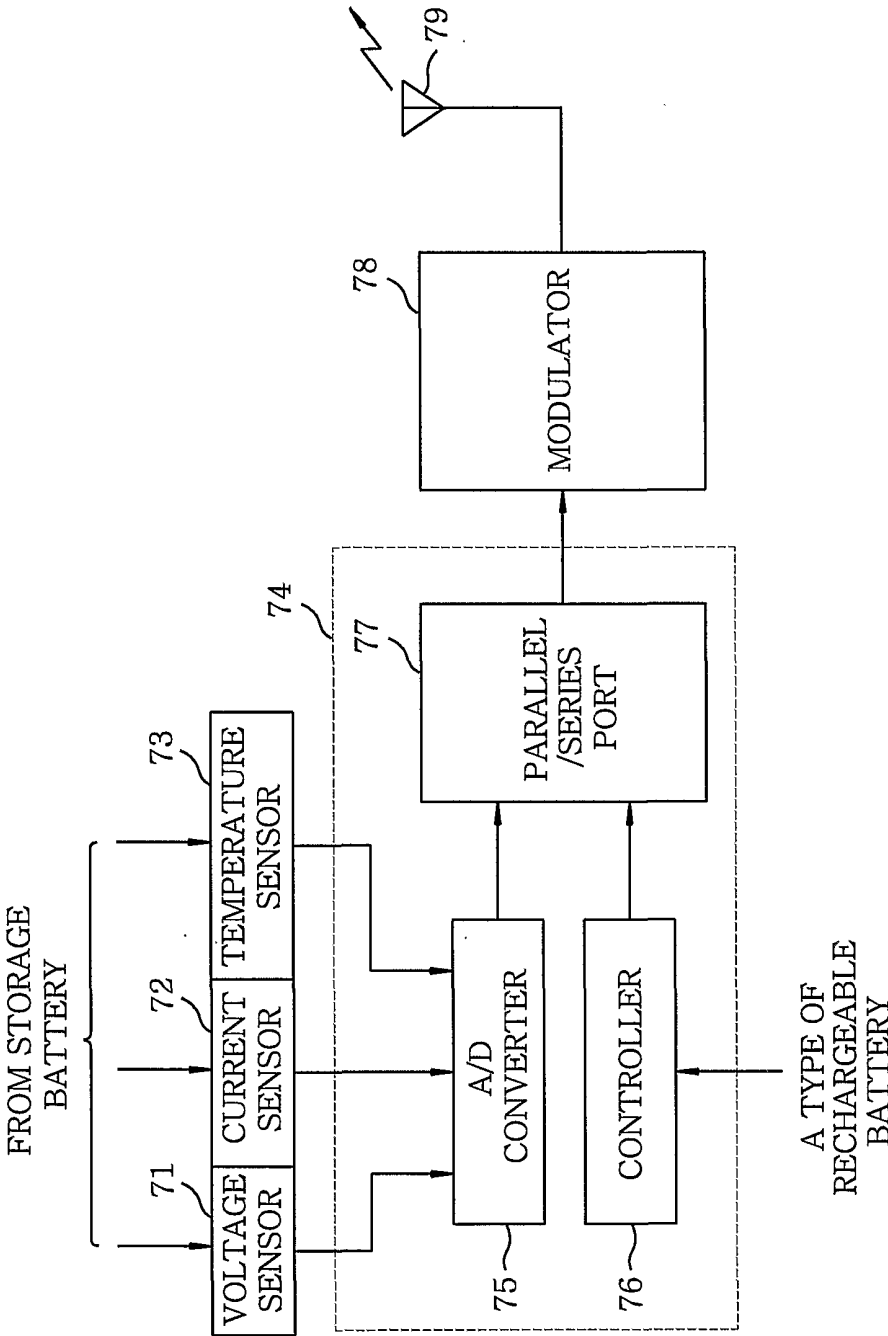
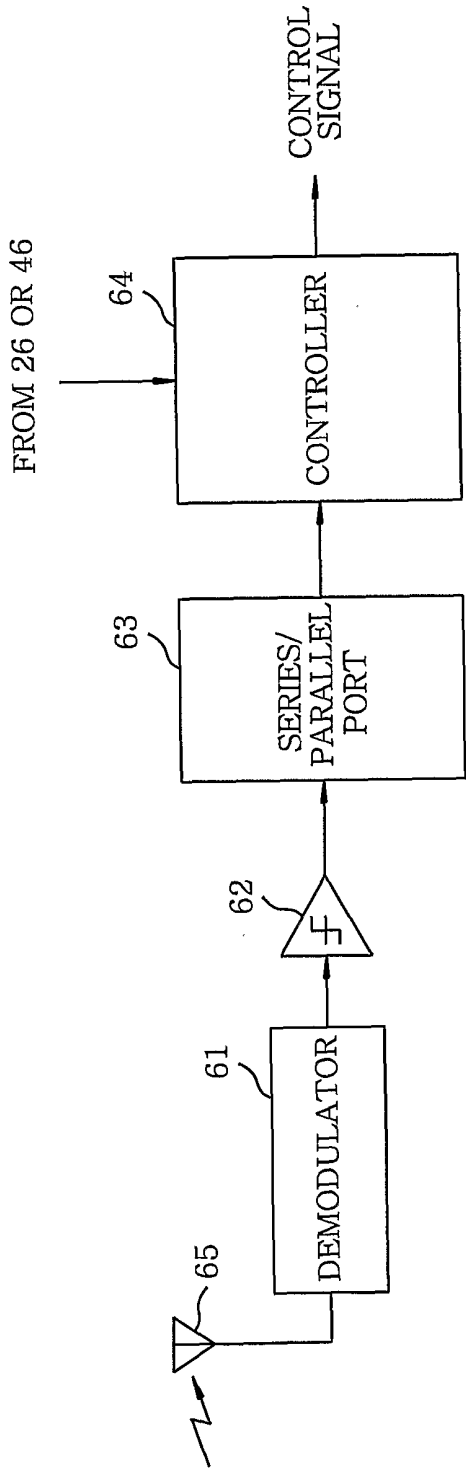


FIG. 14



INTERNATIONAL SEARCH REPORT

international application No.

PCT/KR01/01880

A. CLASSIFICATION OF SUBJECT MATTER**IPC7 H02J 7/02**

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)

IPC7 (The entire class)

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

KR : IPC as above

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

NPS[(noncontact<or>non-contact<or>contactless)<and>charg*].

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 9-103037 A (NIPPON IDO TSUSHIN KK) 15 April 1997 Fig. 1	1, 9, 13
X	US 5157319 A (Electric Power Research Institute) 20 Oct. 1992 Fig. 2,3,4,6,7	1,8
X	JP 6-54455 A (MATSUSHITA ELECTRIC WORKS LTD) 25 Feb. 1994 Fig. 1,4	1,10
X	JP 7-177667 A (VICTOR CO OF JAPAN LTD) 14 Jul. 1995 Fig. 1,2	1
X	KR 95-5819 B1 (C.S. Hong) 31 May 1995 Fig. 2,3	1,13

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

21 FEBRUARY 2002 (21.02.2002)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon, 920 Dunsan-dong, Seo-gu,
Daejeon Metropolitan City 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

LEE, Kyoung Hong

Telephone No. 82-42-481-5645

