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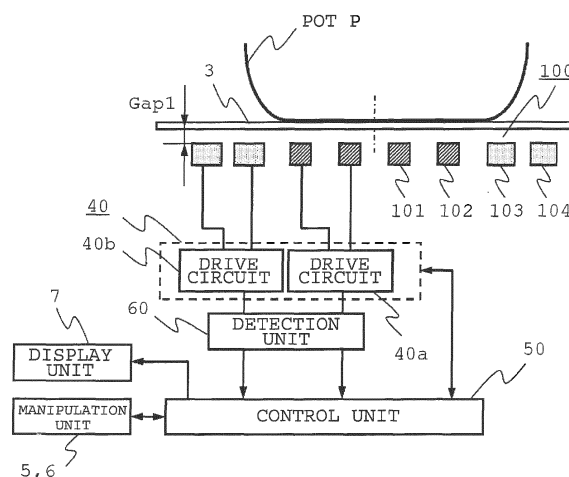
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(54) **INDUCTION-HEATING COOKER AND CONTROL METHOD THEREFOR**

(57) The induction-heating cooker (1) includes a drive unit (40) which supplies high-frequency current to an electromagnetic coil (100) for generating a magnetic field, and a detection unit (60) which detects load characteristics of a load placed on the electromagnetic coil (100) on the basis of electric characteristics regarding the drive unit (40). If the load is determined to be a heating target on the basis of a result of detection by the detection unit (60), the maximum output power value of the output range of the drive unit (40) is set in a first range and the electromagnetic coil (100) is operated as an induction heating coil. If the load is determined to be a power receiving subject, the maximum output power value of the output range of the drive unit (40) is set in a second range and the electromagnetic coil (100) is controlled as a power feed coil so as to supply power to the power receiving subject by electromagnetic induction. Thus, an appropriate amount of power can be efficiently supplied in accordance with the target load both when a heating target is inductively heated and when power is supplied to a power receiving subject.

FIG. 3

III-III SECTIONAL VIEW



DescriptionTechnical Field

5 **[0001]** The present invention relates to an induction-heating cooker for inductively heating a heating target such as a pot, and a control method therefor, and in particular, relates to: an induction-heating cooker with a non-contact power feeding function, which performs so-called non-contact power feeding in which power is supplied to a power receiving device placed on an induction-heating cooker main body, using a high-frequency magnetic field from the induction-heating cooker main body, by magnetic field coupling; and a control method therefor.

Background Art

10 **[0002]** An induction-heating cooker is a device that supplies high-frequency current at 20 kHz to 100 kHz to a coil and interlinks a magnetic flux generated by the coil with a metallic heating target such as a pot or a frying pan, thereby inductively heating the heating target. The principle of induction heating is based on electromagnetic induction. Therefore, if a power receiving device having a power receiving coil is placed instead of the heating target, power can be supplied to the power receiving device by electromagnetic induction.

15 **[0003]** Such a method of supplying (feeding) power to a power receiving device which is a load wirelessly, not via a power supply cord or the like, using a magnetic flux, i.e., a magnetic field, is called non-contact power feeding of magnetic field coupling type, or may be simply called non-contact power feeding. Therefore, non-contact as used herein does not refer to whether or not devices are in contact with each other.

20 **[0004]** As used herein, a non-contact state refers to a state in which devices are not electrically coupled with each other and not physically coupled (directly connected) with each other, but also includes a state in which devices are merely in contact with each other, that is, a state in which a device such as a heating target or a power receiving device is placed on a device.

25 **[0005]** It is noted that, unless otherwise stated, the term "non-contact power feeding" as used herein refers to non-contact power feeding of magnetic field coupling type, without distinguishing among electromagnetic induction type, magnetic field resonance type, and the like.

30 **[0006]** A conventional non-contact power feeding device described in Patent Document 1 includes: a top plate on which a load is placed; a primary coil which is provided under the top plate and generates high-frequency current; an inverter which supplies high-frequency power to the primary coil; a control unit which controls the inverter; and a load determination unit which determines whether the load is a heating target or a power receiving device, wherein the inverter is controlled in accordance with a result of the load determination. Accordingly, whether a load placed on the non-contact power feeding device is a heating target which is an induction heating target, or a predetermined power receiving device, is determined, and appropriate control is performed in accordance with the type of the load. Therefore, even if a load different in a power amount, a power adjustment range, or the like is placed, a user does not need to greatly change manipulation in accordance with the type of the load.

35 **[0007]** If the load is determined to be a power receiving device, power supplied to the primary coil is reduced as compared to the case where the load is determined to be a heating target. A display unit for displaying the function of a manipulation unit which controls the amount of energization of the primary coil, is provided so that a manipulation according to the type of the load is displayed on the display unit.

40 **[0008]** If the load determination unit determines that the load is a power receiving device, a load determination criterion level is lowered as compared to the case where the load is determined to be a heating target. For example, if the load is a pot, the control unit enables the maximum output to be outputted to the primary coil and maximizes the output adjustment range for the primary coil in the manipulation unit.

45 **[0009]** On the other hand, if the load is determined to be a power receiving device, the input maximum power, the power adjustment range, the load determination level, and the like are changed, and manipulation specifications and display specifications are changed. Specifically, if the load is determined to be such a small power receiving device that requires input power of 100 W or less, the control unit controls the amount of energization of the primary coil so that 100 W is the maximum power that can be received by a secondary coil of the power receiving device. In addition, the manipulation range of manipulation is limited, and the display of the display unit is changed in accordance with the manipulation content.

50 **[0010]** Thus, the amount of energization of the primary coil is limited in accordance with the magnitude of power consumption of the load, and along with this, the manipulation range and the display content are changed, thereby providing a non-contact power feeding device with high usability.

55 **[0011]** A conventional non-contact power receiving device described in Patent Document 2 includes: a power receiving coil which receives a high-frequency magnetic field from an induction heating device and outputs power; a load device which is supplied with power from the power receiving coil; a switchover unit which opens and closes connection between

the power receiving coil and the load device; and a control unit which controls the switchover unit, wherein the control unit on the power receiving device side controls open/close operation to control an open/close period of the switchover unit and adjust power supplied from the power receiving coil to the load device.

[0012] The open period in the open/close operation of the power receiving device is set so that an induction heating device which is a power feeding device does not determine that there is no load, and the heating is not stopped. Thus, the received power can be controlled through control on the non-contact power receiving device side. Therefore, a general-purpose induction heating device can be used as a power feeding device, and thus a non-contact power receiving device with high usability, for which power feeding devices are less restricted, can be realized.

[0013] A conventional cordless device described in Patent Document 3 includes a magnetism generating unit and a load unit. The magnetism generating unit includes: a top plate on which the load unit is placed; a primary coil which generates a high-frequency magnetic field provided under the top plate; an inverter which drives the primary coil; reception means; and pot detection means for detecting whether or not a pot is present.

[0014] The load unit includes: a secondary coil to be magnetically coupled with the primary coil; transmission means; and a load circuit which is supplied with power from the secondary coil. The inverter supplies high-frequency current to the primary coil when the reception means has received a predetermined signal from the transmission means and when the pot detection means has detected that there is a load on the top plate.

[0015] In the case where the pot detection means determines that a load on the top plate of the magnetism generating unit is not a pot in accordance with a determination criterion, at the time of starting usage, high-frequency magnetism is not supplied to the secondary coil on the load side and therefore the transmission means on the load side is not operating. Then, when the pot detection means generates a high-frequency magnetic field for pot detection, the secondary coil is magnetically coupled and the load circuit operates, so that the transmission means operates to generate a radio wave.

[0016] The generated radio wave is received by the reception means, and if it is detected that a load is placed, the primary coil supplies high-frequency current. As a result, the load placed on the top plate, e.g., a coffee mill, operates. The load is opened/closed by a switch provided to the coffee mill, to turn on/off a motor for rotating a blade for cutting coffee beans into an appropriate size.

[0017] On the other hand, if the detection means determines that there is a pot in accordance with a determination criterion, high-frequency current continues to be supplied to inductively heat the pot. That is, the inverter operates to supply high-frequency current to the primary coil when the reception means has received a predetermined signal from the transmission means of the load device and when the pot detection means has detected that there is a pot.

[0018] A conventional electromagnetic cooker described in Patent Document 4 includes: a heating coil; a power feed coil arranged around the outer periphery of the heating coil; an adapter which can be attachably and detachably placed on a top plate and surrounds the pot; a power supply circuit which supplies power to the heating coil or the power feed coil; a relay which connects the heating coil and the power feed coil alternately to the power supply circuit while switching therebetween; and a control unit which controls the relay. In order to receive supply of power by magnetic coupling, the adapter has a power receiving coil arranged so as to be opposed to the power feed coil, and an auxiliary coil which is connected to the power receiving coil and inductively heats the side surface of a pot.

[0019] When power consumed by the power feed coil is smaller than a predetermined value, the control unit stops the alternate switching of the relay, and selectively connects the heating coil to supply power thereto. Whether or not the adapter for inductively heating the side surface of the pot is placed is determined on the basis of whether or not power is being consumed by the power feed coil. If it is determined that the adapter is not placed, the control unit commands the relay, to switch to heating by only the heating coil.

[0020] If it is determined that a pot is not placed, operation of the inverter is stopped. Thereafter, the relay is switched to the power feed coil side, and the power feed coil and an outer side coil are energized. At this time, if it is determined that the adapter is not placed, the relay is switched to an inner side heating coil, to perform heating operation. When the adapter is placed and heating is started, power is supplied to the inner side heating coil and the outer side heating coil, and the outer side heating coil and the power feed coil, alternately in a predetermined cycle.

[0021] A non-contact power receiving device described in Patent Document 5 relates to a power receiving device used by being placed on an induction-heating cooker, and includes: a power receiving coil which receives power by using a high-frequency magnetic field from an induction-heating cooker; a load device which operates by the power receiving coil; and a control unit which supplies power to the load device and controls the load device. Current or voltage supplied to the load device is detected by overload detection means. Power reception amount control means is provided which controls the power reception amount to be reduced when the detected value becomes equal to or greater than a first predetermined value. Further, safety control means is provided which performs control so as to stop supply of power to the load device when the detected value becomes equal to or greater than a second predetermined value. As a method for controlling the received power, it is possible to reduce the power reception amount by changing the number of turns of the power receiving coil to decrease the number of turns. The number of turns can be manually changed. For stopping energization of the load device, the circuit of the power receiving coil is opened.

List of CitationsPatent Document5 **[0022]**

Patent Document 1: WO 2013/094174 A1

Patent Document 2: WO 2013/038694 A1

Patent Document 3: JP H05-184471 A

10 Patent Document 4: JP H06-29082 A

Patent Document 5: JP 2013-115893 A

Summary of the Invention15 Problems to be Solved by the Invention

[0023] As described above, in the conventional induction-heating cooker with a non-contact power feeding function, whether a load on a top plate is a heating target to be subjected to induction heating or a power receiving device to be subjected to non-contact power feeding, is determined, and if the load is determined to be a power receiving device, the inverter is controlled to reduce output power to the inverter. Therefore, it is possible to supply appropriate power to the power receiving device which only requires smaller power than that required for the heating target. In addition, the power receiving device can supply high-frequency power received by the power receiving coil, to a power consuming unit (load unit) of the power receiving device, such as a DC motor.

[0024] For example, in the configuration described in Patent Document 1, a function as an induction heating device and a function as a power supply device for the power receiving device are provided, and appropriate operation can be performed with power corresponding to the type of a load. Therefore, a device that requires small power can be prevented from being erroneously operated with large power. Further, a user does not need to greatly change the setting in accordance with the type of a load.

[0025] However, the setting range, the setting method, and the like vary according to the type of a load, thus causing a problem that manipulation is complicated. In addition, since feed power control is performed on the power receiving side, it is impossible to adapt to power-ON/OFF operation or control of power or the like from the power transmitting side. In addition, when power on the power transmitting side increases, it might be impossible to adapt to power exceeding the energization amount control range on the power receiving device side. In this case, supply of power to the load device is stopped, thus causing a problem that convenience for a user is lost.

[0026] According to Patent Document 2, since the feed power control is performed on the power receiving side, it is impossible to adapt to power-ON/OFF operation or control of power or the like from the power transmitting side. Further, it is necessary to exchange information through communication between the power receiving device and the induction-heating cooker which is a power feeding device. Therefore, there is a problem that a dedicated device is targeted and thus it is impossible to adapt to a power receiving device that is not capable of communication.

[0027] Patent Document 3 describes performing load determination, but regarding means for controlling received power, there is no description except for ON and OFF of a switch, and thus the rotation rate cannot be adjusted. Similarly, also in the case of water heater pot, certain fixed power is merely supplied but control of the amount of supplied power is not performed, and therefore it is impossible to cope with excess and deficiency of the power feed amount. In addition, in the case of placing a power receiving device having characteristics similar to a pot, there is a problem that the power receiving device is erroneously recognized as a pot and as a result, an induction heating operation is performed.

[0028] In this case, there is a problem that, if the power required by the power receiving device is different from the output range in the induction heating operation, non-contact power feeding operation is hampered. Further, it is necessary to exchange information through communication between the power receiving device and the induction-heating cooker which is a power feeding device. Therefore, there is a problem that a dedicated device is targeted and thus it is impossible to adapt to a power receiving device that is not capable of communication.

[0029] According to Patent Document 4, for supplying power to the adapter, it is necessary to alternately switch between the power feed coil and the heating coil for heating a pot. Therefore, there is a problem that, while power is being supplied to the adapter, power is not supplied to the inner side coil for heating the bottom of the pot, and that a switchover circuit needs to be provided separately.

[0030] According to Patent Document 5, for reducing the power reception amount when the detected value is equal to or greater than the first predetermined value, a user needs to manually perform the switching, and thus there is a problem of depending on the user's operation. In addition, since the power amount reduction control and the power reception stop control are performed on the power receiving device side, there is a problem that a high-frequency

magnetic field itself supplied from the induction-heating cooker side cannot be controlled.

[0031] The present invention has been made to solve the above problems, and an object of the present invention is to obtain an induction-heating cooker and a control method therefor that enable an appropriate amount of power to be efficiently supplied in accordance with a target load both when a heating target is inductively heated and when power is supplied to a power receiving subject by electromagnetic induction.

Solution to the Problems

[0032] In order to achieve the above object, an induction-heating cooker according to the present invention includes: an electromagnetic coil for generating a magnetic field; a drive unit which supplies high-frequency current to the electromagnetic coil; a control unit which controls the drive unit; and a detection unit which has detection means for detecting electric characteristics of the drive unit and detects load characteristics of a load placed near the electromagnetic coil on the basis of the electric characteristics. The control unit has load determination means for determining whether the load is a heating target or a power receiving subject on the basis of the load characteristics.

[0033] The control unit performs control such that, if the load is determined to be the heating target, a range of an output power value of the drive unit is set to a first range having a first maximum output power value and operation is performed in an induction heating operation mode in which the heating target is heated by the electromagnetic coil, and if the load is determined to be the power receiving subject, a range of an output power value of the drive unit is set to a second range having a second maximum output power value and operation is performed in a non-contact power feeding operation mode in which power is supplied to the power receiving subject by the electromagnetic coil.

[0034] A control method for induction-heating cooker according to the present invention includes: detecting load characteristics of a load placed near an electromagnetic coil for generating a magnetic field, on the basis of electric characteristics of a drive unit which drives the electromagnetic coil; and performing control such that, if the load is determined to be a heating target, a range of an output power value of the drive unit is set to a first range having a first maximum output power value and operation is performed in an induction heating operation mode in which the heating target is heated by the electromagnetic coil, and if the load is determined to be a power receiving subject, a range of an output power value of the drive unit is set to a second range having a second maximum output power value and operation is performed in a non-contact power feeding operation mode in which power is supplied to the power receiving subject by the electromagnetic coil.

Effect of the Invention

[0035] The induction-heating cooker according to the present invention can provide an induction-heating cooker that enables an appropriate amount of power to be efficiently supplied in accordance with a target load on the basis of whether the target load is a heating target to be heated by electromagnetic induction or a power receiving subject to be supplied with power by electromagnetic induction.

[0036] The control method for induction-heating cooker according to the present invention can provide a control method for induction-heating cooker that enables an appropriate amount of power to be efficiently supplied in accordance with a target load both when a heating target is inductively heated and when power is supplied to a power receiving subject by electromagnetic induction.

Brief Description of the Drawings

[0037]

- FIG. 1 is an entire perspective view schematically showing an induction-heating cooker according to Embodiment 1.
- FIG. 2 is a plan view showing examples of the shape of an electromagnetic coil in Embodiment 1.
- FIG. 3 is a sectional view of the electromagnetic coil when the induction-heating cooker in FIG. 1 is cut along plane S, and a block diagram of a major part.
- FIG. 4 is a circuit diagram showing the configuration of the induction-heating cooker according to Embodiment 1.
- FIG. 5 is a timing chart of control signals in an induction heating operation mode in Embodiment 1.
- FIG. 6 is a circuit diagram showing the details of a drive unit in Embodiment 1.
- FIG. 7 is a circuit diagram showing the configuration of the electromagnetic coil and the drive unit in the induction heating operation mode in Embodiment 1.
- FIG. 8 is a diagram showing a relationship between an adjustment value and an output power value in Embodiment 1.
- FIG. 9 is a diagram illustrating an example of display of a display unit in Embodiment 1.
- FIG. 10 is a circuit diagram showing the configuration of the electromagnetic coil and the drive unit in a non-contact power feeding operation mode in Embodiment 1.

- FIG. 11 is a circuit diagram showing equivalent circuits in the induction heating operation mode and the non-contact power feeding operation mode in Embodiment 1.
- FIG. 12 is a sectional view of the electromagnetic coil and a block diagram of a major part in the non-contact power feeding operation mode in Embodiment 1.
- 5 FIG. 13 is a diagram showing frequency characteristics of a load resistance with respect to each type of load in Embodiment 1.
- FIG. 14 is a circuit diagram showing the details of the drive unit in the non-contact power feeding operation mode in Embodiment 1.
- FIG. 15 is a timing chart of control signals in the non-contact power feeding operation mode in Embodiment 1.
- 10 FIG. 16 is a flowchart showing the processing procedure of load detection in Embodiment 2.
- FIG. 17 is a circuit diagram showing a resonant circuit including the drive unit, and a diagram showing a relationship between a frequency and high-frequency current, in Embodiment 3.
- FIG. 18 is a circuit diagram showing the configuration of the electromagnetic coil and the drive unit, for explaining switchover of a resonant capacitor in the non-contact power feeding operation mode, in Embodiment 4.
- 15 FIG. 19 is a circuit diagram showing a resonant circuit including the drive unit, and a diagram showing a relationship between a frequency and high-frequency current for explaining a resonant frequency in the induction heating operation mode and the non-contact power feeding operation mode, in Embodiment 4.
- FIG. 20 is a circuit diagram showing the configuration of the electromagnetic coil and the drive unit, and a timing chart of control signals, in the induction heating operation mode, in Embodiment 5.
- 20 FIG. 21 is a circuit diagram showing the configuration of the electromagnetic coil and the drive unit in the non-contact power feeding operation mode in Embodiment 5.
- FIG. 22 is a diagram showing a configuration example of a manipulation unit in Embodiment 6.
- FIG. 23 is a diagram showing an output power value table representing a relationship between an adjustment value and an output power value in Example 1 of Embodiment 7.
- 25 FIG. 24 is a graph representing the relationship between the adjustment value and the output power value in Example 1 of Embodiment 7.
- FIG. 25 is a diagram showing an output power value table representing a relationship between an adjustment value and an output power value in another mode of Example 1 of Embodiment 7.
- FIG. 26 is a graph showing the relationship between the adjustment value and the output power value in the other mode of Example 1 of Embodiment 7.
- 30 FIG. 27 is a diagram showing an output power value setting table representing a relationship between an adjustment value and an output power value in Example 2 of Embodiment 7.
- FIG. 28 is a graph representing the relationship between the adjustment value and the output power value in Example 2 of Embodiment 7.
- 35 FIG. 29 is a diagram showing an output power value setting table representing a relationship between an adjustment value and output power in another mode of Example 2 of Embodiment 7.
- FIG. 30 is a graph showing the relationship between the adjustment value and the output power value in the other mode of Example 2 of Embodiment 7.
- 40 FIG. 31 is a graph showing a relationship between an adjustment value and an output power value in Example 3 of Embodiment 7.

Description of Embodiments

Embodiment 1

45 **[0038]** The configuration and operation of an induction-heating cooker according to Embodiment 1 of the present invention will be described with reference to FIG. 1 to FIG. 15.

[0039] FIG. 1 is an entire perspective view schematically showing the induction-heating cooker. In FIG. 1, the induction-heating cooker 1 roughly includes: an induction-heating cooker main body 2 having a housing mainly made of sheet metal; a top plate 3 made of glass material or the like and covering almost the entirety of the top surface of the induction-heating cooker main body 2; heating parts 9, 10 arranged at right and left; another heating part 11 arranged behind them; and a cooking grill 4.

[0040] The heating parts 9, 10 are induction heating parts (IH heating parts) with high-frequency magnetic field generating coils 100 (hereinafter, referred to as electromagnetic coils) (see FIG. 3) arranged under the top plate 3. The other heating part 11 may be formed by a radiant heater as a heating source, or may be an IH heating part using an electromagnetic coil instead of a radiant heater. Here, the electromagnetic coil 100 is a coil made of a material suitable for induction heating, e.g., copper.

[0041] In the present embodiment, the IH heating part will be shown and described, using the heating part 10 shown

at the left in FIG. 1 as an example. However, the same configuration may be applied also to the other heating part 9, and further, to the rearward heating part 11 if the heating part 11 is an IH heating part.

[0042] In the present embodiment, three heating parts are provided. However, the number and the arrangement of the heating parts are not limited thereto, and one or two heating parts may be provided, or more than three heating parts shown in FIG. 1 may be provided. In addition, the heating parts may be arranged in one row laterally, or in a reversed-triangular form. In the present embodiment, the induction-heating cooker 1 having a so-called center-grill structure in which the cooking grill 4 is located approximately at the center of the housing 2 is described as an example. However, without limitation thereto, an induction-heating cooker in which the cooking grill 4 is located close to one side surface, or an induction-heating cooker not having the cooking grill 4, is also applicable in the same manner.

[0043] The induction-heating cooker 1 in the present embodiment includes: a manipulation unit 5 provided at the top surface and used for manipulating the heating parts 9, 10, 11 and the cooking grill 4; manipulation units 6a, 6b provided at the front surface and formed by adjustment dials for adjusting outputs (power) or the like; and a display unit 7 formed from liquid crystal or the like and including display units 7a, 7b, 7c for displaying the control states of those manipulation units, manipulation guides therefor, and the like. Further, the manipulation unit 5 may be provided with a display unit formed by a display such as LEDs indicating the magnitude of the set output. The configurations, the numbers, and the arrangements of the manipulation unit 5 and the display unit 7 are not limited to those shown in FIG. 1, and optimum configurations can be selected therefor in view of convenience or device specifications.

[0044] The induction-heating cooker 1 has suction/exhaust windows 8a, 8b, 8c provided at the rear on the top plate 3. In FIG. 1, although not shown in detail, a drive unit 40 which supplies high-frequency current to the heating parts 9, 10 is provided in the induction-heating cooker 1. The arrangement and the numbers of the components of the induction-heating cooker 1 are not limited to those shown in FIG. 1.

[0045] The electromagnetic coil 100 in the induction-heating cooker 1 according to the present embodiment operates as an induction heating coil when a load placed nearly directly above the electromagnetic coil 100 with the top plate 3 therebetween is a heating target, and operates as a power feed coil when the load is a power receiving device.

[0046] Hereinafter, operation of the induction-heating cooker 1 will be described with reference to the drawings.

[0047] FIG. 2 is a plan view showing the configuration of the electromagnetic coil 100 provided under the heating part 10 on the top plate 3. The electromagnetic coil 100 is composed of a plurality of coils which are so-called windings formed by winding linear conductors and which are arranged concentrically. The electromagnetic coil 100 shown in FIG. 2(a) is composed of a plurality of individually wound coils (hereinafter, referred to as individual coils) 101 to 104 forming an inner side coil group and an outer side coil group.

[0048] For example, the individual coil 101 and the individual coil 102 compose the inner side coil group (hereinafter, referred to as center coils), and the individual coil 103 and the individual coil 104 compose the outer side coil group (hereinafter, referred to as peripheral coils). The individual coil 101 and the individual coil 102 forming the center coils, and the individual coil 103 and the individual coil 104 forming the peripheral coils, may be respectively connected in series, or may be formed as independent coils.

[0049] In the electromagnetic coil 100 shown in FIG. 2(a), the individual coils 101 to 104 thereof are each formed in a round shape and arranged concentrically, as an example. However, the shape of the electromagnetic coil 100 is not limited thereto. For example, as shown in FIG. 2(b), the electromagnetic coil 100 may be composed of six individual coils 101, 102, 103, 104, 105, 106, and the individual coils 103 to 106 as the peripheral coils may be a plurality of divided small-diameter coils and may be arranged so as to surround the center coils. The configurations of the coils provided in the heating parts 9, 10 and the heating part 11 are not limited to the number of the plurality of individual coils forming the electromagnetic coil 100 shown in FIGS. 2(a), 2(b). These coils may have configurations as shown in FIGS. 2(c), 2(d).

[0050] In the electromagnetic coil 100 shown in FIG. 2(a), the individual coil 101 and the individual coil 102 form the center coils, and the individual coil 103 and the individual coil 104 form the peripheral coils, as an example. However, combination thereof is not limited to that shown in FIG. 2. The individual coils 101 to 104 may be all independent of each other, or may be connected in series to any of them, as long as they are formed by the center coils and the peripheral coils.

[0051] Similarly, in the coil formed by a plurality of coils shown in FIGS. 2(b), 2(c), 2(d), combination of the plurality of coils may be set arbitrarily. In the present embodiment, mainly, a coil formed by a combination of the center coils and the peripheral coils will be described.

[0052] Here, the electromagnetic coil 100 is configured such that, approximately, output power of 1,500 W is obtained by the center coils and output power of 1,500 W is obtained by the peripheral coils.

[0053] In FIG. 2(a) and FIG. 3, the electromagnetic coil 100 is composed of a plurality of coils including the center coils formed by the individual coils 101, 102 and the peripheral coils formed by the individual coils 103, 104. The number of coils forming the center coils and the number of coils forming the peripheral coils are not limited to those shown in FIG. 2.

[0054] Here, preferably, the outer shape of the individual coil 102 forming the center coil shown in FIGS. 2(a) to 2(c) has a size suitable for heating a so-called small pot of up to about 14 cm. Preferably, the outer shape of the individual coil 103 forming the peripheral coil shown in FIG. 2(a) has a size suitable for heating a middle-size pot of about 20 cm larger than a small pot, and is approximately equal to the size of the individual coil 103 shown in FIG. 2(c) and the size

of the individual coil 102 shown in FIG. 2(d). Preferably, the outer shape of the individual coil 104 forming the outer coil shown in FIG. 2(a), and the outer shape of the outer coil formed by the individual coils 103 to 106 in FIG. 2(b), have sizes suitable for heating a so-called large pot which is larger than the above sizes.

[0055] FIG. 3 is a sectional view along plane S of the electromagnetic coil 100 provided under the heating part 10 on the top plate 3 shown in FIG. 1, and a block diagram showing the configuration of components connected thereto.

[0056] In FIG. 3, description will be given using the configuration of the electromagnetic coil 100 shown in FIG. 2(a). The electromagnetic coil 100 is composed of the plurality of individual coils 101 to 104. The center coil 101 is connected in series to the individual coil 102 with a gap of about 20 mm provided therebetween for attaching a temperature sensor. The individual coil 103 is provided independently of the individual coil 102 with a gap of about 10 mm provided therebetween.

[0057] On the outer side of the individual coil 103, the individual coil 104 is connected in series thereto with a gap of about 15 mm provided therebetween. The individual coil 103 and the individual coil 104 are provided as outer coils around the individual coil 102. The electromagnetic coil 100 is located with a gap Gap1 of about 3 mm between the top surface thereof and the top plate 3.

[0058] It is noted that the numerical values such as gap sizes shown here do not limit operation of the present embodiment.

[0059] The electromagnetic coil 100 is supplied with high-frequency current from the drive unit 40. The drive unit 40 includes a drive circuit 40a which drives the center coils formed by the individual coil 101 and the individual coil 102 connected in series, and a drive circuit 40b which drives the peripheral coils formed by the individual coil 103 and the individual coil 104 connected in series. A detection unit 60 is connected to the drive unit 40. The detection unit 60 includes a plurality of detection circuits 60a, 60b connected independently to the respective plurality of drive circuit units. On the basis of electric characteristics detected by the detection circuits 60a, 60b, frequency characteristics of a load resistance on the heating part 10 are detected which are used for determining whether or not a load is present on the top plate 3, and determining the shape, the size, the material, and the like of a load placed above the electromagnetic coil 100 with the top plate 3 therebetween.

[0060] The electric characteristics in the heating part 10 are, for example, electric characteristics of the drive unit 40 itself and electric characteristics of the electromagnetic coil 100, a resonant capacitor 80, and the like connected to the drive unit 40, which vary by a load being placed above the electromagnetic coil 100 with the top plate 3 therebetween. A typical example of the electric characteristics as used herein is an electric signal converted from voltage, current, frequency, resistance, or temperature information.

[0061] The control unit 50 determines a load by using load determination means (not shown here) on the basis of a detection result of load characteristics of a load detected by the detection unit 60 for the individual coils 101, 102 as the center coils and the individual coils 103, 104 as the peripheral coils, and controls the drive unit 40 so as to operate under a condition suitable for the load placed on the top plate 3. The load characteristics as used herein refer to characteristics unique to a load which allow determination of the type of the load, e.g., frequency characteristics of a load resistance which are obtained from electric characteristics of the load.

[0062] For example, in order to obtain load characteristics of a load, the control unit 50 selects a drive frequency suitable for the material of the load, or changes a drive condition of the drive unit 40 so as to supply the electromagnetic coil 100 with high-frequency current having a magnitude corresponding to the content (set value) of a manipulation performed via the manipulation unit 5 or the manipulation unit 6 provided to the induction-heating cooker main body 2, and changes the display content of the display unit 7. If the load determination means determines that no load is present on the top plate 3 on the basis of a result of detection of load characteristics for the heating part 10 by the detection unit 60, the control unit 50 stops driving of the drive unit 40 and reports that no load is placed, via the display unit 7. As means for reporting, although not shown here, display on the display unit 7 or sound means such as buzzer may be used, for example.

[0063] If a pot P which is a load is placed being deviated from the center of the electromagnetic coil 100, the control unit 50 controls the drive unit 40 so as to stop supplying high-frequency current to the electromagnetic coil 100 for which the area on which the pot P is placed is determined to be small, on the basis of the load characteristics of the load detected by the detection unit 60. That is, each drive circuit of the drive unit 40 is individually controlled so as to drive, of the plurality of coils, only a coil above which the pot P is placed, thus suppressing unnecessary power consumption and efficiently performing induction heating operation.

[0064] It is noted that determination of the manipulation states of the manipulation units 5 and 6 and setting of the display content of the display unit 7 may be performed by, for example, a microcomputer provided separately from the control unit 50. Although the heating part 10 is mainly described here, the same applies also to the other heating parts 9, 11. In addition, although the coil shape shown in FIG. 2(a) is used as a representative in the description, the same effect can be obtained also by the coil shapes in FIG. 2(b) and FIG. 2(c) formed from a plurality of coils.

[0065] FIG. 4 is a circuit diagram showing the further detailed configuration of the drive unit 40, the control unit 50, the detection unit 60, and the electromagnetic coil 100 shown in FIG. 3.

[0066] FIG. 4 is a circuit diagram including an example of the drive unit 40 which generates a high-frequency magnetic field. A power supply unit 30 shown in FIG. 4 rectifies AC power supplied from a commercial power supply 31 by a diode bridge 32, converts the resultant power to DC power by a smoothing circuit 33 composed of a choke coil 331 and a smoothing capacitor 332, and supplies power to the drive unit 40. The drive unit 40 supplies high-frequency current to the electromagnetic coil 100 on the basis of a command from the control unit 50. For example, in order to heat a pot P, the manipulation unit 5 or the manipulation unit 6 is manipulated to adjust output for heating the pot P, and then, in order to heat the pot P with the set output (power), the control unit 50 controls the drive frequency and the magnitude of high-frequency current to control the drive unit 40 so as to supply high-frequency current according to the set output, to the electromagnetic coil 100.

[0067] The drive unit 40 is composed of: the drive circuit 40a which supplies high-frequency current to the individual coil 101 and the individual coil 102 forming the center coils; and the drive circuit 40b which supplies high-frequency current to the individual coils 103, 104 forming the peripheral coils.

[0068] The drive circuit 40a includes: a semiconductor switching element pair 401 (hereinafter, referred to as an arm 401) composed of two semiconductor switching elements 401a, 401b connected in series; and a semiconductor switching element pair 402 (hereinafter, referred to as an arm 402) composed of two semiconductor switching elements 402a, 402b connected in series, and is formed as a full-bridge circuit in which the center coils 101, 102 and a resonant capacitor 81 are connected in series between the intermediate points in the arm 401 and the arm 402.

[0069] The drive circuit 40b includes: the semiconductor switching element pair 401 (hereinafter, referred to as an arm 401) composed of two semiconductor switching elements 401a, 401b connected in series; and a semiconductor switching element pair 403 (hereinafter, referred to as an arm 403) composed of two semiconductor switching elements 403a, 403b connected in series, and is formed as a full-bridge circuit in which the peripheral coils 103, 104 and a resonant capacitor 83 are connected in series between intermediate points in the arm 401 and the arm 403.

[0070] For the drive circuit 40a and the drive circuit 40b, the detection circuits 60a, 60b are provided which detect electric characteristics of a load for the drive circuit 40a and the drive circuit 40b, and the detection circuits 60a, 60b are connected to the detection unit 60. The detection unit 60 detects load characteristics, e.g., frequency characteristics of a load resistance, on the basis of the electric characteristics of the load.

[0071] The control unit 50 determines the state on the top plate 3, e.g., whether or not a load is present, the material of the load, or positional deviation, on the basis of load characteristics detected by the detection unit 60. Here, electric characteristics of a load of the drive unit 40 detected by the detection circuits 60a, 60b of the detection unit 60 are, for example, current flowing through the power supply unit 30, currents flowing through the individual coils 101 to 104, voltages applied to the resonant capacitors 81, 83, output voltage of the drive unit 40, and the like. It is noted that means for detecting the state of a load placed on the top plate 3 may be a temperature sensor, an optical sensor, or the like.

[0072] If the inductance of the center coils formed by the individual coil 101 and the individual coil 102 is denoted by L_a and the capacitance of the resonant capacitor 81 connected in series thereto is denoted by C_a , a resonant frequency f_{0a} of a series resonant load formed by the inductance L_a and the capacitance C_a is calculated by Expression (1).

$$f_{0a} = \frac{1}{2\pi\sqrt{(L_a \times C_a)}} \quad \dots (1)$$

[0073] If the inductance of the peripheral coils formed by the individual coil 103 and the individual coil 104 is denoted by L_b and the capacitance of the resonant capacitor 83 connected in series thereto is denoted by C_b , a resonant frequency f_{0b} of a series resonant load formed by L_b and C_b is calculated by Expression (2).

Mathematical 2

$$f_{0b} = \frac{1}{2\pi\sqrt{(L_b \times C_b)}} \quad \dots (2)$$

[0074] For example, it is desirable that a drive frequency f_{swa} for driving the full-bridge circuit (drive circuit 40a) composed of the arm 401, the arm 402, the individual coils 101, 102, and the resonant capacitor 81 is greater than the resonant frequency f_{0a} calculated from the inductance L_a and the capacitance C_a shown above.

[0075] In addition, it is desirable that a drive frequency f_{swb} for driving the full-bridge circuit (drive circuit 40b) composed of the arm 401, the arm 403, the individual coils 103, 104, and the resonant capacitor 83 is greater than the resonant

frequency f_{0b} calculated from the inductance L_b and the capacitance C_b shown above. The reason is to prevent increase in loss in each switching element of the drive unit 40 and prevent damage.

[0076] A snubber capacitor may be connected in parallel to each semiconductor switching element of each arm, as appropriate, in order to reduce noise in switching.

[0077] Here, it is desirable to select the inductance of the center coils formed by the individual coil 101 and the individual coil 102 and the inductance of the peripheral coils formed by the individual coil 103 and the individual coil 104 so that, when no load is placed on the top plate, i.e., in a so-called no-load state, the resonant frequency f_{0a} and the resonant frequency f_{0b} are each about 20 kHz and a difference Δf_0 between the resonant frequency f_{0a} and the resonant frequency f_{0b} is smaller than 3 kHz.

[0078] The reason for selecting the resonant frequency f_{0a} and the resonant frequency f_{0b} so as to be close to each other is to prevent the following phenomenon: when the drive circuit 40a and the drive circuit 40b are driven at the same frequency f_{swc} , the magnitude of high-frequency current flowing through a coil corresponding to the greater one of a frequency difference between the drive frequency f_{swc} and the resonant frequency f_{0a} and a frequency difference between the drive frequency f_{swc} and the resonant frequency f_{0b} becomes small, and as a result, unevenness of heating distribution occurs due to difference between the magnitudes of current in the center coils and current in the peripheral coils.

[0079] FIG. 5 shows a timing chart of control signals S1 to S6 for driving the semiconductor switching element pairs 401 to 403. These control signals S1 to S6 are outputted from the control unit 50. As shown in FIG. 4, signal circuits for supplying the control signal S1 and the control signal S2 from the control unit 50 are respectively connected to the semiconductor switching elements 401a and 401b composing the semiconductor switching element pair 401. The phase relationship between the control signal S1 and the control signal S2 is fixed, and the control signal S1 and the control signal S2 are a pair of complementary signals having exclusive ON/OFF periods.

[0080] In FIG. 5, for example, regarding the control signal S1, the semiconductor switching element 401a is turned on when the control signal S1 is at H (high) level, and is turned off when the control signal S1 is at L (low) level. It is noted that the control signals S1, S2 (or control signals S3, S4, control signals S5, S6) which are a pair of complementary signals are provided with stop periods (dead times T_{da} , T_{db}) so as not to cause a period during which the semiconductor switching elements 401a and 401b connected in series on the upper and lower sides in the semiconductor switching element pair 401 (or semiconductor switching element pair 402, 403) become conductive at the same time (turned on at the same time) in such a case where distortion or delay occurs in the drive signal waveforms.

[0081] If the upper and lower semiconductor switching elements become conductive at the same time, excessive current flows through the semiconductor switching elements. Therefore, the above stop periods are provided as a protection measure for preventing breakage of the semiconductor switching elements. Here, the ON period of each signal is equal to half a period obtained by subtracting the dead time from a cycle T . That is, if the dead time is "0", the ON period of each signal is half the cycle T (i.e., duty: 50%).

[0082] Similarly, signal circuits for supplying the control signal S3 and the control signal S4 from the control unit 50 are respectively connected to the semiconductor switching element 402a and the semiconductor switching element 402b composing the semiconductor switching element pair 402, and signal circuits for supplying the control signals S5 and S6 from the control unit 50 are respectively connected to the semiconductor switching element 403a and the semiconductor switching element 403b composing the semiconductor switching element pair 403. The control signal S3 and the control signal S4, and the control signal S5 and the control signal S6, are pairs of complementary signals for which dead times T_{da} , T_{db} are respectively set, as in the control signal S1 and the control signal S2.

[0083] The magnitude of high-frequency current supplied to the center coils formed by the individual coil 101 and the individual coil 102 is determined by a phase difference θ_a ($0 < \theta_a < 2\pi$) between the control signal S1 and the control signal S3 (control signal S2 and control signal S4). The greater the phase difference θ_a is, the greater the high-frequency current flowing through the center coils is. On the other hand, the magnitude of high-frequency current supplied to the peripheral coils formed by the individual coil 103 and the individual coil 104 is determined by a phase difference θ_b ($0 < \theta_b < 2\pi$) between the control signal S1 and the control signal S5 (control signal S2 and control signal S6).

[0084] Therefore, the control unit 50 adjusts the phase difference θ_a or θ_b so as to obtain the output set via the manipulation units 5, 6.

[0085] Meanwhile, the control unit 50 sets frequencies f ($= 1/T$) of the control signals S1 to S6 to the same frequency in order to prevent interference sound due to frequency difference between high-frequency currents supplied to the center coils and the peripheral coils. The frequencies f of the drive signals S1 to S6 are drive frequencies f_{sw} for driving the respective semiconductor switching elements of the drive unit 40, and are equal to the frequency of the high-frequency current supplied to the electromagnetic coil 100. The drive frequency f_{sw} at this time is determined by the control unit 50 on the basis of load characteristics detected by the detection unit 60.

[0086] The detection unit 60 detects electric characteristics of the drive unit 40 when a load is placed on the top plate 3, and the control unit 50 determines the frequency ($=$ drive frequency f_{sw}) of high-frequency current optimum for heating the load, on the basis of a result of the detection by the detection unit 60. The drive frequency f_{sw} may be set in advance

in accordance with a detection result, i.e., load characteristics of a load placed on the top plate 3, or a resonant frequency f_0 may be calculated using electric characteristics detected by the detection unit 60 and the drive frequency f_{sw} may be determined using the resonant frequency f_0 as a reference.

[0087] Here, as described above, the drive frequency f_{sw} set by the control unit 50 is determined by electric characteristics of the drive unit 40. When a load is placed on the top plate 3, the load is coupled with the individual coils 101 to 104, whereby the inductance of each coil changes. Along with the changes in the inductances when the load is coupled with the coils, the resonant frequency f_{0a} of the series resonant load formed by the individual coils 101 and 102 and the resonant capacitor 81, and the resonant frequency f_{0b} of the series resonant load formed by the individual coils 103 and 104 and the resonant capacitor 83, also change. That is, the resonant frequency f_{0a} of the drive circuit 40a and the resonant frequency f_{0b} of the drive circuit 40b in FIG. 4 vary in accordance with a load, and therefore the control unit 50 can determine the material of a pot P on the top plate 3 on the basis of the difference in the electric characteristics.

[0088] It is desirable that the frequency f_{swa} of a signal for driving the full-bridge circuit (drive circuit 40a) composed of the arm 401, the arm 402, the individual coils 101, 102, and the resonant capacitor 81 is greater than the resonant frequency f_{0a} calculated from L_a and C_a shown above. In addition, it is desirable that the frequency f_{swb} of a signal for driving the full-bridge circuit (drive circuit 40b) composed of the arm 401, the arm 403, the individual coils 103, 104, and the resonant capacitor 83 is greater than the resonant frequency f_{0b} calculated from L_b and C_b shown above.

[0089] For example, it is desirable that a difference Δf between the resonant frequency f_0 and the drive frequency f_{sw} is 1 kHz or greater, and further, the difference Δf may be set to such a value as to reduce loss in the drive unit 40, in accordance with electric characteristics which vary in accordance with the load placement state.

[0090] The reason therefor is to prevent the following phenomenon: if the resonant frequency f_0 and the drive frequency f_{sw} become close to each other so that $f_0 > f_{sw}$ is satisfied, loss in each switching element of the drive unit 40 increases, leading to breakage. Further, in order to prevent interference sound due to frequency difference between high-frequency currents for driving the center coils and the peripheral coils, it is desirable to set the frequencies f ($= 1/T$) of the control signals S1 to S6 to the same frequency.

[0091] Therefore, the control unit 50 calculates the resonant frequencies f_{0a} and f_{0b} of the drive circuits 40a, 40b from a result of detection by the detection circuit 60a and the detection circuit 60b composing the detection unit 60, and then, if a difference between the resonant frequencies f_{0a} and f_{0b} is smaller than a value set in advance, a frequency f_c greater than f_{0a} and greater than f_{0b} is used as the drive frequency f_{sw} and is set as the frequency f of the control signals S1 to S6.

[0092] Alternatively, the control unit 50 may select the frequency f_c suitable for detected electric characteristics from among drive frequencies f_{sw} set in advance for respective electric characteristics, on the basis of electric characteristics of the respective drive circuits obtained from a detection result of the detection circuit 60a which detects electric characteristics of the drive circuit 40a and a detection result of the detection circuit 60b which detects electric characteristics of the drive circuit 40b.

[0093] FIG. 6 schematically shows the configuration of the drive unit 40 in this case. Hereinafter, the detailed description will be given for the heating part 10 as an example. However, the same configuration may be applied also to the heating part 9 and the heating part 11.

[0094] In FIG. 6, one end of the resonant capacitor 81 is connected to the intermediate point in the series unit (arm 401) composed of the semiconductor switching element 401a and the semiconductor switching element 401b, and the other end thereof is connected to one end of the individual coil 101, which is a start point of winding of the individual coil 101. The other end of the individual coil 101 is connected to a winding start end of the individual coil 102, and the other end of the individual coil 102 is connected to the intermediate point in the series unit (arm 402) composed of the semiconductor switching element 402a and the semiconductor switching element 402b.

[0095] In FIG. 6, one end of the resonant capacitor 83 is connected to the intermediate point in the series unit (arm 401) composed of the semiconductor switching element 401a and the semiconductor switching element 401b, and the other end thereof is connected to one end of the individual coil 103, which is a start point of winding of the individual coil 103. The other end of the individual coil 103 is connected to a winding start end of the individual coil 104, and the other end of the individual coil 104 is connected to the intermediate point in the series unit (arm 403) composed of the semiconductor switching element 403a and the semiconductor switching element 403b.

[0096] In FIG. 6, black "points" shown at the individual coils 101 to 104 denote the winding start points of the coils. In FIG. 6, I_a denotes high-frequency current flowing through the individual coils 101, 102 and the resonant capacitor 81 connected in series to each other, and I_b denotes high-frequency current flowing through the individual coils 103, 104 and the resonant capacitor 83 connected in series to each other.

[0097] As shown in FIG. 6, the high-frequency current I_a flows through the full-bridge circuit (drive circuit 40a) composed of the arm 401 and the arm 402, and the high-frequency current I_b flows through the full-bridge circuit (drive circuit 40b) composed of the arm 401 and the arm 403. At this time, both of the high-frequency current I_a and the high-frequency current I_b flow through the arm 401. Thus, high-frequency currents flow through the arm 402 and the arm 403 at the same time, while sharing the arm 401.

[0098] In FIG. 6, as routes through which the high-frequency currents I_a and I_b flow, only a flow route between the semiconductor switching element 401a and the semiconductor switching element 402b and a flow route between the semiconductor switching element 401a and the semiconductor switching element 403b are shown. However, needless to say, in another cycle, the currents also flow through a route between the semiconductor switching element 401b and the semiconductor switching element 402a and a route between the semiconductor switching element 401b and the semiconductor switching element 403a. In addition, the connection arrangement of the resonant capacitor 81 and the individual coils 101, 102, and the connection arrangement of the resonant capacitor 83 and the individual coils 103, 104, are not limited to those shown in FIG. 6.

[0099] Hereinafter, with reference to FIG. 7, the case where a load placed above the electromagnetic coil 100 of the heating part 10 with the top plate 3 therebetween is determined to be a heating target, will be described.

[0100] FIG. 7 shows a state in which a pot P as a heating target is placed on the electromagnetic coil 100. In FIG. 7, the individual coils 101, 102 are connected in series to the resonant capacitor 81, and then connected to the drive unit 40. Similarly, the individual coils 103, 104 are connected in series to the resonant capacitor 83 and further a switch 21, and then connected to the drive unit 40.

[0101] It is noted that the switch 21 is merely shown for convenience sake for describing the operation of the induction-heating cooker 1, and actually the switch 21 is not included as a constituent component.

[0102] When a load is placed above the electromagnetic coil 100 with the top plate 3 therebetween, in order to detect the load, the control unit 50 controls the drive unit 40 to supply high-frequency current to the electromagnetic coil 100 under a drive condition for detection, and then, for example, high-frequency current flowing through the individual coils 101, 102 is detected by the current sensor 61, and high-frequency current flowing through the individual coils 103, 104 is detected by the current sensor 62. In addition, current of the power supply input is detected by the current sensor 63. On the basis of information from the current sensors, these detection values detected by the detection unit 60 are compared with a predetermined determination value set in advance. Then, if the load determination means determines that the load placed on the top plate 3 is the pot P which is a heating target, the drive unit 40 supplies high-frequency current to the electromagnetic coil 100 as an induction heating coil on the basis of a command from the control unit 50, to inductively heat the pot P. This state is defined as an induction heating operation mode.

[0103] For example, in order to heat the pot P, when the manipulation unit 5 or the manipulation unit 6 is manipulated to adjust the output for heating the pot P, the control unit 50 controls the drive signals S1 to S6 so as to obtain high-frequency power corresponding to the set output, thereby controlling the drive unit 40 so as to supply high-frequency current to the electromagnetic coil 100. At this time, the electromagnetic coil 100 is operated as an induction heating coil, and the pot P is heated at a predetermined output by a high-frequency magnetic field generated by the electromagnetic coil 100.

[0104] Here, the case where the induction-heating cooker uses a commercial power supply of 200 V as the power supply thereof will be described as an example. In the induction-heating cooker for 200 V, the maximum output power value that is required in general for one heating source (heating part) is about 3,000 W. It is noted that, if the induction-heating cooker has a plurality of heating sources (including a grill or the like), the maximum output power value when the plurality of heating sources operate at the same time is limited to 5,800 W or smaller, for example.

[0105] Therefore, when shifting to the induction heating operation mode, the control unit 50 sets the adjustment range of the output power value and the drive condition such as the drive frequency f_{sw} such that a maximum output power value MP1 of the drive unit 40 becomes about 3,000 W. It is noted that the maximum output power value when a plurality of heating sources are operated at the same time is not limited to the above value.

[0106] Here, in the case where the pot P placed on the top plate 3 is a pot having a diameter almost equal to the diameter of the individual coil 104, e.g., a large pot having a pot bottom diameter of about 240 mm, when manipulation is performed so as to heat the pot P at the maximum output power value of 3,000 W, the control unit 50 controls the drive unit 40 so as to supply high-frequency currents to all the individual coils 101 to 104. At this time, in FIG. 7, the switch 21 is closed. Actually, as shown in FIG. 5, all the control signals S1 to S6 are supplied from the control unit 50 to the drive unit 40. In this state, high-frequency currents are supplied to all the individual coils 101 to 104, and therefore this state is equivalent to the state in which the switch 21 is closed.

[0107] For example, in the case where the center coils and the peripheral coils of the electromagnetic coil 100 are both configured with specifications capable of output power of about 1,500 W, power of up to 3,000 W can be outputted by driving the center coils and the peripheral coils (individual coils 101 to 104).

[0108] FIG. 8 shows a relationship between an adjustment value and an output power value in the induction heating operation mode and a non-contact power feeding operation mode. Here, the horizontal axis indicates an adjustment value α , and the vertical axis indicates an output power value P obtained by the electromagnetic coil 100. When output adjustment is performed through manipulation on the manipulation units 5, 6 as an output manipulation unit, the adjustment value α on the horizontal axis varies accordingly. The control unit 50 controls the drive unit 40 in accordance with the adjustment value α , to change the magnitude of the high-frequency current I. Thus, the output power value P increases or decreases. In FIG. 8, when the adjustment value α in the induction heating operation mode is the maximum value

$\alpha 1$, the output power value P becomes the maximum value $MP1$, which is defined as a first maximum output power value $MP1$.

[0109] In general, the maximum output power value $MP1$ in the induction heating operation mode is about 3,000 W. Therefore, for the drive unit 40, the control unit 50 changes the phase difference θ between the drive signals S shown in FIG. 5 so as to obtain output of up to 3,000 W. In FIG. 8, $\alpha 1$ is the adjustment value at which the maximum output power value $MP1$ is obtained. Thus, by the control unit 50 changing the adjustment value α , the output power can be accurately changed over a wide range from low output to high output, whereby excellent cooking performance is obtained.

[0110] Further, as shown in FIG. 8, the state of the display unit 7, e.g., the lighting state of the LEDs indicating the adjustment value of the output power, changes in accordance with increase or decrease in the output power, and all the LEDs are lit at the maximum output power value $MP1$. The adjustment value may be indicated by, for example, a numerical value, and any means that enables recognition of state change, the set value, or the like may be used.

[0111] FIG. 9 is a diagram illustrating the lighting state of the LEDs as an example of the display unit 7. When the manipulation units 5, 6 are manipulated, the lighting state of the LEDs changes in accordance with the adjustment value α . FIG. 9(a) shows the lighting state of the LEDs in the case of maximum output corresponding to the first maximum output power value $MP1$ in the induction heating operation mode. Here, in FIG. 9(a), all the LEDs are lit. FIG. 9(c) shows change in the lighting state of the LEDs in accordance with the adjustment value α . When heating is stopped, all the LEDs are extinguished so as to indicate that the output is "0", and then, as the adjustment value α is raised by one level, the number of lit LEDs increases by one. Thus, the setting state of the output power during cooking can be recognized, and therefore the output power can be optimally adjusted in accordance with a cooking process.

[0112] As described above, in the induction heating operation mode, when the adjustment value α is the maximum value $\alpha 1$, the drive unit 40 outputs the first maximum output power value $MP1$. Through adjustment of the output power by the manipulation units 5, 6 as the output manipulation unit, it is possible to obtain a wide range of output powers from a low output power value to the maximum output power value (about 3,000 W), and further, cooking can be performed while the setting state of the output power is confirmed by the display unit 7. Thus, a cooker with high usability can be obtained.

[0113] Next, operation in the case where a power receiving device is placed as a load will be described. FIG. 10 is a circuit diagram showing the block configuration of the induction-heating cooker in the non-contact power feeding operation mode. FIG. 10 shows the same configuration as in FIG. 7, but shows the non-contact power feeding operation mode in which a power receiving device A is placed as a load, unlike FIG. 7. FIG. 11 is circuit diagrams showing equivalent circuits in the induction heating operation mode and the non-contact power feeding operation mode. FIG. 12(a) shows a configuration example of the power receiving device A, which is composed of a power receiving device housing 501 and a power receiving circuit AX and includes a power receiving coil 502, a power supply circuit 503, a load circuit 504 such as a resistor and a rotary object, and the like.

[0114] An example of the power receiving device that can be realized by such a configuration is a mixer having a heating function. FIG. 12(b) shows a sectional view along plane S at the heating part 10 in the induction-heating cooker main body 2 when the power receiving device A is placed at the heating part 10 on the top plate 3, and shows the configuration of components connected thereto. The sectional view of the electromagnetic coil 100 in FIG. 12(b) is the sectional view of the electromagnetic coil 100 having the configuration shown in FIG. 2(a).

[0115] In FIG. 10, when a load is placed above the electromagnetic coil 100 with the top plate 3 therebetween, in order to detect load characteristics by the detection unit 60 on the basis of electric characteristics of the drive unit 40 and determine the load by the load determination means provided in the control unit 50 on the basis of the detection result, high-frequency current is supplied to the electromagnetic coil 100 under a drive condition for detection, and then, for example, high-frequency current flowing through the individual coils 101, 102 is detected by the current sensor 61 which is detection means, and high-frequency current flowing through the individual coils 103, 104 is detected by the current sensor 62. In addition, current of the power supply input is detected by the current sensor 63.

[0116] On the basis of information from the current sensors, these load characteristics detected by the detection unit 60 are compared with a predetermined determination value set in advance. Then, if the load determination means determines that the load placed on the top plate 3 is the power receiving device A, the drive unit 40 supplies high-frequency current to a magnetic field generation excitation circuit EX including the electromagnetic coil 100 as a power feed coil, on the basis of a command from the control unit 50, to supply power to the power receiving device A. This state is defined as the non-contact power feeding operation mode.

[0117] In FIG. 12, electric characteristics of the load placed above the electromagnetic coil 100 composed of the individual coils 101 to 104 with the top plate 3 therebetween are detected by the current sensors 61, 62 of the detection circuits 60a, 60b and voltage sensors of the detection circuits 60a, 60b (the detection circuits and the voltage sensors are not shown in FIG. 12), and load characteristics detected on the basis of the above electric characteristics are outputted from the detection unit 60. If the load determination means provided in the control unit 50 determines that the load is the power receiving device A, the control unit 50 controls the drive condition of the drive unit 40 so that the electromagnetic coil 100 operates as a power feed coil.

[0118] As an example of the load determination means, electric characteristics such as high-frequency current or output voltage of the drive unit 40 are acquired, and load characteristics obtained on the basis of the electric characteristics are compared with a determination value set in advance, thus making determination. For example, a relationship of a resonant frequency and an impedance of a load of the drive unit 40 may be used. Alternatively, a relationship of input current and output current may be used to perform comparison with a threshold value set in advance, thereby making determination.

[0119] As an example of means for detecting a load, any known circuit configuration that detects electric characteristics of a heating target on the basis of drive voltage V applied across the electromagnetic coil 100 and drive current I flowing through the electromagnetic coil 100, may be used. For example, the same circuit configuration as a load detection unit disclosed in Japanese Laid-Open Patent Publication No. 2012-054179 may be used.

[0120] In order to determine the type of a load, a determination characteristics curve T in frequency characteristics of a load resistance is generated using electric characteristics acquired in advance for each load. As shown in FIG. 13, the determination characteristics curve T is represented with a frequency f indicated by a horizontal axis and a load resistance R indicated by a vertical axis, for example. The determination characteristics curve T using the frequency f and the load resistance R is generated through calculation based on drive voltage and drive current of a circuit shown separately. The determination characteristics curve T is a determination basis (corresponding to the setting content of the determination value) for load determination.

[0121] In the case of determining whether a load is a power receiving device, a heating target, or a non-heating target by detecting electric characteristics, a result of detection of electric characteristics when such a load is placed on the top plate 3 is compared with the determination characteristics curve T , and the type of the load is determined on the basis of whether or not the result is within a region where the determination characteristics curve T is present. The determination characteristics curve T is used as a threshold value for load determination. It is noted that, in FIG. 13, the determination characteristics curve T has a curve shape as an example, but may have a linear shape or a polygonal-line shape as long as load determination can be performed.

[0122] Hereinafter, an example of a load determination procedure for determining whether a load placed on the top plate 3 is a power receiving subject composed of the power receiving device A, or a heating target such as a pot P, will be described.

[0123] A load resistance R and an impedance Z , as seen from the drive unit 40, of the magnetic field generation excitation circuit EX including the electromagnetic coil 100 which generates a magnetic field, vary by the power receiving device A being placed in (coupled with) a magnetic field of the electromagnetic coil 100. In addition, the load resistance R and the impedance Z also vary by a heating target such as a pot P being placed in (coupled with) the magnetic field.

[0124] The load resistance R of the magnetic field generation excitation circuit EX including the electromagnetic coil 100 which generates a magnetic field, varies depending on whether or not a heating target such as a pot P is present and the placement state thereof (AC magnetic field interlinked with the pot P). That is, the load resistance R is obtained by adding an apparent load resistance R_L of the pot P due to placement of the pot P, to a wire resistance R_C of the heating electromagnetic coil 100 itself when the pot P is not placed ($R = R_C + R_L$), and the load resistance R varies in accordance with the frequency of an electric input to the magnetic field generation excitation circuit EX.

[0125] A power receiving subject composed of the power receiving device A and a heating target such as a pot P are different in their variation characteristics. Determination for the power receiving device A is performed using the difference in the characteristics.

[0126] Determination for the power receiving device A is executed by the load determination means provided in the control unit 50 using a result of load characteristics obtained on the basis of electric characteristics detected by the detection unit 60 which are electric characteristics regarding the drive unit 40, i.e., electric characteristics of the drive unit 40 in the magnetic field generation excitation circuit EX including the electromagnetic coil 100 which is driven by being supplied with high-frequency current from the drive unit 40.

[0127] As the electric characteristics, besides characteristics regarding the frequency and the load resistance in the magnetic field generation excitation circuit EX as described above, characteristics regarding input current and output current in the magnetic field generation excitation circuit EX, or the like may be used. Such characteristics are greatly different between when the power receiving device A is placed and when a heating target such as a pot P is placed, and on the basis of a result of detection of the characteristics by the detection unit 60, determination is performed by the load determination means provided in the control unit 50.

[0128] First, the control unit 50 acquires electric characteristics by the detection unit 60 while varying the frequency for driving the switching elements of the drive unit 40 in arbitrary steps, for example, from 10 kHz to 100 kHz, and compares the electric characteristics with the aforementioned determination characteristics curve T represented with the frequency indicated by the horizontal axis and the load resistance indicated by the vertical axis, for example. In the case where the power receiving device A is composed of a resonant circuit having a power receiving coil and a capacitor, a resonance characteristics curve is obtained as shown by a characteristics curve A in FIG. 13 which has a local maximum point of the resistance value. On the other hand, in the case of a heating target such as a pot P, the resistance value

gradually increases as the frequency increases, and therefore a characteristics curve is obtained as shown by a characteristics curve P different from that for the power receiving device A.

[0129] Accordingly, the detection unit 60 discriminates between the power receiving device A and a heating target such as a pot P, and then obtains load characteristics of the heating target such as a pot P, to determine the material thereof and the like through comparison with the determination characteristics curve T. The control unit 50 controls the drive unit 40 on the basis of the above results.

[0130] As shown in FIG. 13, the determination characteristics curve T of the determination value (load determination threshold value) is set along the characteristics curve P regarding a heating target such as a pot P. Electric characteristics detected by the detection circuits 60a, 60b of the detection unit 60 are acquired to generate load characteristics. On the basis of the load characteristics from the detection unit 60 and the determination characteristics curve T, the control unit 50 determines and detects the load as the power receiving device A which is a power receiving subject, if the load characteristics are included in a region above the curve T.

[0131] As also shown in Patent Document 1, in general, the power receiving device A which operates by being supplied with power in a non-contact manner only requires low power of about several hundreds W as compared to a load such as a pot P which is a heating target. That is, as compared to the maximum output power value MP1 (for example, 3,000 W) in the induction heating operation mode, a low output power value is sufficient for the maximum power required by the power receiving device A. Further, the maximum output power value MP2 that can be supplied by the power feeding device in a non-contact manner might be limited to 1,500 W by regulation. That is, the maximum output power value MP2 supplied to the power receiving device may be, at most, only about half the maximum output power value MP1 in the induction heating operation mode.

[0132] Accordingly, if the load is determined to be the power receiving device A, the control unit 50 performs control to open the switch 21 shown in FIG. 10 and disconnect the peripheral coils (individual coils 103, 104) from the drive unit 40, thereby switching to only the center coils (individual coils 101, 102), so that the maximum value of power outputted from the drive unit 40 becomes 1,500 W or lower.

[0133] This switchover operation will be described with reference to FIG. 10, FIG. 11, FIG. 13, FIG. 14, and FIG. 15. It is noted that the switch 21 is merely shown for convenience sake for describing the operation of the induction-heating cooker 1 of the present embodiment, and actually the switch 21 is not included as a constituent component.

[0134] When a load is placed above the electromagnetic coil 100 with the top plate 3 therebetween, in order to detect the load, by the drive unit 40 and the control unit 50, high-frequency current is supplied to the electromagnetic coil 100 under a drive condition (e.g., a setting condition such as the frequency of high-frequency current and the magnitude of the current) for detection, and then, for example, high-frequency current I flowing through the individual coils 101, 102 is detected by the current sensor 61, and high-frequency current I flowing through the individual coils 103, 104 is detected by the current sensor 62. In addition, current of the power supply input is detected by the current sensor 63.

[0135] At this time, for example, as shown in FIG. 13, if the control unit 50 continuously changes the frequency f of the high-frequency current I, a resistance component detected by the detection unit 60 exhibits a peak as compared to the case of a pot P which is a heating target. Therefore, by using the fact that change in the electric characteristics is different from that of the pot load, the control unit 50 compares the above load characteristics detected by the detection unit 60 with a predetermined determination value set in advance, and determines, by the load determination means, that the load placed on the top plate 3 is the power receiving device A (non-contact power feeding operation mode).

[0136] In the non-contact power feeding operation mode in which the power receiving device A is placed above the electromagnetic coil 100, the electromagnetic coil 100 serves as a power feeding (power transmitting) coil, and a coil provided in the power receiving device A serves as the power receiving coil 502. As shown in FIG. 11(a), the circuit in the induction heating operation mode can be represented as a transformer formed from a pot with one turn and the electromagnetic coil 100 with N turns composing the magnetic field generation excitation circuit EX.

[0137] On the other hand, as shown in FIG. 11(b), the circuit in the non-contact power feeding operation mode can be represented as a transformer model having a turns ratio of $N1 : N2$, wherein $N1$ is the number of turns of the electromagnetic coil 100 on the power feeding side composing the magnetic field generation excitation circuit EX (primary winding) and $N2$ is the number of turns of the power receiving coil 502 provided in the power receiving device (secondary winding).

[0138] Here, if high-frequency current flowing through the electromagnetic coil 100 is denoted by $I1$ and high-frequency current flowing through the power receiving coil 502 is denoted by $I2$, the magnitude of $I2$ is represented as $I1 \times (N1/N2)$ (under the assumption that the transformer model is an ideal transfer model).

[0139] That is, by controlling the magnitude of high-frequency current I flowing through the individual coils 101, 102, the control unit 50 can vary a high-frequency magnetic field interlined with the power receiving coil 502 and thus can control the magnitude of high-frequency current I flowing through the power receiving coil 502, i.e., the feed power for the power receiving device A. Here, the feed power refers to power supplied to the power receiving device A. As described above, the magnitude of the supplied power can be controlled by changing the magnitude of a high-frequency magnetic field interlinked with the power receiving coil 502, i.e., the magnitude of high-frequency current flowing through the

electromagnetic coil 100 which is the primary coil.

[0140] On the other hand, if operation of the electromagnetic coil 100 on the power feeding side is stopped, a high-frequency magnetic field is not supplied to the power receiving coil 502, so that power feeding to the power receiving device A is stopped. That is, through manipulation on the induction-heating cooker main body 2, power adjustment and ON/OFF control for the power receiving device A can be performed, whereby the feed power can be accurately adjusted. In the case where fine power adjustment is not required for the power receiving device A, the control unit 50 may change the adjustment value α in stages (i.e., change the adjustment value α in a stepwise manner), whereby simple adjustment steps, e.g., high, middle, low, can be realized. In this way, through manipulation on the induction-heating cooker main body 2, power feeding and ON/OFF control for the power receiving device A can be performed, and thus a power feeding device with high usability can be realized.

[0141] As described above, the maximum output power value MP required by the power receiving device A may be low as compared to that in the induction heating operation mode. Therefore, in order to suppress the maximum output power value of the drive unit 40, the control unit 50 disconnects the individual coils 103, 104 which are the peripheral coils, from the drive circuit 40b, to switch to only the individual coils 101, 102 which are the center coils, in FIG. 6 showing the detailed block diagram of the drive unit 40. That is, in the circuit of the induction-heating cooker 1 in FIG. 10, the switch 21 is opened.

[0142] The detailed configuration of the drive unit in the non-contact power feeding operation mode in this state is shown in a circuit diagram in FIG. 14. This circuit diagram corresponds to a part of the circuit configuration of the drive unit 40 shown in FIG. 6. Actually, as shown by a timing chart of control signals in FIG. 15, the control unit 50 fixes the signal levels of the control signals S4, S5 supplied to the drive unit 40 shown in FIG. 14, at L (low) level. Thus, the semiconductor switching elements 403a, 403b of the arm 403 shown in FIG. 14 are not driven and operation of the drive circuit 40b is stopped.

[0143] Therefore, no high-frequency current flows through the individual coils 103, 104 which are the peripheral coils. As a result, only the arm 402 and the arm 401 are driven, and high-frequency current I_a is supplied to only the individual coils 101, 102 which are the center coils connected between the intermediate points in the arm 402 and the arm 401. This state is equivalent to a state in which the switch 21 is opened in the circuit of the induction-heating cooker 1 in FIG. 10.

[0144] As a result, high-frequency current I_a flows through, of the electromagnetic coil 100, only the individual coils 101, 102 which are the center coils. Therefore, the maximum output power value in this case is different from the maximum output power value MP1 in the induction heating operation mode. That is, in the non-contact power feeding operation mode, the maximum output power value is set at the second maximum output power value MP2.

[0145] This case will be described returning to FIG. 8 again. FIG. 8 is a graph showing a relationship between the adjustment value α indicated by the horizontal axis, and the output power value P obtained by the electromagnetic coil 100, indicated by the vertical axis. If adjustment is performed by manipulating the manipulation units 5, 6 which are the output manipulation unit, the adjustment value α on the horizontal axis varies accordingly. The control unit 50 controls the drive unit 40 in accordance with the adjustment value α , to adjust the magnitude of high-frequency current I flowing through the individual coils 101, 102. Thus, the output power value P increases or decreases. If the load is the power receiving device A, the output power value P corresponds to the feed power. In FIG. 8, the maximum output power value in the non-contact power feeding operation mode when the adjustment value α is the maximum value α_1 is denoted by MP2 and defined as the second maximum output power value.

[0146] In the non-contact power feeding operation mode, since no high-frequency current is supplied to the individual coils 103, 104 which are the outer coils, the maximum output power value MP2 of the individual coils 101, 102 which are the inner coils are limited to about 1,500 W. In FIG. 8, when the adjustment value α is the maximum value α_1 , the maximum output power value MP2 becomes about half the maximum output power value MP1.

[0147] As shown in FIG. 9, in accordance with increase or decrease in the output power value P, the state of the display unit 7, e.g., the lighting state of the LEDs changes, and at the maximum output power value MP2, half of all the LEDs are lit. The adjustment value may be indicated by, for example, a numerical value, and any means that enables recognition of state change, the set value, or the like may be used.

[0148] Returning to FIG. 9 again, the lighting state of the LEDs in the non-contact power feeding operation mode is shown. When the manipulation units 5, 6 are manipulated, the lighting state of the LEDs changes in accordance with the selected adjustment value α . FIG. 9(b) shows the lighting state of the LEDs at the maximum output power value MP2 in the non-contact power feeding operation mode. In FIG. 9(b), the number of lit LEDs is half of all the LEDs. FIG. 9(d) shows change in the lighting state of the LEDs in accordance with the adjustment value α . The state in which all the LEDs are extinguished indicates that no power is supplied to the power receiving device A.

[0149] In FIG. 8, the lighting state of the LED indicator at the second maximum output power value MP2 is shown as a state corresponding to half the maximum output power value MP1 in the induction heating operation mode.

[0150] However, since the number of lit LEDs at the maximum output power value (maximum adjustment value α_1) is different between the induction heating operation mode and the non-contact power feeding operation mode, difference in operation mode can be recognized.

[0151] Accordingly, the control unit 50 controls the number of lit LEDs so as to be increased by two every time the adjustment value α is raised by one level by the manipulation units 5, 6. This is shown in FIG. 9(d). If the display unit 7 and the manipulation units 5, 6 as the output manipulation unit are controlled in this way, the manipulation range and the display content are not different between the induction heating operation mode and the non-contact power feeding operation mode, so that confusion can be avoided. Thus, an induction-heating cooker with high usability can be provided.

[0152] Here, only the individual coils 101, 102 which are the inner coils are driven. However, in accordance with the size of the power receiving coil 502 of the power receiving device A, the control unit 50 may control the drive unit 40 such that, if the outer diameter of the power receiving coil 502 is large, driving of the individual coils 101, 102 which are the inner coils is stopped and the individual coils 103, 104 which are the outer coils are driven. That is, if the individual coil having a coil diameter close to the outer diameter of the power receiving coil 502 is used as a power feed coil, it is possible to supply power efficiently.

[0153] Alternatively, even in the case where the power receiving coil 502 of the power receiving device A is small, the electromagnetic coil 100 may be operated as a large power feed coil to supply power. Such a configuration enables power to be efficiently supplied even when the positional relationship between the power receiving coil and the power feed coil is deviated.

[0154] Regarding the configuration and the like of the power receiving device A, the following (a) and (b) are conceivable.

(a) Communication functions may be provided on both sides so that communication can be performed between the power receiving device A on the power receiving side and the drive unit 40 on the power transmitting side provided in the induction-heating cooker main body 2.

Thus, when power is supplied from the electromagnetic coil 100 as the power feed coil to the power receiving subject composed of the power receiving device A, the power receiving subject can transmit a signal indicating that the power receiving subject is in a power receiving state, to the control unit 50. In this case, an effect of enabling more accurate determination is obtained. However, for example, the following complexity occurs: the drive unit 40 on the power transmitting side needs to supply initial power for the power receiving side to perform communication, and the power receiving side needs to transmit an identification signal to the power transmitting side (or the power transmitting side needs to make an inquiry to the power receiving device A); and determination data based on communication needs to be acquired for each power receiving device A in advance and stored, and it is necessary to check the data at the time of communication. If it is required to adapt to communications with power receiving devices A provided by many and unspecified power receiving device makers, it is desirable to set a common communication standard among the makers.

(b) In the power receiving circuit AX including the power receiving coil 502 of the power receiving device A, a resonant circuit is formed by the power receiving coil 502 and a resonant capacitor.

[0155] In this configuration, if electric characteristics are acquired by the detection unit 60 while the frequency of high-frequency current supplied from the drive unit 40 to the magnetic field generation excitation circuit EX including the electromagnetic coil 100 is varied, for example, from 10 kHz to 100 kHz, the load resistance R in the magnetic field generation excitation circuit EX has the maximum value at a resonant point of the resonant circuit of the power receiving circuit AX of the power receiving device A. Thus, it is possible to more accurately perform determination operation for the power receiving subject composed of the power receiving device A.

[0156] The configuration and operation effect of the induction-heating cooker according to Embodiment 1 will be summarized below.

(1) Entire configuration

[0157] As shown in FIG. 1 and FIG. 3, the induction-heating cooker 1 includes: the top plate 3 which is provided to the induction-heating cooker main body 2 and on which a load is placed; an electromagnetic coil 100 for generating, on the top plate 3, a magnetic field to perform heating operation for a heating target such as a pot P as a load by electromagnetic induction or perform power feeding operation for a power receiving subject such as a power receiving device A as a load by electromagnetic induction; the drive unit 40 which supplies high-frequency current to the electromagnetic coil 100; and the control unit 50 which controls the drive unit 40.

[0158] In addition, the detection unit 60 is provided which detects electric characteristics of a load placed on the top plate 3 on the basis of electric characteristics regarding the drive unit 40.

[0159] Here, the electric characteristics regarding the drive unit 40 are voltage, current, a frequency, a resistance value, temperature, or the like of the drive unit 40 itself, or those of the electromagnetic coil 100, the resonant capacitor 80, and the like connected to the drive unit 40. Specifically, examples of the electric characteristics include output voltage V and output current I of the drive unit 40, and the load resistance R of the magnetic field generation excitation circuit EX including the electromagnetic coil 100 and the resonant capacitor 80.

[0160] The control unit 50 has the load determination means for determining the type of the load, i.e., whether the load is a heating target or a power receiving subject, on the basis of a result of detection by the detection unit 60.

[0161] The control unit 50 determines the type of the load on the basis of a result of detection by the detection unit 60, and if the load is determined to be a heating target, the control unit 50 sets the output range of the drive unit 40 to a first range (0 to MP1) having the first maximum output power value MP1 and causes the electromagnetic coil 100 to operate as an induction heating coil in the induction heating operation mode.

[0162] If the load is determined to be a power receiving subject, the control unit 50 sets the output range of the drive unit 40 to a second range (0 to MP2) which is narrower than the first range (0 to MP1) and which has the second maximum output power value MP2 smaller than the first maximum output power value MP1, and controls the electromagnetic coil 100 to operate as a power feed coil in the non-contact power feeding operation mode to supply power to the power receiving subject by electromagnetic induction.

[0163] Here, it is not necessary to change the setting range or the setting method on the control unit 50 for controlling the drive unit 40, between the induction heating operation mode and the non-contact power feeding operation mode. In adjustment of output from the drive unit 40 by the manipulation units 5, 6 as the output manipulation unit, it is possible to perform the output adjustment through the same procedure by the same manipulation units 5, 6 in both operation modes, and also, the manipulation manner is not changed therebetween. Thus, operability is not lost.

[0164] Thus, it becomes possible to efficiently supply an appropriate amount of power in accordance with a target load, on the basis of whether the target load is a heating target to be heated by electromagnetic induction or a power receiving subject to be supplied with power by electromagnetic induction.

[0165] At this time, the maximum output power value is switched between the induction heating operation mode and the non-contact power feeding operation mode so that operation is performed in an optimum power range in each operation mode. Therefore, occurrence of unnecessary power is prevented, efficient operation can be performed, and power can be prevented from being excessively supplied in the non-contact power feeding operation mode.

[0166] This can be achieved by setting, in the non-contact power feeding operation mode, the output range of the drive unit 40 to the second range (0 to MP2) having the second maximum output power value MP2 smaller than the first maximum output power value MP1. Thus, it is not necessary to change the setting range, the setting method, or the like in accordance with whether the present operation mode is the induction heating operation mode or the non-contact power feeding operation mode. Therefore, operability is kept and convenience is not lost.

[0167] In addition, determination as to whether the load is a heating target or a power receiving subject by the control unit 50 is performed on the basis of electric characteristics regarding the drive unit 40 detected by the detection unit 60. Therefore, control for the drive unit 40 based on the detection result can be easily performed using a simple control configuration.

(2) Output power adjustment

[0168] Adjustment of output power in the output range (first range: 0 to MP1, or second range: 0 to MP2) of the drive unit 40 is performed through manipulation on the manipulation units 5, 6 as the output manipulation unit provided to the induction-heating cooker main body 2.

[0169] Thus, in both of the induction heating operation mode and the non-contact power feeding operation mode, power for heating a heating target such as a pot P and power supplied to a power receiving subject such as a power receiving device A can be adjusted through manipulation on the induction-heating cooker main body 2. Therefore, it becomes possible to adjust output power by only manipulation on the induction-heating cooker main body 2 side, and start and stop of operation can also be performed on the induction-heating cooker main body 2 side. Thus, usability is improved.

(3) Configuration of electromagnetic coil

[0170] As shown in FIG. 3(a), the electromagnetic coil 100 is formed by the induction heating coil composed of: the center coils 101, 102 formed by the individual coils wound in a planar shape; and the peripheral coils 103, 104 formed by one or more individual coils arranged around the center coils.

[0171] Thus, the electromagnetic coil 100 is formed by a plurality of individual coils, so that any individual coil can be selectively operated in accordance with the state of a load. Therefore, in the induction heating operation mode, efficient operation according to the shape of a pot can be performed through switchover operation of the individual coils, or the like, and cooking performance can be improved by switching the heating area. In addition, in the non-contact power feeding operation mode, by stopping operation of an unnecessary individual coil, efficiency is improved, and excessive supply of power is prevented, whereby stable operation can be performed.

(4) Configuration of individual drive circuit

[0172] As shown in FIG. 3 and FIG. 4, the electromagnetic coil 100 which is driven by the drive unit 40 is composed of a plurality of individual coils, and the drive circuits are provided for the respective plurality of individual coils.

[0173] Thus, by providing the drive circuits for the respective plurality of individual coils, it becomes possible to operate necessary individual coils in accordance with the state of a load. Therefore, in the induction heating operation mode, efficient operation according to the shape of a pot can be performed through switchover operation of the individual coils, or the like, and cooking performance can be improved by switching the heating area. In addition, in the non-contact power feeding operation mode, by stopping operation of an unnecessary individual coil, efficiency is improved, and excessive supply of power is prevented, whereby stable operation can be performed.

(5) Switchover of maximum output power value in accordance with operation mode

[0174] As shown in FIG. 8, the control unit 50 controls the drive unit 40 such that the maximum output power value MP2 in the non-contact power feeding operation mode in which power is supplied to a power receiving subject by electromagnetic induction using a magnetic field generated by the electromagnetic coil 100 is smaller than the maximum output power value MP1 in the induction heating operation mode in which a heating target is heated by the electromagnetic coil 100.

[0175] Thus, the maximum output power value MP2 required in the non-contact power feeding operation mode is smaller (e.g., up to 1.5 kW) than the maximum output power value MP1 (e.g., up to 3 kW) required in the induction heating operation mode. Therefore, through control of the maximum output power values MP1, MP2, unnecessary power consumption is suppressed and efficient operation can be performed, and in addition, power can be prevented from being excessively supplied in the power feeding, whereby stable operation can be performed.

(6) Switchover of individual coils

[0176] When it is detected that the load is a power receiving subject and thus the non-contact power feeding operation mode is applied, the control unit 50 controls the drive unit 40 so as to supply high-frequency current I to any arbitrary individual coil of the plurality of individual coils composing the electromagnetic coil 100 and set the maximum output power value MP2 to be smaller than the maximum output power value MP1 in the induction heating operation mode.

[0177] Thus, the maximum output power value MP2 required in the non-contact power feeding operation mode is smaller (e.g., up to 1.5 kW) than the maximum output power value MP1 (e.g., up to 3 kW) required in the induction heating operation mode. Therefore, through control of the maximum output power values MP1, MP2, unnecessary power consumption is suppressed and efficient operation can be performed, and in addition, power can be prevented from being excessively supplied in the power feeding, whereby stable operation can be performed.

[0178] In addition, it is not necessary to add any particular components or circuits for switchover, and control is performed so as to selectively switch the individual coils to be driven. Therefore, the power suppression by switchover of the individual coils can be realized with a simple configuration.

(7) Changeover of frequency of high-frequency current

[0179] As shown in FIG. 17, the control unit 50 controlling the drive unit 40 switches the frequency of high-frequency current supplied from the drive unit 40 to the electromagnetic coil, between the induction heating operation mode in which a heating target is heated by the electromagnetic coil 100 and the non-contact power feeding operation mode in which power is supplied to a power receiving subject by electromagnetic induction using a magnetic field generated by the electromagnetic coil 100. That is, the operation frequency in the non-contact power feeding operation mode is greater (higher) than the maximum value in the range of the operation frequency in the induction heating operation mode.

[0180] Thus, by switching the frequency of the high-frequency current, the maximum output power values MP1, MP2 can be adjusted. Therefore, it is possible to easily change the output range (first range: 0 to MP1, or second range: 0 to MP2) between the induction heating operation mode and the non-contact power feeding operation mode, without the need for complicated control.

(8) Switchover of resonant frequency of high-frequency current

[0181] As shown in FIG. 18 and FIG. 19, the control unit 50 switches the resonant frequency of the resonant circuit in the magnetic field generation excitation circuit EX including the electromagnetic coil 100, between the induction heating operation mode in which a heating target is heated by the electromagnetic coil 100 and the non-contact power feeding operation mode in which power is supplied to a power receiving subject by electromagnetic induction using a magnetic

field generated by the electromagnetic coil.

[0182] Thus, by switching the value of the resonant capacitor to change the frequency of the resonant circuit, the maximum output power values MP1, MP2 can be adjusted. Therefore, it is possible to easily change the output range (first range: 0 to MP1, or second range: 0 to MP2) between the induction heating operation mode and the non-contact power feeding operation mode, without the need for complicated control.

(9) Switchover of drive circuit configuration

[0183] As shown in FIG. 20 and FIG. 21, the control unit 50 switches the circuit configuration of the drive unit 40 such that, in the induction heating operation mode in which a heating target is heated by the electromagnetic coil 100, operation is performed with a full-bridge circuit configuration, and in the non-contact power feeding operation mode in which power is supplied to a power receiving subject by electromagnetic induction using a magnetic field generated by the electromagnetic coil 100, operation is performed with a half-bridge circuit configuration.

[0184] Thus, by controlling the drive signals to switch the circuit configuration of the drive unit 40, the maximum output power values MP1, MP2 can be adjusted. Therefore, it is possible to easily change the output range (first range: 0 to MP1, or second range: 0 to MP2) between the induction heating operation mode and the non-contact power feeding operation mode, without the need for complicated control.

(10) Switchover of operation mode

[0185] Frequency characteristics of a load resistance indicating load characteristics when a heating target is placed in the magnetic field is set in advance as determination characteristics in the control unit 50 itself, and the control unit 50 determines whether or not a power receiving subject is placed, by comparison with determination characteristics that are frequency characteristics of a load resistance indicating load characteristics when a power receiving subject is placed in the magnetic field.

[0186] Thus, a load placed on the top plate 3 is detected on the induction-heating cooker main body 2 side, whereby it is possible to swiftly and reliably determine whether to execute the induction heating operation mode or the non-contact power feeding operation mode. Further, since the display and the manipulation setting are changed in accordance with the operation mode, switchover manipulation or the like is not needed, and thus usability is improved.

(11) Power receiving subject with communication function

[0187] The control unit 50 for controlling the drive unit 40, and a power receiving subject such as the power receiving device A, are provided with communication functions. When power is supplied to the power receiving subject by electromagnetic induction by the electromagnetic coil 100, the power receiving subject transmits a signal indicating that the power receiving subject is in a power receiving state, to the control unit 50.

[0188] Thus, when a power receiving subject such as the power receiving device A is placed on the top plate 3, it can be confirmed that the power receiving subject is in a power receiving state, whereby determination for the power receiving subject can be more accurately performed.

(12) Power receiving subject having resonant circuit

[0189] A power receiving subject such as the power receiving device A is provided with the power receiving circuit AX forming a resonant circuit composed of the resonant capacitor and the power receiving coil 502 to which power is supplied by electromagnetic induction by the electromagnetic coil 100.

[0190] As described above, in induction-heating cooker according to Embodiment 1, in the induction heating operation mode, high-frequency current can be supplied selectively to a plurality of individual coils in accordance with the size, the shape, or positional deviation of a pot, and thus highly efficient heating can be achieved. In the non-contact power feeding operation mode, only the individual coil that can supply necessary power is driven in accordance with the maximum output power value required by the power receiving device, whereby excessive supply of power to the power receiving device can be prevented, and thus efficient power feeding can be achieved.

[0191] Further, power control for the power receiving device can be performed from the induction-heating cooker main body, and thus usability can be improved. In addition, unnecessary leakage of a magnetic flux from the individual coil above which a power receiving device is not placed can be suppressed. In addition, the output adjustment range of the manipulation unit and the display content of the display unit are set to be the same between the induction heating operation mode and the non-contact power feeding operation mode, and thus usability can be improved.

Embodiment 2

[0192] FIG. 16 is a flowchart showing a processing procedure of load detection in an induction-heating cooker according to Embodiment 2. In Embodiment 2, when a load is placed on any or all of heating parts of the induction-heating cooker main body, the type of the load is determined and the maximum output power value is switched.

[0193] When a load is placed at the heating part 10 on the top plate 3 and heating operation or power feeding operation is started at the heating part 10, electric characteristics of the placed load are detected by the detection circuits 60a, 60b of the detection unit 60, and load characteristics are detected by the detection unit 60 on the basis of the electric characteristics. The control unit 50 detects whether the load is the power receiving device A, a pot P which is a heating target, or a non-heating target (small object or the like), or whether a load is present, and switches the maximum output power value MP of the drive unit 40 (see FIG. 7, FIG. 8, and FIG. 10).

[0194] Next, the load detection operation will be described with reference to the flowchart showing the load detection processing procedure in FIG. 16.

[0195] First, when a load is placed on the heating part 10 and operation of the induction-heating cooker main body 2 is started by the manipulation units 5, 6, the detection unit 60 starts detection of electric characteristics (electric characteristics of the drive circuit) regarding the electromagnetic coil 100 above which the load is placed (step S11). The control unit 50 controls the phase θ of the drive signal so as to output the high-frequency current I that is insufficient for heating but is great enough for detection, and sweeps the frequency (drive frequency fsw) of the high-frequency current I over a frequency range of, for example, 10 kHz to 100 kHz within a certain time period, thus controlling the drive unit 40 (step S12).

[0196] On the basis of variation in the electric characteristics at this time, the control unit 50 determines whether or not the load is a power receiving subject composed of the power receiving device A, by the load determination means which is provided in the control unit 50 and which determines and detects a power receiving subject (step S13). It is noted that, at the time of the determination in step S13, the threshold value with respect to the determination characteristics curve T in the detection unit 60 is set to a value for power receiving subject detection.

[0197] If the load is determined to be the power receiving device A in step S13, the control unit 50 sets the maximum output value of the drive unit 40 to the second maximum output power value MP2 (step S14), and starts to supply power to the power receiving device A which is the load, in accordance with manipulation of the manipulation unit 6 (step S15).

[0198] On the other hand, if the load is determined not to be the power receiving device A in step S13, the control unit 50 controls the phase θ of the drive signal so as to output the high-frequency current I that is great enough for detection, and sets the drive frequency fsw to a frequency for pot detection, thus controlling the drive unit 40 (step S16).

[0199] On the basis of electric characteristics at this time, whether or not the load is a heating target is determined (step S17), and if the load is determined not to be a heating target (not targeted for heating), the control unit 50 stops operation of the drive unit 40 (step S20).

[0200] Next, if the load is determined to be a heating target by the detection unit 60 in step S17, the control unit 50 sets the maximum output value to the first maximum output power value MP1 (step S18), and starts to heat the load in accordance with manipulation of the manipulation unit 6 (step S19). At the time of the determination in step S17, the threshold value with respect to the determination characteristics curve T in the detection unit 60 is set to a value for heating target detection.

[0201] In accordance with the determination result, the control unit 50 may control the display unit 7 to make such display as to show whether the present operation mode is the induction heating operation mode or the non-contact power feeding operation mode.

[0202] The configuration and operation effect of the induction-heating cooker according to Embodiment 2 will be summarized below.

[0203] In the control method of the induction-heating cooker 1 in Embodiment 2, first, electric characteristics of the drive unit 40 which drives the electromagnetic coil 100 for generating a magnetic field are detected by the detection circuits 60a, 60b, and then, on the basis of the electric characteristics (current, voltage, frequency), the detection unit 60 detects load characteristics (frequency characteristics of load resistance) of a load placed in the magnetic field. Further, the load determination means of the control unit 50 determines whether the load is a heating target or a power receiving subject, on the basis of the load characteristics.

[0204] If the load is determined to be a heating target, the control unit 50 sets the output range of the drive unit 40 to the first range (0 to MP1) having the first maximum output power value MP1, and controls the electromagnetic coil 100 as an induction heating coil so as to heat the heating target.

[0205] If the load is determined to be a power receiving subject, the control unit 50 sets the output range of the drive unit 40 to the second range (0 to MP2) having the second maximum output power value MP2 smaller than the first maximum output power value MP1, and controls the electromagnetic coil 100 as a power feed coil so as to supply power to the power receiving subject by electromagnetic induction.

[0206] Thus, in the induction-heating cooker 1, the type of a load placed on the top plate 3 is automatically determined,

and using the electromagnetic coil 100 normally used as an induction heating coil, normal induction heating cooking can be performed in accordance with the load, while the induction-heating cooker 1 can also operate as a non-contact power feeding device for supplying power in a non-contact manner. Thus, convenience can be improved.

[0207] The flowchart showing the load detection processing procedure includes a step of determining whether a load is a power receiving subject and a step of determining whether a load is a heating target, and the step of determining whether a load is a power receiving device is performed first.

[0208] Thus, determination for a power receiving device can be reliably performed first, so that erroneous shifting to the induction heating operation mode can be prevented.

[0209] As described above, in the induction-heating cooker according to Embodiment 2, whether a load is a heating target or a power receiving device is determined first, whereby determination for a power receiving device is reliably performed, so that erroneous shifting to the heating operation can be prevented. In addition, the maximum output power value is more reliably suppressed, whereby excessive supply of power to the power receiving device can be prevented.

Embodiment 3

[0210] In Embodiment 3, the maximum output power value is switched between the induction heating operation mode and the non-contact power feeding operation mode. Switchover of the maximum output power value by change of the drive frequency of the induction-heating cooker according to Embodiment 3 will be described with reference to mainly a circuit diagram showing a resonant circuit including the drive unit and a graph showing a relationship between a frequency and high-frequency current (output power) in FIG. 17.

[0211] FIG. 17(a) is a simplified circuit diagram of the resonant circuit including the drive unit 40. FIG. 17(b) shows a relationship between the frequency f and the high-frequency current I obtained at the frequency f .

[0212] In FIG. 17(a), a capacitor C corresponds to the resonant capacitor 81, 83 and a reactance L corresponds to the electromagnetic coil 100 in FIG. 7. In FIG. 17(a), although not shown, the drive unit 40, the control unit 50, and the detection unit 60 are provided as in FIG. 7.

[0213] As shown in FIG. 7, when a load is placed above the electromagnetic coil 100 with the top plate 3 therebetween, the detection unit 60 detects load characteristics of the placed load. If the load is determined to be a heating target such as a pot P by the load determination means, the control unit 50 sets, as a frequency f_{sw1} of the drive signal, a frequency that is higher by $\Delta f1$ than a resonant frequency $f0$ obtained from electric characteristics of a resonant load formed by the resonant capacitor C and the coil L (electromagnetic coil 100) coupled with the load, as simply shown in FIG. 17(a), and thus drives the drive unit 40. At this time, from a relationship between the load resistance R and the high-frequency current I flowing through the resonant circuit, as shown in FIG. 17(b), the high-frequency current I is maximized at the resonant frequency $f0$ and thus the maximum output power value $MP1$ is obtained.

[0214] On the other hand, as shown in FIG. 10, when a load is placed above the electromagnetic coil 100 with the top plate 3 therebetween and the detection unit 60 detects that the placed load is the power receiving device A , similarly, the control unit 50 sets, as a frequency f_{sw2} of the drive signal, a frequency that is higher by $\Delta f2$ than a resonant frequency $f0$ obtained from electric characteristics of a resonant load formed by the resonant capacitor C and the coil L (electromagnetic coil 100) coupled with the load, as simply shown in FIG. 17(a). The $\Delta f2$ may be a value set in advance, or may be set to n times the $\theta f1$. In this case, $\Delta f1 < \Delta f2$ is satisfied. That is, as shown in FIG. 17(b), the control unit 50 sets, as the frequency of the drive signal for the drive unit 40, the frequency f_{sw2} at which high-frequency current $I2$ is obtained so that the maximum output power value satisfies $MP2 < MP1$, i.e., the maximum output power value $MP2$ roughly becomes about half the maximum output power value $MP1$.

[0215] Thus, in the non-contact power feeding operation mode, the frequency f_{sw} of the drive signal set for the drive unit 40 is controlled, that is, the range of operation characteristics of the drive unit 40 is controlled using the frequency, whereby the maximum output power value MP can be easily suppressed. Therefore, excessive supply of power to the power receiving device A is prevented and power feeding operation can be efficiently performed, and additional components such as a switchover circuit are not needed and the configuration cost can be reduced.

[0216] The configuration and operation effect of the induction-heating cooker according to Embodiment 3 will be summarized below.

[0217] With the configuration of Embodiment 1 or Embodiment 2 described above, the control unit 50 controlling the drive unit 40 switches the frequency of high-frequency current I supplied to the drive unit 40, between the induction heating operation mode in which a heating target is heated by the electromagnetic coil 100 and the non-contact power feeding operation mode in which power is supplied to the power receiving subject by electromagnetic induction using a magnetic field generated by the electromagnetic coil 100.

[0218] Thus, by changing the drive frequency f_{sw} , the maximum output power values $MP1$, $MP2$ can be adjusted. Therefore, it is possible to easily change the output range (first range: 0 to $MP1$, or second range: 0 to $MP2$) between the induction heating operation mode and the non-contact power feeding operation mode, without the need for complicated control.

[0219] As described above, in the induction-heating cooker according to Embodiment 3, with the configuration of Embodiment 1 or Embodiment 2, the control unit switches the frequency of the drive signal supplied to the drive unit, between the induction heating operation mode and the non-contact power feeding operation mode, that is, the operation frequency in the non-contact power feeding operation mode is set to be greater (higher) than the maximum value in the range of the operation frequency in the induction heating operation mode, whereby the range of the frequency of the high-frequency current is switched and the range of the maximum output power value can be adjusted. Therefore, the output ranges in the induction heating operation mode and the non-contact power feeding operation mode can be easily changed without the need for complicated control.

Embodiment 4

[0220] Embodiment 4 is another embodiment in which the maximum output power values in the induction heating operation mode and the non-contact power feeding operation mode are switched. Suppression of the maximum output power value by switching a resonant capacitor in the induction-heating cooker according to Embodiment 4 will be described with reference to FIG. 18 and FIG. 19.

[0221] The detection unit 60 detects electric characteristics of a load placed above the individual coils 101, 102 with the top plate 3 therebetween. Then, if the load determination means determines that the load is the power receiving device A, the control unit 50 closes the switch 21 connected in parallel to the resonant capacitor 81. When the switch 21 is closed, the resonant capacitor 82 is connected in parallel to the resonant capacitor 81, whereby the capacitance of the resonant capacitor increases. Here, if the capacitance of the resonant capacitor 81 is denoted by C81, the capacitance of the resonant capacitor 82 is denoted by C82, and the combined capacitance of C81 and C82 is denoted by C81', C81 < C81' is satisfied. As a result, a resonant frequency f0' of a resonant load formed by the resonant capacitors 81, 82, the power receiving device A, and the individual coils 101, 102 connected to the drive unit 40, is lowered as compared to the case where the switch 21 is opened. This is shown by Expression (3) and Expression (4).

Mathematical 3

$$f_0 = \frac{1}{2\pi\sqrt{(L \times C_{81})}} \quad \dots (3)$$

[Mathematical 4]

$$f_0' = \frac{1}{2\pi\sqrt{(L \times C_{81}')}} \quad \dots (4)$$

[0222] It is noted that, from C81 < C81', f0 > f0' is satisfied.

[0223] Here, L in Expression (1) and Expression (2) is an inductance in a state in which the power receiving device A as a load and the coil 100 are coupled.

[0224] FIG. 19(a) is a circuit diagram showing the resonant circuit including the drive unit 40. FIG. 19(b) is a graph showing a relationship between the drive frequency fsw and the high-frequency current I.

[0225] In a state in which the switch 21 is closed, the resonant frequency of the circuit is lowered (f0'), and therefore, when the drive unit 40 is operated at the drive frequency fsw, the high-frequency current I outputted is smaller than in the case where the switch 21 is opened. That is, when the load is the power receiving device A, the control unit 50 switches the switch 21 to add a resonant capacitor 82, thereby increasing the capacitance of the resonant capacitor C connected in series to the coil L and lowering the resonant frequency f0 relative to the drive frequency fsw, thus performing control so as to suppress the obtained maximum output power value MP.

[0226] It is noted that, in the case where the load is placed above the individual coils 103, 104 with the top plate 3 therebetween, a resonant capacitor 84 connected in series to a switch 22 is connected in parallel to the resonant capacitor 83, and the switch 22 is closed to increase the capacitance of the capacitor and lower the resonant frequency f0, thereby obtaining the same effect.

[0227] In the above description, the individual coils 101 to 104 of the electromagnetic coil 100 composed of a plurality of coils shown in FIG. 2(a) have been shown as an example. However, coils having another configuration may be applied.

[0228] The configuration and operation effect of the induction-heating cooker according to Embodiment 4 will be

summarized below.

[0229] In the configuration of any of embodiments 1 to 3 described above, the control means composed of the control unit 50 switches the resonant capacitor of the resonant circuit between the induction heating operation mode and the non-contact power feeding operation mode.

[0230] By switching the value of the resonant capacitor C to change the resonant frequency f₀ of the resonant circuit, the maximum output power values MP1, MP2 can be adjusted. Therefore, it is possible to easily change the output range (first range: 0 to MP1, or second range: 0 to MP2) between the induction heating operation mode and the non-contact power feeding operation mode, without the need for complicated control.

[0231] As described above, in the induction-heating cooker according to Embodiment 4, the control unit controls the resonant frequency of the resonant load of the drive unit in accordance with the induction heating operation mode and the non-contact power feeding operation mode, whereby the maximum power value can be easily suppressed. Therefore, by switching the resonant capacitor to control the resonant frequency, excessive supply of power to the power receiving device is prevented, and thus control is performed so that unnecessary power is not supplied, whereby power feeding operation can be efficiently performed.

Embodiment 5

[0232] Embodiment 5 is another embodiment in which the maximum output power values in the induction heating operation mode and the non-contact power feeding operation mode are switched. Switchover of the circuit configuration of the drive unit in Embodiment 5 will be described with reference to FIG. 20 and FIG. 21.

[0233] FIG. 20(a) is a schematic diagram of a circuit block showing a part of the drive unit 40 in the induction-heating cooker 1. FIG. 20(a) shows a full-bridge circuit composed of the switching element pairs 401, 402, the resonant capacitor 80, and the electromagnetic coil 100. The full-bridge circuit is driven by drive signals composed of two pairs of complementary signals a, a' and b, b' shown in FIG. 20(b), thereby supplying high-frequency current I to the electromagnetic coil 100. The control unit 50 sets the frequency of the drive signals to an optimum frequency within a range of 10 kHz to 100 kHz in accordance with electric characteristics detected by the detection unit 60. For example, a frequency obtained by adding a value Δf, which is several kHz, to the resonant frequency f₀ of the drive unit 40 when the electromagnetic coil 100 is coupled with a load placed on the top plate, is set as the drive frequency f_{sw}.

[0234] Here, description will be given using the electromagnetic coil 100 provided at the heating part 10, as a representative example. For facilitating the description, the electromagnetic coil 100 is shown as a single coil. The magnitude of high-frequency current I supplied to the electromagnetic coil 100 can be adjusted using a phase difference θ between the drive signals a, b (a', b') as described in the other embodiment. The operation of the full-bridge circuit is well known, and therefore the description thereof is omitted here.

[0235] Although not shown in FIG. 20(a), the semiconductor switching element pairs 401, 402 composing the drive unit 40 are supplied with power supply voltage V via the commercial power supply 31, the diode bridge 32, and the smoothing circuit 33. When the full-bridge circuit operates, power supply voltage |V| is applied across the resonant capacitor 80 and the electromagnetic coil 100 during a period T_θ corresponding to the magnitude of the phase difference θ, per one cycle of the drive frequency f_{sw} (FIG. 20(d)).

[0236] On the other hand, high-frequency current flowing through an impedance Z of the drive circuit formed from a combined resistance of the resonant capacitor 80, the electromagnetic coil 100, and a load placed on the top plate 3, is denoted by I. The load R is a combined resistance of a resistance component of the electromagnetic coil 100 and the load. The current I flowing through the drive circuit is maximized when ωL-(1/ωC) in Expression (5) is "0", i.e., |Z| = R is satisfied, and at this time, the maximum output power value MP is obtained.

Mathematical 5

$$|Z| = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} \quad \dots (5)$$

[0237] If a load placed on the top plate 3 is determined to be a heating target such as a pot P by the detection unit 60 and the load determination means of the control unit 50, the induction-heating cooker 1 shifts to the induction heating operation mode, and the control unit 50 causes the drive unit 40 to operate with a full-bridge circuit configuration, and controls the phase difference θ between the drive signals a, b (a', b') so as to obtain the output power value P set by the manipulation units 5, 6 which are not shown in FIG. 20, thereby controlling high-frequency current I supplied to the electromagnetic coil 100.

[0238] On the other hand, if the load placed on the top plate 3 is determined to be the power receiving device A by the detection unit 60 and the load determination means of the control unit 50, the control unit 50 outputs the drive signals a, a', b, b' in accordance with timings shown in FIG. 20(c), to the drive unit 40. As shown in FIG. 20(c), the drive signal b is constantly at L (low) level, and the drive signal b' is constantly at H (high) level. Therefore, as shown in FIG. 21(a), the drive signal b supplied to the upper semiconductor switching element 402a of the semiconductor switching element pair 402 is constantly at L (low) level, so that the semiconductor switching element 402a is not driven.

[0239] On the other hand, the drive signal b' supplied to the lower semiconductor switching element 402b is constantly at H (high) level, so that the semiconductor switching element 402b is constantly in an ON state. As a result, the semiconductor switching element pairs 401, 402 composing the drive unit 40 have a circuit configuration shown in FIG. 21(b). That is, if the load is determined to be the power receiving device A, the induction-heating cooker 1 shifts to the non-contact power feeding operation mode, and the control unit 50 controls the drive unit 40 so as to have a half-bridge circuit configuration.

[0240] The semiconductor switching element pairs 401, 402 composing the drive unit 40 are supplied with power supply voltage V via the AC power supply 31, the diode bridge 32, and the smoothing circuit 33 which are not shown in FIG. 20. When the half-bridge circuit operates, the power supply voltage V is applied across the resonant capacitor 80 and the electromagnetic coil 100 during a period T_w corresponding to a pulse width T_w , per one cycle of the drive frequency f_{sw} (FIG. 20(e)). As a result, the magnitude of high-frequency current I_2 flowing through the electromagnetic coil 100 becomes half of that in the induction heating operation mode corresponding to the full-bridge circuit configuration, and the obtained maximum output power value MP is also halved.

[0241] That is, if the load is the power receiving device A which does not require great power, the control unit 50 controls the drive signals to be outputted to the drive unit 40, so as to switch the circuit configuration of the drive unit 40, whereby the maximum output power value MP can be suppressed.

[0242] In the above description, changeover of the circuit configuration has been described using simplified diagrams shown in FIG. 20 and FIG. 21. However, in the case of applying the actual drive circuit shown in FIG. 6, two half-bridge circuits are included, with the semiconductor switching element pair 401 shared.

[0243] The configuration and operation effect of the induction-heating cooker according to Embodiment 5 will be summarized below.

[0244] In the induction-heating cooker 1 according to the present embodiment, with the configuration of any of embodiments 1 to 4, the control unit 50 switches the circuit configuration of the drive unit 40 so as to operate with a full-bridge circuit configuration in the induction heating operation mode, and operate with a half-bridge circuit configuration in the non-contact power feeding operation mode.

[0245] Thus, by switching the circuit configuration, the maximum output power values MP1, MP2 can be adjusted in the induction heating operation mode and the non-contact power feeding operation mode, without the need for complicated control. Therefore, it is possible to easily change the output range (first range: 0 to MP1, or second range: 0 to MP2) in accordance with the operation mode.

[0246] As described above, in the induction-heating cooker according to Embodiment 5, in the induction heating operation mode, operation is performed such that high-frequency current is supplied selectively to a plurality of individual coils in accordance with the size, the shape, positional deviation, or the like of a pot, and thus highly efficient heating can be achieved. In addition, in the non-contact power feeding operation mode, the maximum output power value can be easily suppressed by controlling the drive unit, and operation is performed so as to drive only the coil that can supply necessary power, in accordance with the maximum power required by the power receiving device. Therefore, efficient power feeding can be performed, and additional components such as a switchover circuit are not needed and the configuration cost can be reduced. Further, unnecessary leakage of a magnetic flux from the coil above which the power receiving device is not placed can be suppressed. In addition, power control for the power receiving device can be performed from the induction-heating cooker main body, and thus usability is improved.

Embodiment 6

[0247] FIG. 22 is a diagram showing a configuration example of the manipulation unit in Embodiment 6. Embodiment 6 is another embodiment in which the maximum output power value is switched between the induction heating operation mode and the non-contact power feeding operation mode, through switch manipulation.

[0248] As shown in FIG. 22, in the present embodiment, the non-contact power feeding operation mode can be arbitrarily selected using a manipulation switch, and the manipulation unit 5 of the induction-heating cooker main body 2 is provided with an operation mode switchover switch 511 as a manipulation switch for selecting one of the induction heating operation mode and the non-contact power feeding operation mode. When the non-contact power feeding operation mode is selected by the manipulation switch, the control unit 50 controls the drive unit 40 so as to switch the maximum output power value MP of the drive unit 40 to the second maximum output power value MP2.

[0249] Hereinafter, switchover of the operation mode in the present embodiment will be described with reference to

FIG. 22.

[0250] The manipulation unit 5 shown in FIG. 22(a) has, as manipulation switches, an operation mode switchover switch 511 for selecting one of the induction heating operation mode and the non-contact power feeding operation mode to start the operation, and a down switch 512 and an up switch 513 for adjusting the magnitude of a feed power value or an output power value. Further, the manipulation unit 5 has, as a manipulation switch, a stop switch 514 for stopping operation when operation is being performed in the induction heating operation mode or the non-contact power feeding operation mode. It is noted that the types and the arrangement of the manipulation switches are merely an example, and are not limited to those described above.

[0251] On the operation mode switchover switch 511, a design (pictogram) representing the induction heating operation mode and a design representing the non-contact power feeding operation mode are displayed. When it is detected that the operation mode switchover switch 511 is pressed once, the control unit 50 determines that the induction heating operation mode is selected, and shifts to the induction heating operation mode. The detection unit 60 detects electric characteristics of a load placed on the top plate 3, and detects load characteristics on the basis of the electric characteristics.

[0252] If the load is determined to be a heatable load (pot P) by the load determination means, the control unit 50 sets the maximum output power value MP of the drive unit 40 to the first maximum output power value MP1, and controls the drive unit 40 under a drive condition adapted to the material and the shape of the load, so as to obtain the output power value P of heating in accordance with the set adjustment value α , thus performing heating operation. In the case where the load is determined to be a load unsuitable for heating, e.g., the case where no load is placed or the load is the power receiving device A, the control unit 50 controls the drive unit 40 so as not to shift to heating operation, and stops heating operation.

[0253] On the other hand, when it is detected that the operation mode switchover switch 511 is pressed twice in a row, the control unit 50 determines that the non-contact power feeding operation mode is selected, and shifts to the non-contact power feeding operation mode. Then, electric characteristics of a load placed on the top plate 3 are detected by the detection circuits 60a, 60b in FIG. 4, and the detection unit 60 detects load characteristics on the basis of the electric characteristics.

[0254] Then, if the load determination means determines, on the basis of the load characteristics, that the load is the power receiving device A to which power can be supplied, the control unit 50 sets the maximum output power value of the drive unit 40 to the second maximum output power value MP2, and controls the drive unit 40 so as to supply power in accordance with the adjustment value α to the power receiving device A. In the case where no load is placed or it is detected that the load is not the power receiving device A or is a heating target, the control unit 50 controls the drive unit 40 so as not to shift to power feeding operation, and stops power feeding operation.

[0255] If the operation mode switchover switch 511 is pressed plural times, the operation mode is sequentially switched in order of, from the first pressing, induction heating operation mode, non-contact power feeding operation mode, induction heating operation mode, ..., every time the operation mode switchover switch 511 is pressed. For stopping operation, the stop switch 514 is pressed, whereby the operation being performed in any operation mode is stopped or the selection of the operation mode is cancelled. It is noted that the number of times of pressing of the button is merely an example and each mode may be identified on the basis of difference in the length of the pressing time period.

[0256] The manipulation unit 5 is provided with the operation mode switchover switch 511 to form a switchover manipulation unit so as to allow the operation mode to be arbitrarily selected. Thus, usability can be improved. In the example shown in FIG. 22(a), the operation mode switchover switch 511 for switching between the induction heating operation mode and the non-contact power feeding operation mode is integrated into one part, different designs for the induction heating operation mode and the non-contact power feeding operation mode are displayed on the surface of the button, and the stop switch 514 is provided independently. Thus, the manipulation switch is provided for each function without increase in the number of manipulation switches, whereby the manipulation content can be easily understood and convenience is improved.

[0257] In addition, the operation mode can be selected, and the time period for the control unit 50 to determine a load can be reduced. Further, even if a load that is difficult to determine is placed, it is possible to perform proper operation by selecting the operation mode appropriately.

[0258] FIG. 22(b) shows an example of the manipulation unit 5 in which operation mode switchover switches are independently provided. That is, an induction heating operation mode switch 511a and a non-contact power feeding operation mode switch 511b are provided separately, and each manipulation switch has both functions of starting and stopping operation. For example, when the non-contact power feeding operation mode switch 511b is pressed once, the control unit 50 detects that the non-contact power feeding operation mode switch is pressed, and shifts to the non-contact power feeding operation mode.

[0259] The operation subsequent to the shifting is the same as that described above, and therefore the detailed description thereof is omitted here. The non-contact power feeding operation mode switch 511b serves also as a stop switch. Therefore, when the non-contact power feeding operation mode switch 511b is pressed again during power

feeding operation, the control unit 50 controls the drive unit 40 so as to stop the power feeding operation.

[0260] Similarly, when the induction heating operation mode switch 511 a is pressed, the control unit 50 detects that the induction heating operation mode switch is pressed, and shifts to the induction heating operation mode. The operation subsequent to the shifting is the same as that described above, and therefore the detailed description thereof is omitted here. The induction heating operation mode switch 511a serves also as a stop switch. Therefore, when the induction heating operation mode switch 511a is pressed again during heating operation, the control unit 50 controls the drive unit 40 so as to stop the heating operation.

[0261] FIG. 22(c) shows an example of the manipulation unit 5 in which a stop switch 514 is further provided to the manipulation unit 5 shown in FIG. 22(b), and the operation mode switchover switch 511 and the stop switch 514 are provided separately from each other. Operation when each manipulation switch is pressed is the same as that described above, and therefore the detailed description thereof is omitted.

[0262] In order to allow recognition of the selected operation mode, although not shown here, the selected manipulation switch may be lit when the operation mode switchover switch 511 is pressed. For example, the manipulation switch itself may be caused to light up, or the periphery of the manipulation switch may be lit up. Alternatively, at any easily visible location on the top plate 3 near the heating part for which the operation mode is selected, a display such as an LED lamp may be provided and may be lit up in different colors according to the respective operation modes.

[0263] Further, the display unit 7 may be provided with such a function as to display the operation mode so as to show whether the present operation modes is the induction heating operation mode or the non-contact power feeding operation mode, and thus the display unit 7 may form an operation mode display unit. When a pot is placed on the top plate 3, even if the non-contact power feeding operation mode switch is erroneously pressed, it is possible to recognize that the manipulation is wrong owing to the display indicating the non-contact power feeding operation mode.

[0264] In the above description, manipulation of the manipulation switch is detected by the control unit 50. However, the following configuration may be adopted: a microcomputer provided separately or the like determines the manipulation state, a command corresponding to the manipulation is given to the control unit 50, and the control unit 50 controls the drive unit 40 on the basis of the command. By providing, to the manipulation unit 5, the operation mode switchover switch for switching the operation mode, convenience can be improved.

[0265] In the above description, manipulation of the manipulation unit 5 for one of the plurality of heating parts has been described as an example. However, the above configuration may be provided to the respective manipulation units 5 correspondingly for the heating parts so that the plurality of heating parts 9, 10, 11 can be operated in arbitrary operation modes. For example, cooking in the induction heating operation mode may be performed by the heating part 10, and at the same time, the heating part 11 may be operated in the non-contact power feeding operation mode to simultaneously make a sauce by a blender or the like which operates by receiving power in a non-contact manner. Thus, usability is further improved.

[0266] The configuration and operation effect of the induction-heating cooker according to Embodiment 6 will be summarized below.

[0267] The induction-heating cooker 1 according to the present embodiment has, in the configuration of any of embodiments 1 to 5, the switchover manipulation unit composed of the manipulation unit 5 having the manipulation switch for switching between the induction heating operation mode in which a heating target is heated by the electromagnetic coil 100 and the non-contact power feeding operation mode in which power is supplied to a power receiving subject by electromagnetic induction using a magnetic field generated by the electromagnetic coil 100.

[0268] Thus, it is possible to arbitrarily select between the induction heating operation mode and the non-contact power feeding operation mode, and therefore convenience is improved.

[0269] The induction-heating cooker 1 according to the present embodiment has, in the configuration of any of embodiments 1 to 5, the display unit 7 which displays indication items including the control state and the operation guide and which has the operation mode display unit for indicating whether operation is being performed in the induction heating operation mode in which a heating target is heated by the electromagnetic coil 100 or the non-contact power feeding operation mode in which power is supplied to a power receiving subject by electromagnetic induction using a magnetic field generated by the electromagnetic coil 100.

[0270] Thus, the state of the operation mode can be visually recognized, and therefore convenience is improved.

[0271] As described above, in the induction-heating cooker according to Embodiment 5, a dedicated manipulation switch for selecting the operation mode is provided, whereby the induction heating operation mode and the non-contact power feeding operation mode can be switched. Thus, convenience can be improved.

Embodiment 7

[0272] In Embodiment 7, when an adjustment value is selected on the manipulation unit, the output power value of the induction-heating cooker can be adjusted using an output power value setting table in which output power values are set in advance in accordance with adjustment values (setting levels) in the induction heating operation mode and

the non-contact power feeding operation mode.

[0273] FIG. 23 to FIG. 31 illustrate operations in Examples 1 to 3 of the induction-heating cooker 1 according to Embodiment 7. Hereinafter, the details of the operations in these examples will be described.

[0274] Here, as the configuration of the induction-heating cooker 1 in Embodiment 7, the one shown in FIG. 3 and FIG. 4 in Embodiment 1 can be used, and therefore the description of the components thereof is omitted. It is noted that the configurations in the other embodiments can be also applied.

[0275] In general, in cooking using the induction-heating cooker, the cooking is performed while adjusting the output power value (power) to a suitable value for cooking in accordance with the cooking content. The present embodiment relates to a method in which, in cooking, in order to adjust the magnitude of the output power value P using the manipulation unit 5 or the manipulation unit 6 so as to obtain a desired output power value in accordance with the cooking content, the control unit 50 of the induction-heating cooker 1 sets the magnitude of the output power value P corresponding to the adjustment value α , to a different value according to each operation mode, without changing the adjustment range of the adjustment value α (setting level) between the induction heating operation mode and the non-contact power feeding operation mode.

[0276] That is, the control unit 50 controls the drive unit 40 such that the adjustable range of the adjustment value α (setting level) that can be adjusted using the manipulation unit 5 or the manipulation unit 6 is the same between both operation modes, and the output power value P corresponding to the same adjustment value α is different between both operation modes.

[0277] The magnitude of the output power value P of each heating part 9, 10 of the induction-heating cooker 1 is changed by changing the magnitude of high-frequency current I supplied from the drive unit 40 to the electromagnetic coil 100. That is, the control unit 50 controls the drive unit 40 so as to obtain the output power value P having a desired magnitude, thereby changing the magnitude of high-frequency current I supplied to the electromagnetic coil 100.

Example 1

[0278] Operation in Example 1 of Embodiment 7 will be described with reference to FIG. 23 showing an output power value setting table representing a relationship between the adjustment value α and the output power value P, and FIG. 24 showing a graph representing a relationship between the adjustment value α and the output power value P.

[0279] FIG. 23 is a data table showing a relationship between the adjustment value α (setting level) at ten stages in the adjustment range and the output power value P. FIG. 24 shows the relationship between the adjustment value α (setting level) and the output power value P in FIG. 23, as a graph in which the horizontal axis indicates the adjustment value α and the vertical axis indicates the output power value P, for the purpose of facilitating the understanding of the data table in FIG. 23. Here, different output power values P are set for the induction heating operation mode and the non-contact power feeding operation mode. The data table may be stored in advance in a memory of the control unit 50, or the like, or may be described as a data table in a program.

[0280] Next, with reference to these drawings, an example in which the magnitude of the output power value P is adjusted by selecting the adjustment value α (setting level) on the manipulation unit 6 shown in FIG. 1, will be described. Regarding the adjustment range, for example, in FIG. 23, the setting level is indicated in stages by numerical values of 1 to 10 on the display unit 7 provided to the induction-heating cooker 1.

[0281] By the manipulation unit 6 being manipulated to select any of 10 stages of setting levels, a desired output power value P corresponding to the adjustment value α (setting level) can be obtained. At this time, the control unit 50 controls the drive unit 40 so as to obtain the output power value P corresponding to the set adjustment value α (setting level), thereby adjusting the magnitude of high-frequency current I supplied to the electromagnetic coil 100.

[0282] In the adjustable range (adjustment range) of the manipulation unit 6 when the manipulation unit 6 is manipulated to adjust the output power value P, the output power value P at the maximum adjustment value α_1 is defined as the maximum output power value MP. Then, the output power values P including the maximum output power value MP1 in the case of performing operation in the induction heating operation mode and the maximum output power value MP2 in the case of performing operation in the non-contact power feeding operation mode are set in advance by the control unit 50 of the induction-heating cooker 1, for the respective operation modes. It is noted that the magnitude relationship of these maximum output power values MP is MP1 > MP2.

[0283] That is, in the adjustable range when the manipulation unit 6 is manipulated to adjust the output power value P, the magnitude of the output power value P corresponding to the set adjustment value α (setting level) is set so that the output power value P different between both operation modes is obtained.

[0284] The output power value P (power) corresponding to the adjustment value α set by the manipulation unit 6 is stored in advance in, for example, a memory inside the induction-heating cooker 1. When operation is being performed in the induction heating operation mode, if the manipulation unit 6 is manipulated to select the adjustment value α (setting level) at "8", the control unit 50 determines that the operation mode is the induction heating operation mode, and controls the drive unit 40 so that the electromagnetic coil 100 is supplied with high-frequency current I by which an output power

value of 2,000 W is obtained, on the basis of a value given by the data table shown in FIG. 23.

[0285] On the other hand, when operation is being performed in the non-contact power feeding operation mode, if the manipulation unit 6 is manipulated to select the adjustment value α (setting level) at "8", the control unit 50 determines that the operation mode is the non-contact power feeding mode, and controls the drive unit 40 so that the electromagnetic coil 100 is supplied with high-frequency current I by which an output power value of 1,000 W is obtained, on the basis of a value given by the data table shown in FIG. 23. It is noted that the numerical values shown in FIG. 23 are merely an example, and are not limited thereto.

[0286] FIG. 23 and FIG. 24 show an example in which the output power value P is set so as to linearly vary with respect to the adjustment value α , whereas FIG. 25 and FIG. 26 show an example in which the output power value P varies in a stepwise manner in each operation mode. Here, FIG. 25 and FIG. 26 are a data table and a graph thereof, in which the output power value P is set in three stages of setting levels, as an example. Also in this example, the output power value P is set so that the maximum output power value MP different between both operation modes is obtained in the same adjustment range (adjustment value α).

[0287] As described above, different values for the respective operation modes are set with respect to the adjustment value of the output power value (power), so that adjustment operation for the output power value can be performed in the same adjustment range without considering the operation mode. Therefore, it is not necessary to change the way of manipulation for each operation mode, and thus convenience can be improved. In addition, in the non-contact power feeding operation mode, even if the output power value is set to the maximum output power value in the adjustment range, excessive supply of power to a power receiving device can be prevented.

Example 2

[0288] Operation in Example 2 of Embodiment 7 will be described with reference to FIG. 27 showing an output power value setting table representing a relationship between the adjustment value α and the output power value P, and FIG. 28 showing a graph representing a relationship between the adjustment value α and the output power value P.

[0289] FIG. 27 is a data table showing a relationship between the adjustment value α (setting level) at ten stages in the adjustment range and the output power setting value based on a proportion k_a . FIG. 28 shows the relationship between the adjustment value α (setting level) and the output power setting value based on the proportion k_a in FIG. 27, as a graph in which the horizontal axis indicates the adjustment value α and the vertical axis indicates the output power value P, for the purpose of facilitating the understanding of the data table in FIG. 27. Here, different output power values P are set for the induction heating operation mode and the non-contact power feeding operation mode. The data table may be stored in advance in a memory of the control unit 50, or the like, or may be described as a data table in a program.

[0290] In Example 2, the magnitude of the output power value P (power) corresponding to the adjustment value α (setting level) in each operation mode is set such that, instead of representing the output power value P as numerical values as shown in FIG. 23 in Example 1, for example, as shown by the output power value setting table in FIG. 27, the output power value P (power) in the non-contact power feeding operation mode is outputted as a value obtained by multiplying a certain proportion k_a ($0 < k_a < 1$) with respect to the magnitude of the output power value P set in advance correspondingly for each adjustment value α in the induction heating operation mode.

[0291] For example, in the case where the maximum output power value MP1 corresponding to the maximum adjustment value α_1 in the adjustment range in the induction heating operation mode is 3,000 W, in FIG. 27, the output power value setting table is set such that, over the entire adjustment range, the output power value P in the non-contact power feeding operation mode is outputted at a proportion of 0.5 ($k_a = 0.5$) with respect to the output power value P in the induction heating operation mode.

[0292] As shown in the graph in FIG. 28 which shows the magnitude of the output power value P corresponding to each adjustment value α in each operation mode obtained using the output power value setting table in FIG. 27, in this example, the maximum output power value MP2 in the non-contact power feeding operation mode is half (0.5 times) as great as the maximum output power value MP1 in the induction heating operation mode. That is, the maximum output power value MP2 at the maximum adjustment value α_1 in the non-contact power feeding operation mode is given as $MP1 \times k_a$ ($0 < k_a < 1$), and therefore becomes $3,000 \text{ W} \times 0.5 = 1,500 \text{ W}$.

[0293] It is noted that the maximum output power value MP2 in the non-contact power feeding operation mode might be limited to 1,500 W or smaller by regulation. Therefore, it is necessary to set MP2 to 1,500 W or smaller. If the maximum output power value in the induction heating operation mode exceeds 3,000 W, the proportion k_a for the maximum output power value needs to be set so as to satisfy $MP2 = k_a \times MP1 < 1,500 \text{ W}$.

[0294] In the above description, the proportion k_a with respect to the output power value P in the induction heating operation mode has been used. However, conversely, a proportion k_b ($k_b > 1$) with respect to the output power value P in the non-contact power feeding operation mode may be used.

[0295] The proportion k_a may be given as numerical data with respect to the induction heating operation mode as

shown by the output power value setting table in FIG. 27, or a proportion k_c may be changed for each adjustment value α as shown by an output power value setting table in FIG. 29. FIG. 30 shows a relationship between the adjustment value α (setting level) and the output power setting value P in FIG. 29, as a graph in which the horizontal axis indicates the adjustment value α and the vertical axis indicates the output power value P . The output power value P is changed in a stepwise manner with respect to the adjustment value α .

Example 3

[0296] Operation in Example 3 of Embodiment 7 will be described with reference to FIG. 31 showing graphs representing a relationship between the adjustment value α and the output power value P .

[0297] In Example 3 of Embodiment 7, the control unit 50 changes the output power value P (power) in accordance with the adjustment value α , on the basis of a formula set in advance. At this time, the output power value P may be determined on the basis of the formula in both of the induction heating operation mode and the non-contact power feeding operation mode, or the output power value P may be determined on the basis of the formula in one of the modes.

[0298] For example, in the adjustment range, a formula is set in advance such that the output power value P is represented as a linear line having a positive slope. As an example, the case where, in both operation modes, the output power value P (power) is given by a linear equation with respect to the adjustment value α in the adjustment range as shown in FIG. 31(a), will be described.

[0299] In the induction heating operation mode, if the adjustment value is denoted by α_m and the output power value obtained at the adjustment value α_m is denoted by P_m , P_m is given by Expression (6).

Mathematical 6

$$P_m = a \times \alpha_m + b \quad (0 < a, 0 \leq b) \quad \dots (6)$$

[0300] Here, a relationship between the output power value P_1 corresponding to the adjustment value α_m and the maximum output power value MP_1 in the adjustment range in the induction heating operation mode satisfies $0 \leq P_m \leq MP_1$.

[0301] On the other hand, in the non-contact power feeding operation mode, if the adjustment value is denoted by α_n and the output power value obtained at the adjustment value α_n is denoted by P_n , P_n is given by Expression (7).

Mathematical 7

$$P_n = c \times \alpha_n + d \quad (0 < c, 0 \leq d) \quad \dots (7)$$

[0302] Here, similarly, a relationship between the output power value P_n corresponding to the adjustment value α_n and the maximum output power value MP_2 in the adjustment range in the non-contact power feeding operation mode satisfies $0 \leq P_n \leq MP_2$.

[0303] Regarding a relationship between the adjustment value α and the output power value P in each operation mode, as shown in the graph in FIG. 31(a), $MP_1 > MP_2$ is satisfied, and it is possible to obtain different output power values P with respect to the same adjustment value α by setting the values of a , b , c , d in advance so as to obtain a desired output power value P with respect to each adjustment value α . For example, if $MP_1 > MP_2$ is satisfied, the values of a , b , c , d may be set so as to satisfy $a > c$ ($b \geq d$). In FIG. 31(a), $b = d = 0$ is assumed as an example.

[0304] As described above, by changing the slope (a or c) of the formula, it is possible to change the output power value P (power) with respect to the set adjustment value α . Thus, selectively using a plurality of formulas, the control unit 50 determines the output power value P in accordance with each formula, and controls the output of the drive unit 40 so that the electromagnetic coil 100 is supplied with high-frequency current I by which the determined output power value P is obtained.

[0305] As a result, in the induction heating operation mode, the induction-heating cooker 1 can set the output range of the drive unit 40 to the first range having the first maximum output power value Mop_1 , and in the non-contact power feeding operation mode, the induction-heating cooker 1 can set the output range of the drive unit 40 to the second range having the second maximum output power value MP_2 . That is, in the induction-heating cooker 1, in each operation mode, the control unit 50 controls the drive unit 40 on the basis of a formula set in advance, whereby different output power values P can be obtained with respect to the same adjustment value α in the adjustment range of the manipulation unit 6.

[0306] In FIG. 31 (a), an example in which the output power value P corresponding to the adjustment value α in each operation mode is obtained by a linear equation has been described. However, without limitation thereto, a formula may be set such that the output power value P is obtained with a change amount at an arbitrary slope with respect to the adjustment value α .

[0307] In FIG. 23 to FIG. 31, change in the output power value P in the adjustment range in the induction heating operation mode is represented as a line obtained by a linear equation, for convenience sake. Without limitation thereto, as shown in FIG. 31(b) to FIG. 31(d), the way of change in the output power value P with respect to the adjustment value α may be arbitrarily set in accordance with convenience for cooking.

[0308] In the non-contact power feeding operation mode in FIG. 31(a), the output power value P is set so as to linearly increase with increase in the adjustment value α , whereas, in the non-contact power feeding operation mode in FIG. 31(b), the output power value P is set so as to linearly decrease with increase in the adjustment value α .

[0309] In the non-contact power feeding operation mode in FIG. 31(c), the output power value P is set so as to gradually increase in a non-linear manner with increase in the adjustment value α . In the non-contact power feeding operation mode in FIG. 31(d), the output power value P is set so as to gradually increase in a non-linear manner different from FIG. 31(c), with increase in the adjustment value α .

[0310] As described above, in the induction-heating cooker according to Embodiment 7, setting is made such that, in each operation mode, a different output power value is obtained with respect to the same adjustment value. Therefore, adjustment can be performed in the same adjustment range without considering the operation mode. Thus, it is not necessary to change the manipulation method between the operation modes, and convenience can be improved. In addition, in the non-contact power feeding operation mode, even if the adjustment range is set at the maximum output power value, excessive supply of power to the power receiving device can be prevented.

[0311] It is noted that, within the scope of the present invention, the above embodiments may be freely combined with each other, or each of the above embodiments may be modified or simplified as appropriate.

[0312] In the drawings, the same reference characters denote the same or corresponding parts.

Description of the Reference Characters

[0313]

1	induction-heating cooker
2	induction-heating cooker main body
3	top plate
4	cooking grill
5	manipulation unit
6, 6a, 6b	manipulation unit
7, 7a, 7b, 7c	display unit
8a, 8b, 8c	suction/exhaust window
9, 10, 11	heating part
100	electromagnetic coil
101 to 106	individual coil
30	power supply unit
40	drive unit
40a, 40b	drive circuit
50	control unit
60	detection unit
60a, 60b, 60c, 60d, 60e	detection circuit
80 to 84	resonant capacitor
P	pot (heating target)
21 to 23	switch
31	commercial power supply
32	diode bridge
33	smoothing circuit
331	choke coil
332	smoothing capacitor
401 to 403	semiconductor switching element pair (arms 1 to 3)
401a, 401b, 402a, 402b, 403a, 403b	semiconductor switching element
501	power receiving device outer frame
502	power receiving coil
503	power supply circuit
504	load circuit
511	operation mode switchover switch
512	down switch

513	up switch
514	stop switch
A	power receiving device

5

Claims

1. An induction-heating cooker comprising:

10 an electromagnetic coil for generating a magnetic field;
 a drive unit which supplies high-frequency current to the electromagnetic coil;
 a control unit which controls the drive unit; and
 a detection unit which has detection means for detecting electric characteristics of the drive unit and detects
 load characteristics of a load placed near the electromagnetic coil on the basis of the electric characteristics,
 15 wherein
 the control unit has load determination means for determining whether the load is a heating target or a power
 receiving subject on the basis of the load characteristics, and
 the control unit performs control such that, if the load is determined to be the heating target, a range of an output
 power value of the drive unit is set to a first range having a first maximum output power value and operation is
 20 performed in an induction heating operation mode in which the heating target is heated by the electromagnetic
 coil, and if the load is determined to be the power receiving subject, a range of an output power value of the
 drive unit is set to a second range having a second maximum output power value and operation is performed
 in a non-contact power feeding operation mode in which power is supplied to the power receiving subject by
 the electromagnetic coil.

25 2. The induction-heating cooker according to claim 1,
 further comprising a top plate which allows the load to be placed thereon, wherein
 the magnetic field by the electromagnetic coil is generated on the top plate.

30 3. The induction-heating cooker according to claim 1 or 2,
 further comprising a manipulation unit for adjusting the high-frequency current supplied to the electromagnetic coil,
 wherein
 output adjustment is performed in the range of the output power value of the drive unit through manipulation of the
 manipulation unit.

35 4. The induction-heating cooker according to any one of claims 1 to 3,
 wherein the second maximum output power value is set to be smaller than the first maximum output power value.

40 5. The induction-heating cooker according to claim 4,
 Wherein the control unit switches a frequency of the high-frequency current supplied from the drive unit to the
 electromagnetic coil, between the induction heating operation mode and the non-contact power feeding operation
 mode.

45 6. The induction-heating cooker according to claim 4,
 wherein the control unit switches a resonant frequency of a resonant circuit in a magnetic field generation excitation
 circuit including the electromagnetic coil, between the induction heating operation mode and the non-contact power
 feeding operation mode.

50 7. The induction-heating cooker according to claim 4,
 wherein the drive unit is configured to have a full-bridge circuit, and the control unit switches a circuit configuration
 of the drive unit so that, in the induction heating operation mode, the drive unit operates with a full-bridge circuit
 configuration, and in the non-contact power feeding operation mode, the drive unit operates with a half-bridge circuit
 configuration.

55 8. The induction-heating cooker according to claim 4,
 wherein the control unit adjusts the output power value in each of the induction heating operation mode and the
 non-contact power feeding operation mode on the basis of an output power value setting table set in advance.

9. The induction-heating cooker according to claim 4,
wherein the control unit adjusts the output power value in each of the induction heating operation mode and the non-contact power feeding operation mode on the basis of a formula set in advance.

10. The induction-heating cooker according to any one of claims 1 to 9, wherein the electromagnetic coil is composed of a center coil wound in a planar shape, and a peripheral coil arranged around the center coil.

11. The induction-heating cooker according to any one of claims 1 to 10, wherein the electromagnetic coil is composed of a plurality of individual coils, and a drive circuit is provided for each of the plurality of individual coils.

12. The induction-heating cooker according to claim 11,
wherein the control unit controls the drive unit so as to supply high-frequency current to any arbitrary individual coil of the plurality of individual coils if the load is determined to be the power receiving subject.

13. The induction-heating cooker according to any one of claims 1 to 12, wherein the load determination means determines whether the load is the heating target or the power receiving subject, by comparing the load characteristics with determination characteristics set in advance.

14. The induction-heating cooker according to any one of claims 1 to 13, further comprising a switchover manipulation unit having a manipulation switch for switching between the induction heating operation mode and the non-contact power feeding operation mode.

15. The induction-heating cooker according to any one of claims 1 to 14, further comprising an operation mode display unit which displays an operation mode to indicate whether operation is being performed in the induction heating operation mode or the non-contact power feeding operation mode.

16. The induction-heating cooker according to any one of claims 1 to 15, wherein a communication function is set between the control unit and the power receiving subject, and
when power is supplied to the power receiving subject from the electromagnetic coil by electromagnetic induction, a signal indicating that the power receiving subject is in a power receiving state is transmitted from the power receiving subject to the control unit.

17. The induction-heating cooker according to any one of claims 1 to 16, wherein the power receiving subject is provided with a power receiving circuit composed of a resonant circuit formed by a resonant capacitor and a power receiving coil to which power is supplied by the electromagnetic coil.

18. A control method for induction-heating cooker, comprising:

- detecting load characteristics of a load placed near an electromagnetic coil for generating a magnetic field, on the basis of electric characteristics of a drive unit which drives the electromagnetic coil; and
- performing control such that, if the load is determined to be a heating target, a range of an output power value of the drive unit is set to a first range having a first maximum output power value and operation is performed in an induction heating operation mode in which the heating target is heated by the electromagnetic coil, and if the load is determined to be a power receiving subject, a range of an output power value of the drive unit is set to a second range having a second maximum output power value and operation is performed in a non-contact power feeding operation mode in which power is supplied to the power receiving subject by the electromagnetic coil.

19. The control method for induction-heating cooker according to claim 18, further comprising a processing step of determining whether the load is the power receiving subject and a processing step of determining whether the load is the heating target, wherein the processing step of determining whether the load is the power receiving subject is performed prior to the other processing step.

FIG. 1

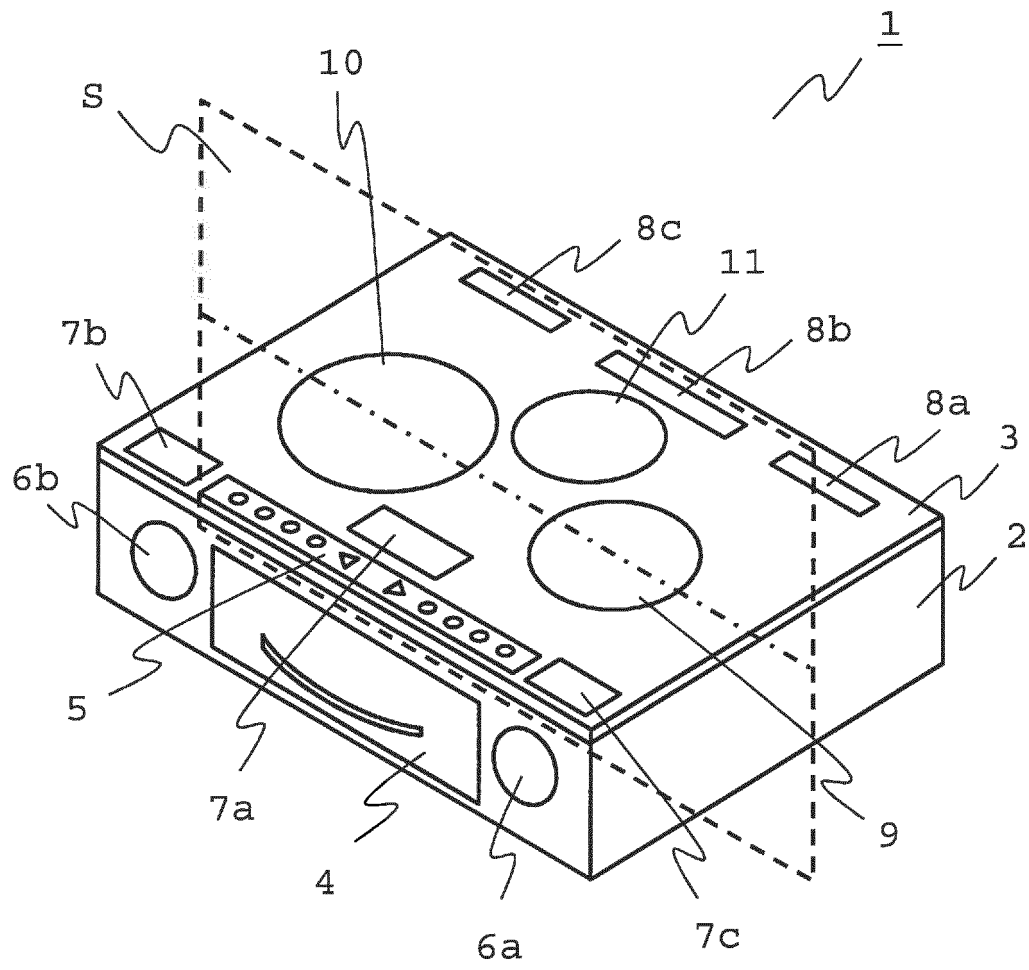
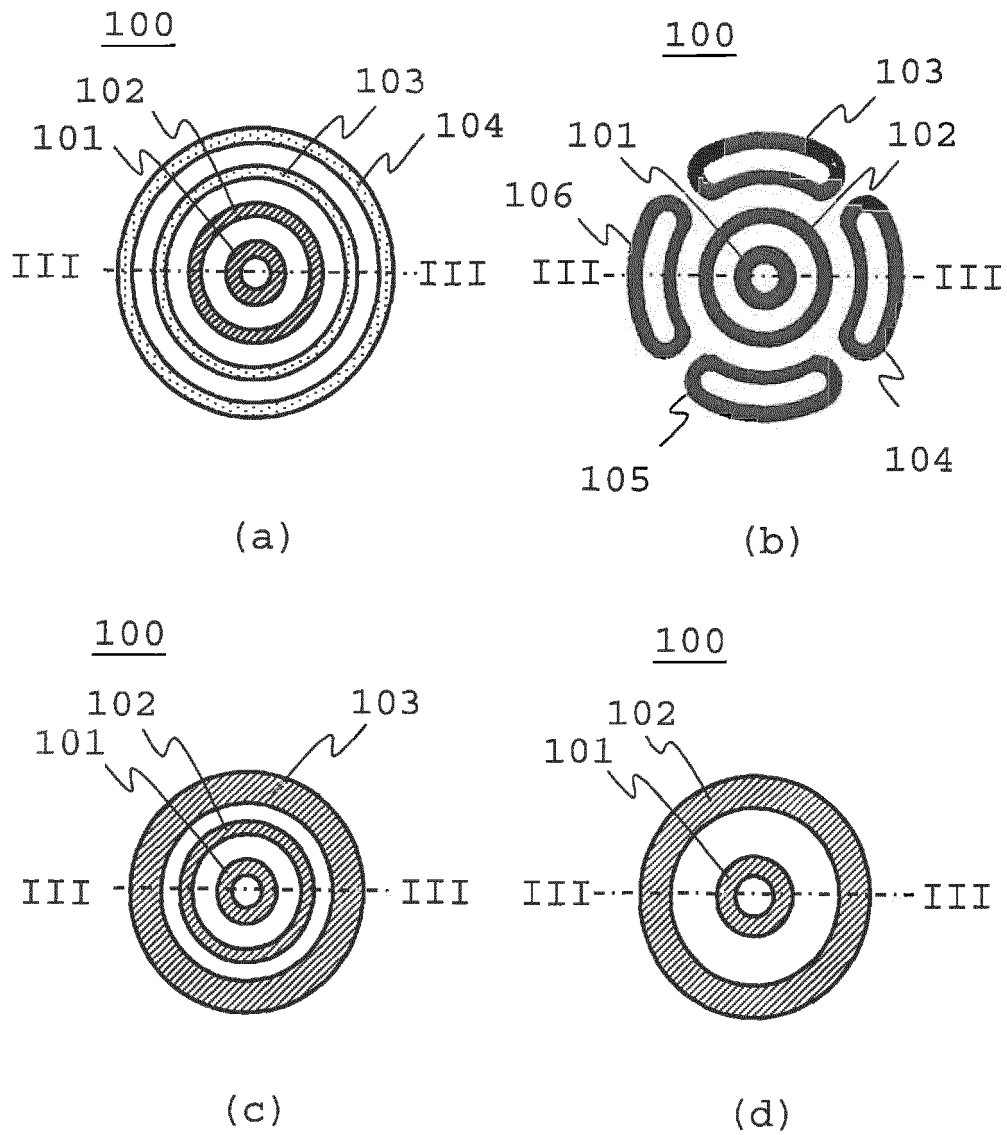


FIG. 2



NOTE    : WINDING PART

FIG. 3

III-III SECTIONAL VIEW

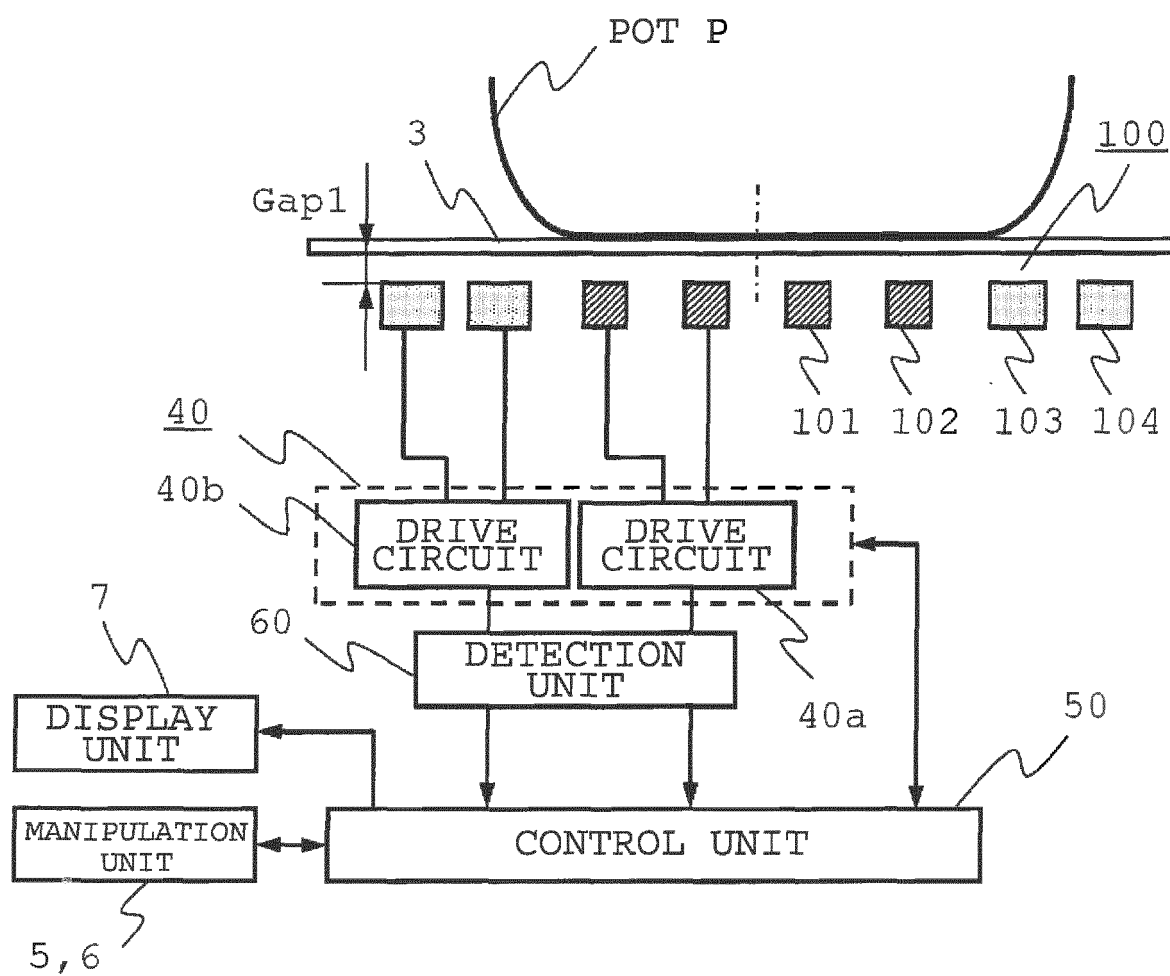


FIG. 4

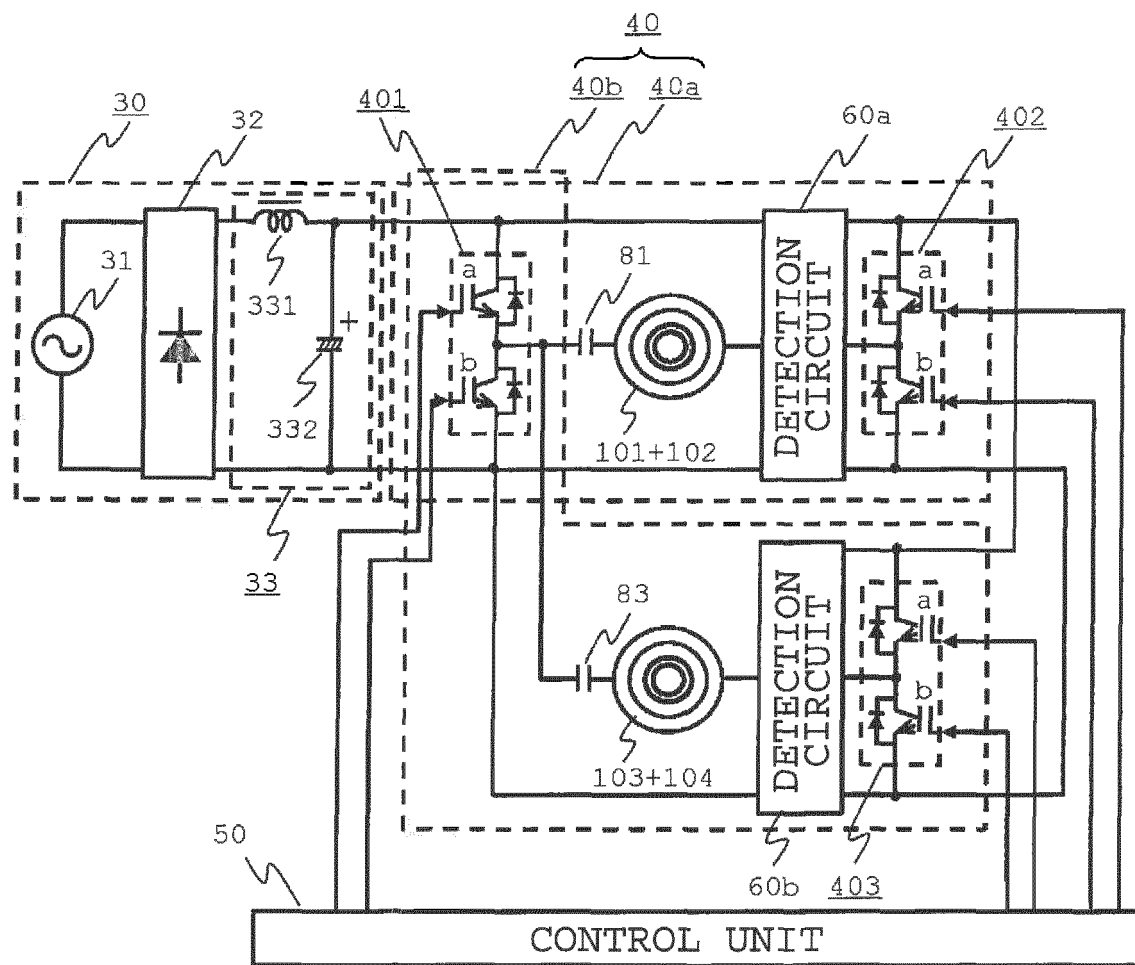


FIG. 5

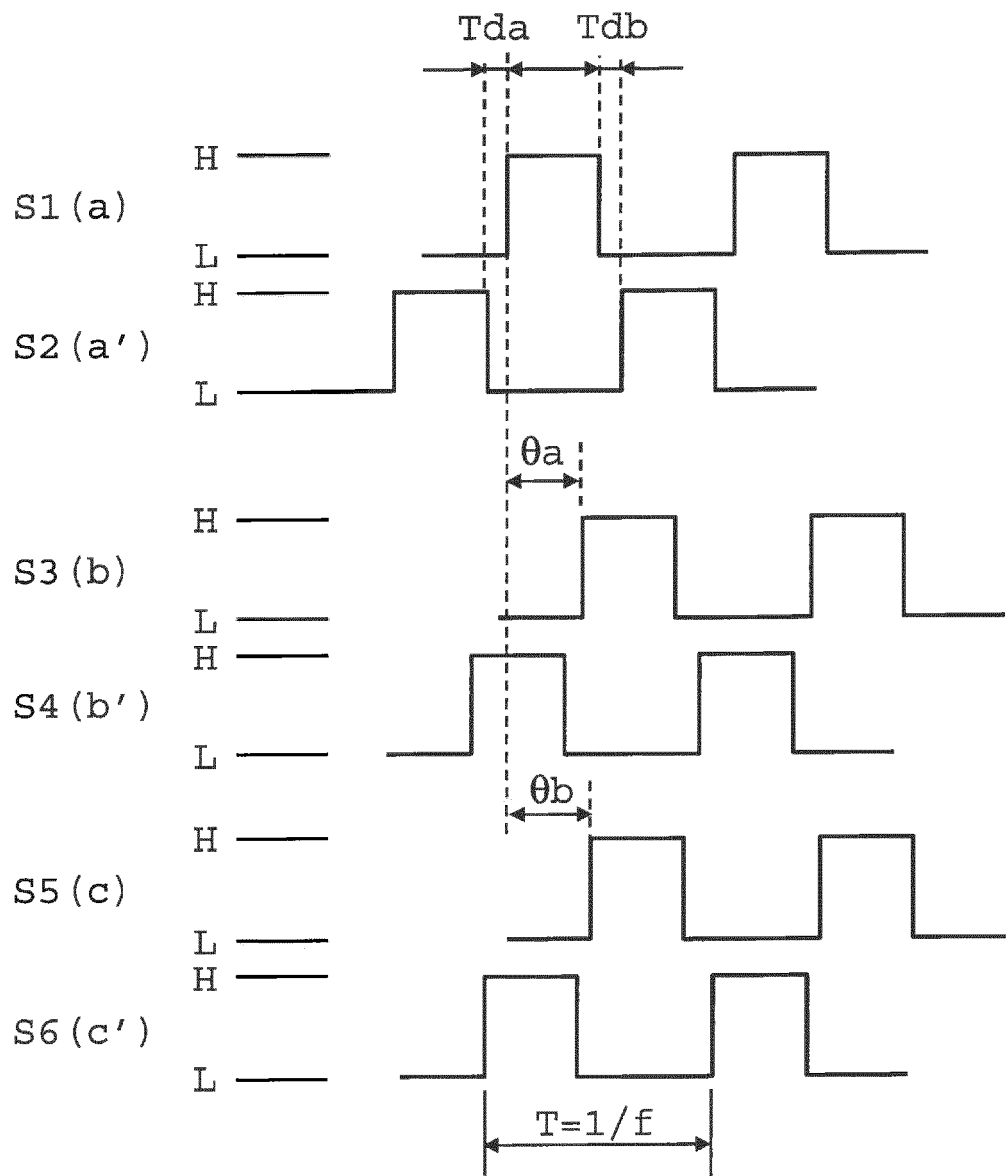


FIG. 6

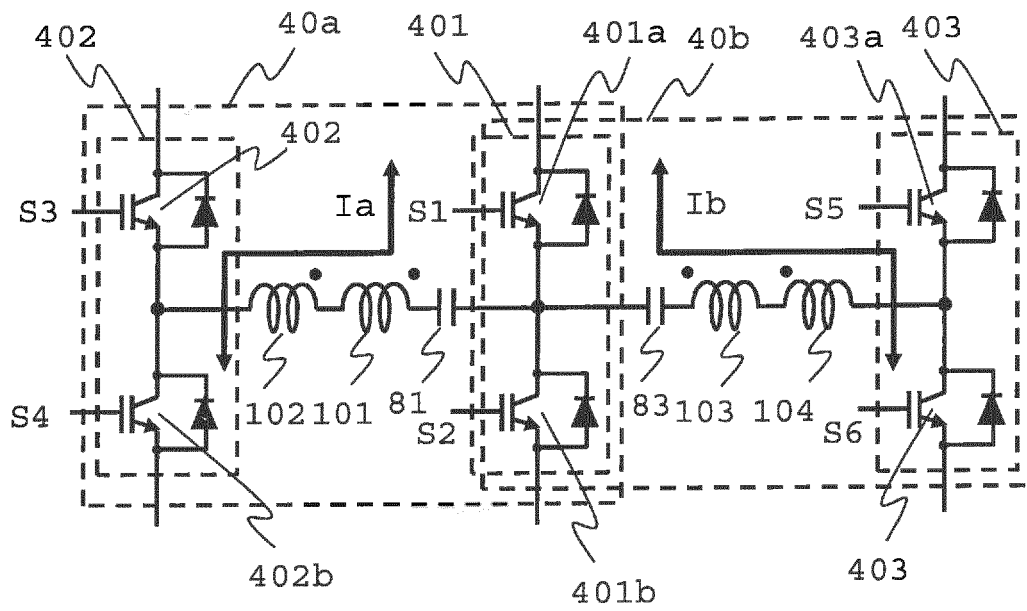


FIG. 7

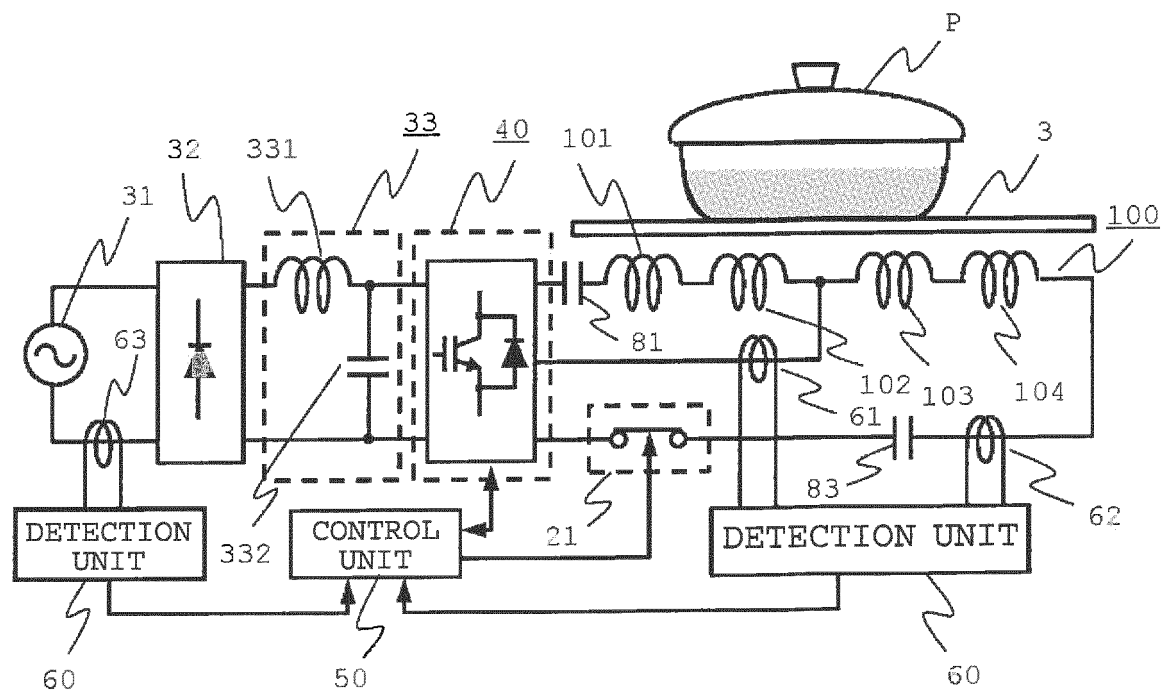


FIG. 8

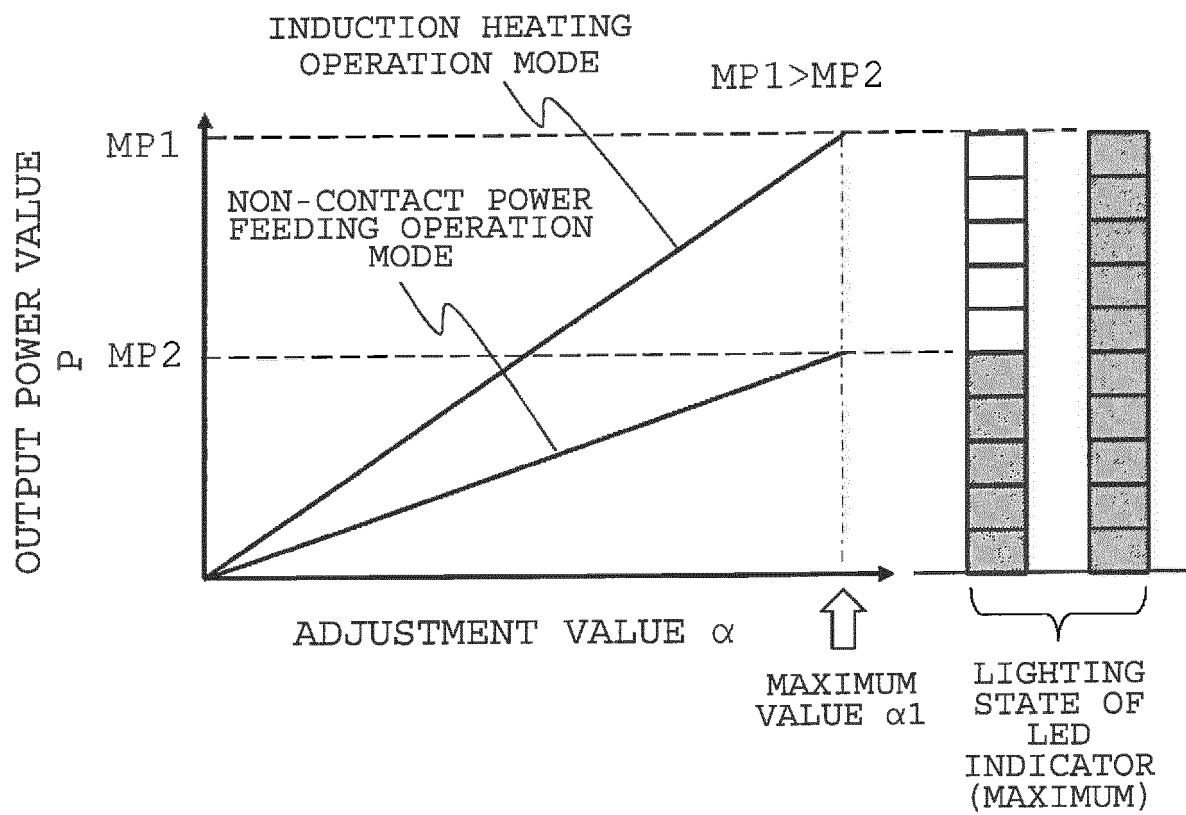
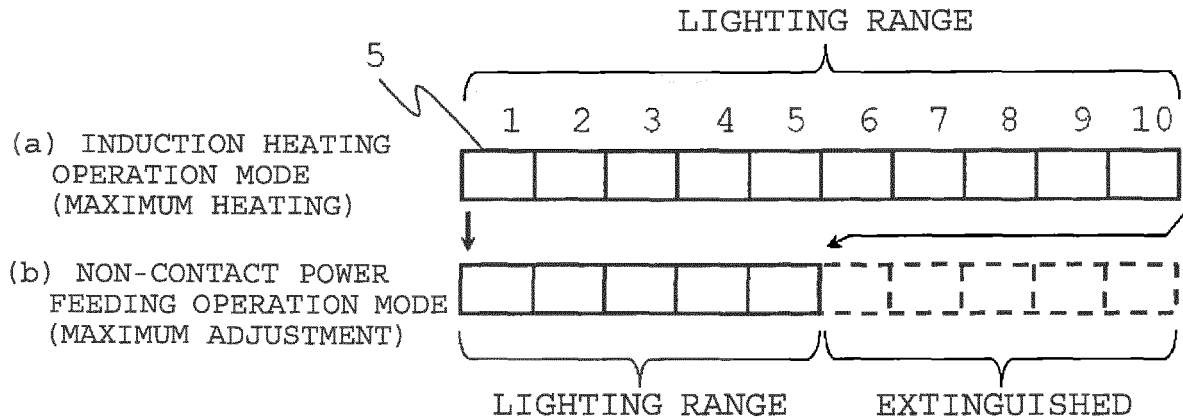


FIG. 9

LED LIGHTING RANGE (PATTERN A)



LED LIGHTING RANGE (PATTERN B)

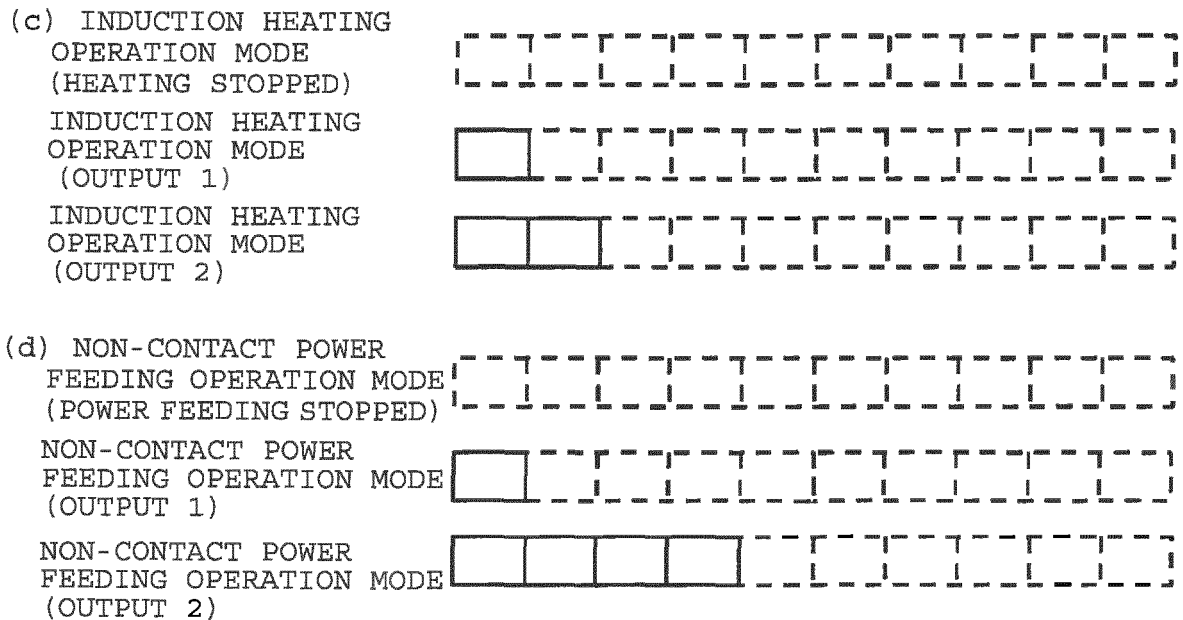


FIG. 10

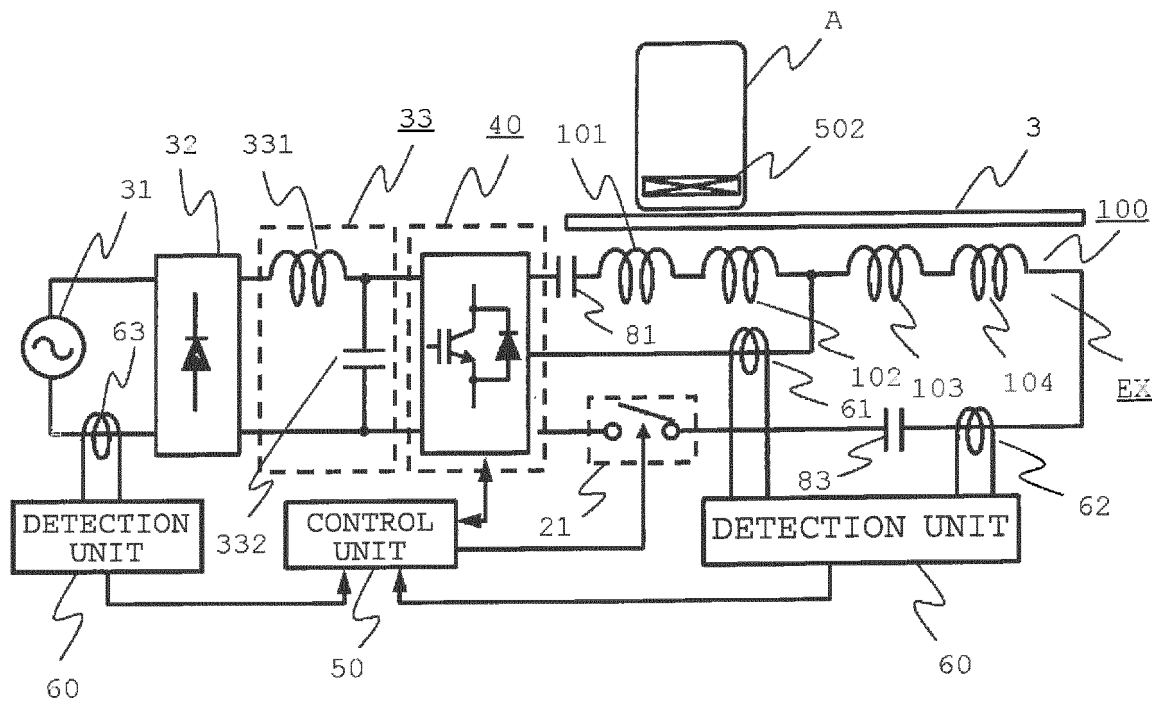
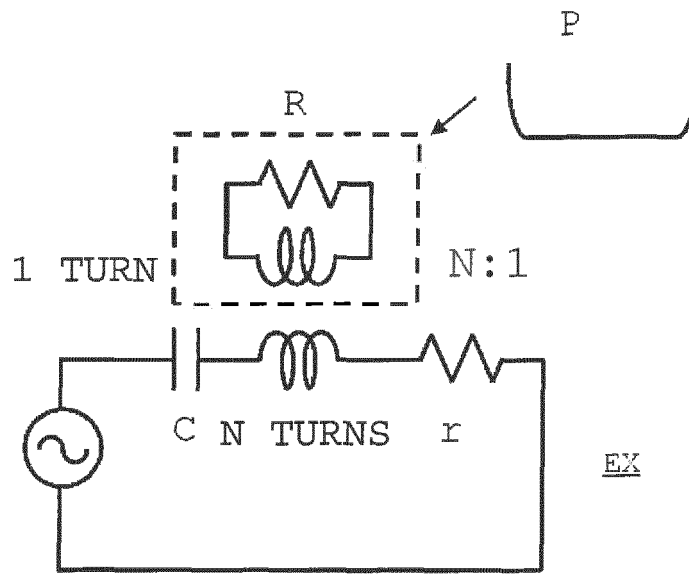
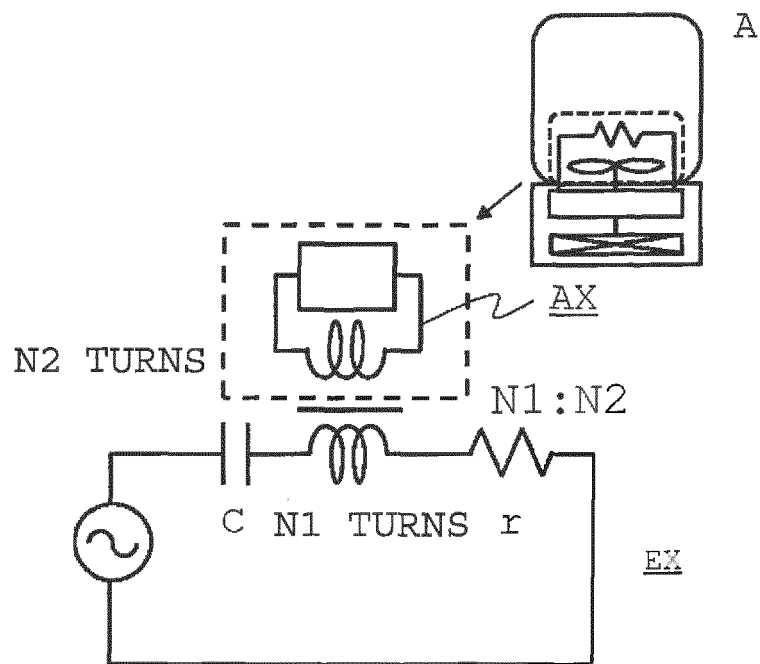


FIG. 11



EQUIVALENT CIRCUIT IN INDUCTION HEATING OPERATION MODE

(a)



EQUIVALENT CIRCUIT IN NON-CONTACT POWER FEEDING OPERATION MODE

(b)

FIG. 12

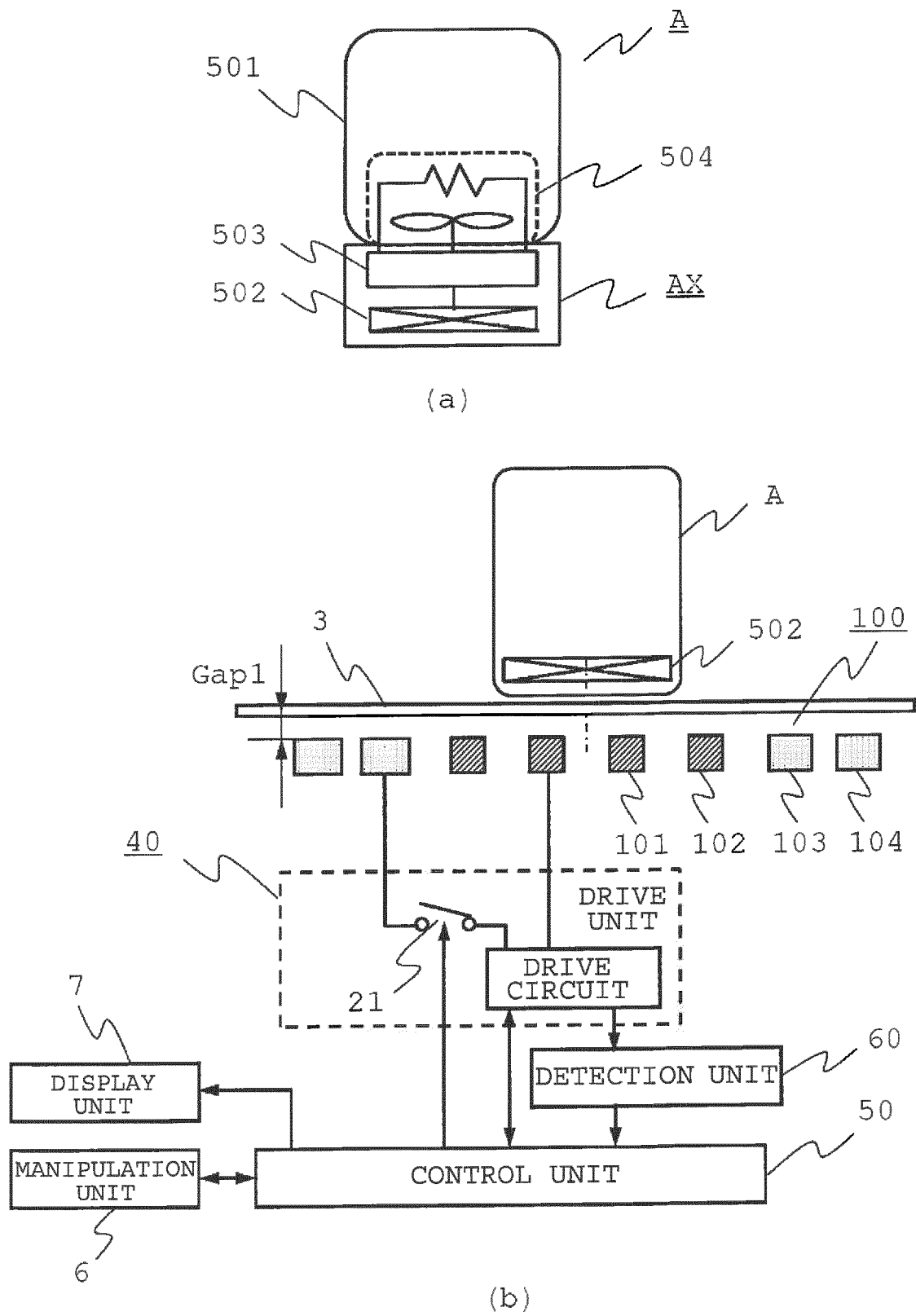


FIG. 13

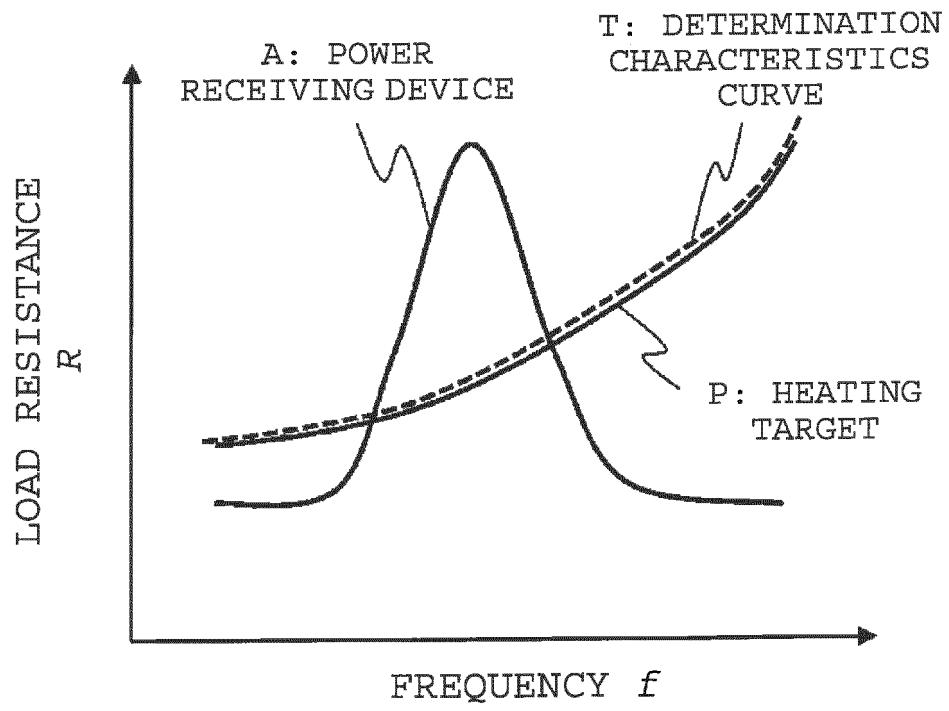


FIG. 14

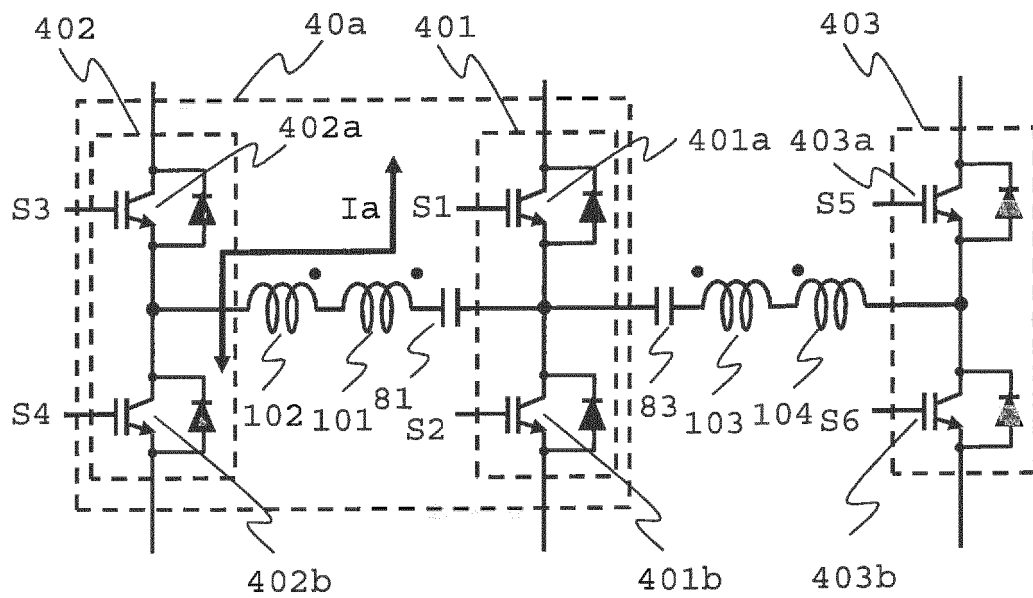


FIG.15

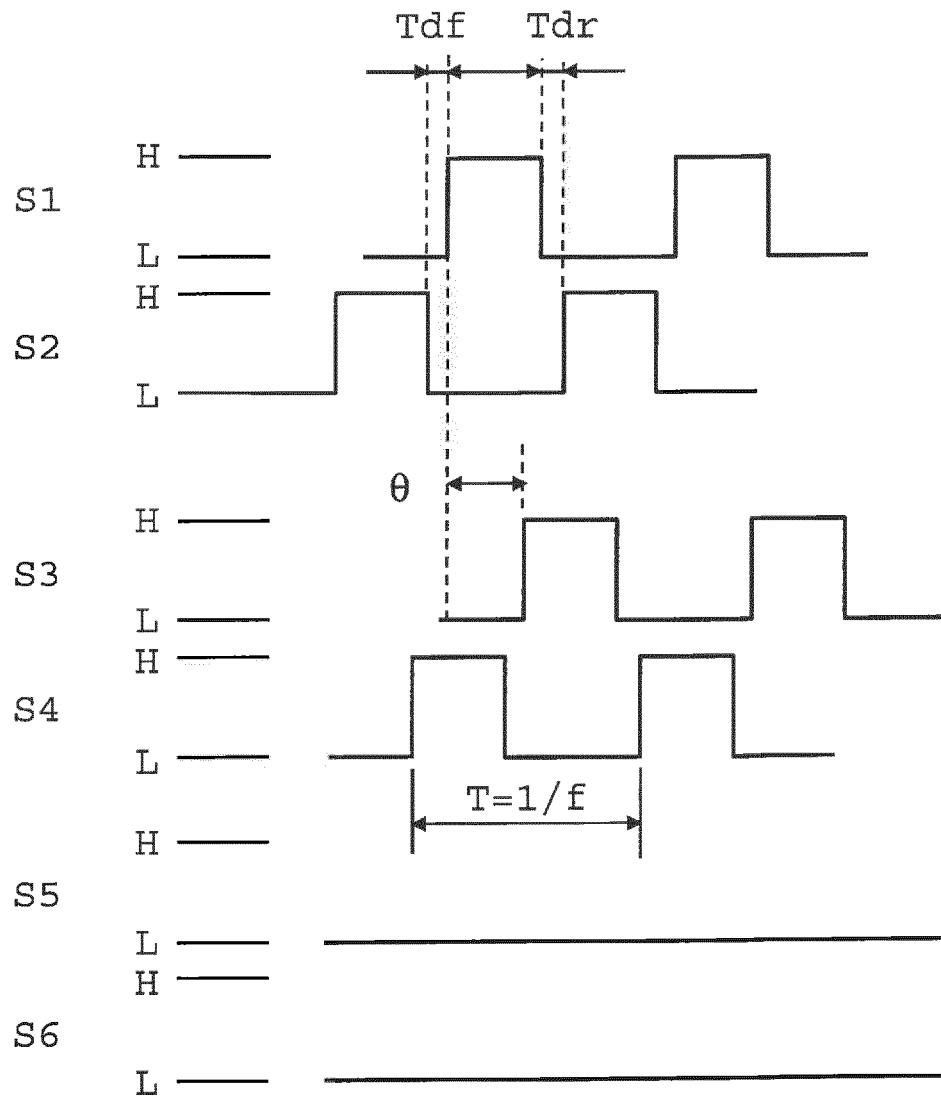


FIG.16

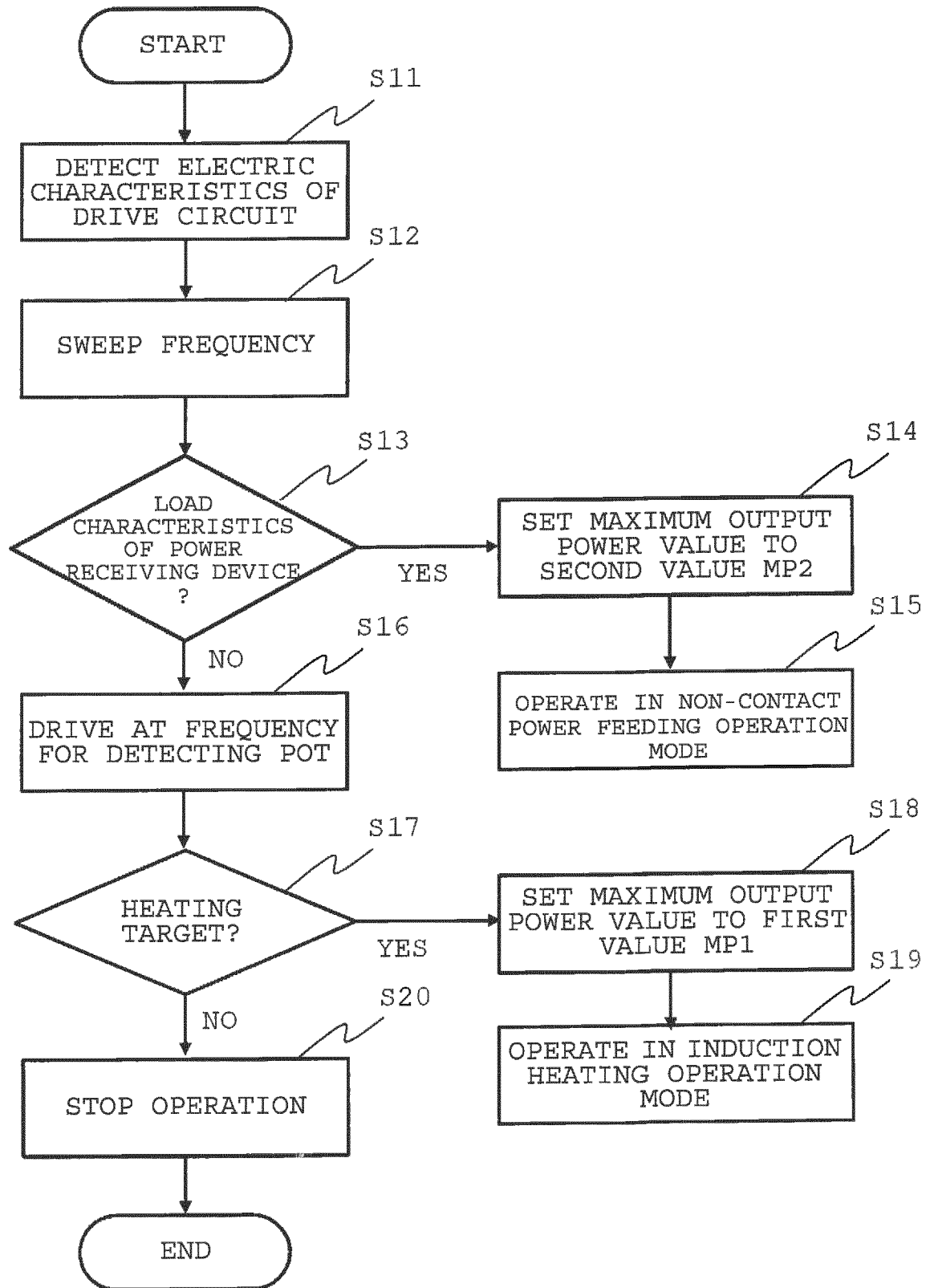
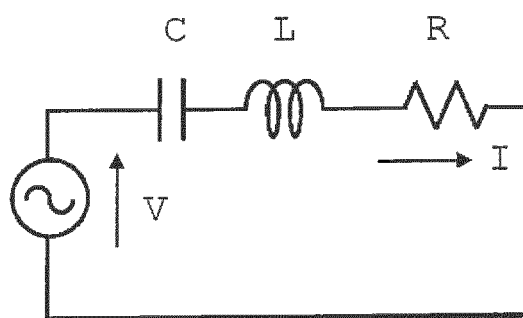
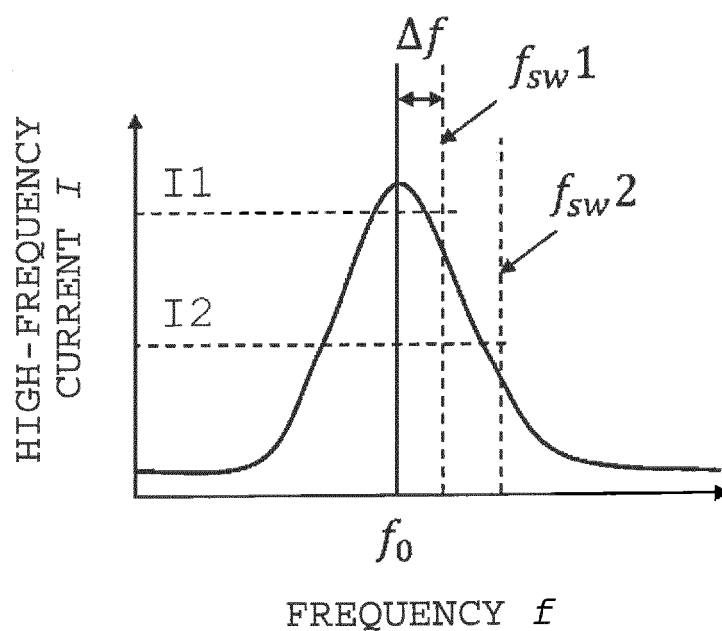


FIG. 17



(a)



RESONANCE FREQUENCY

$$f_0 = \frac{1}{2\pi\sqrt{L \times C}}$$

DRIVE FREQUENCY

$$f_{sw} = f_0 + \Delta f$$

POWER DUE TO
HIGH-FREQUENCY
MAGNETIC FIELD

$$P = k\sqrt{\rho \cdot \mu \cdot f}(NI)^2$$

(b)

FIG. 18

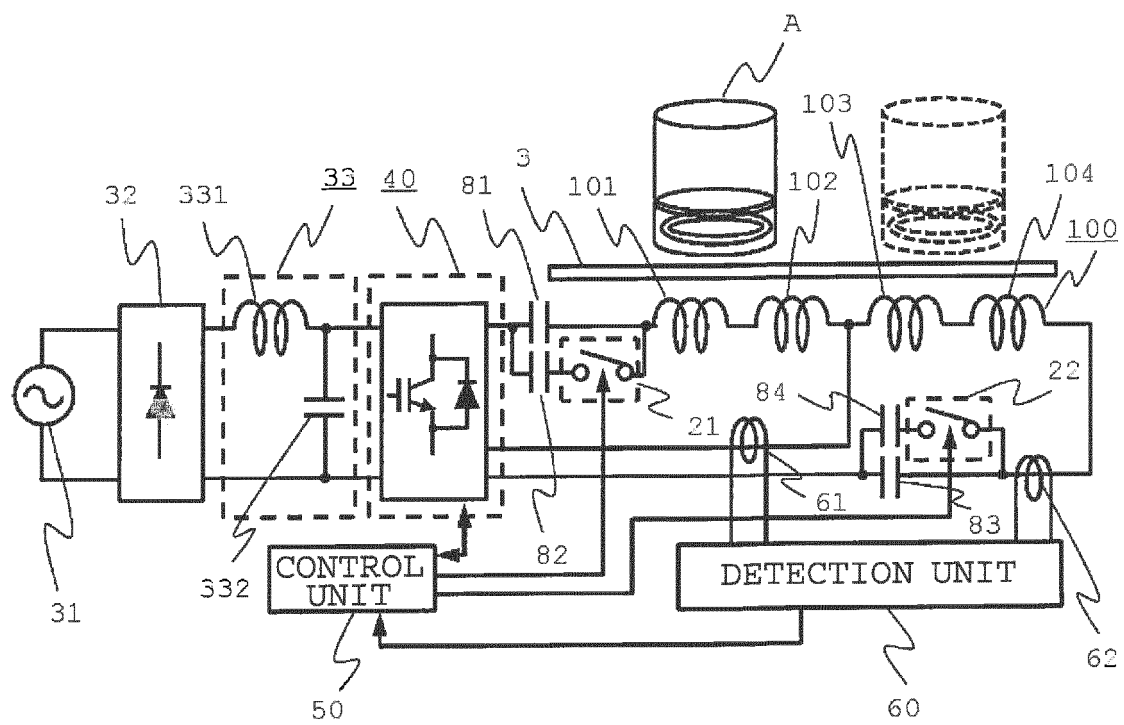
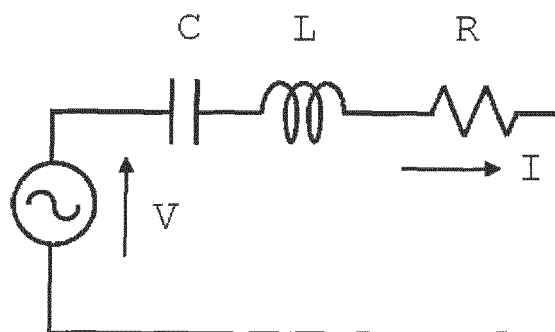
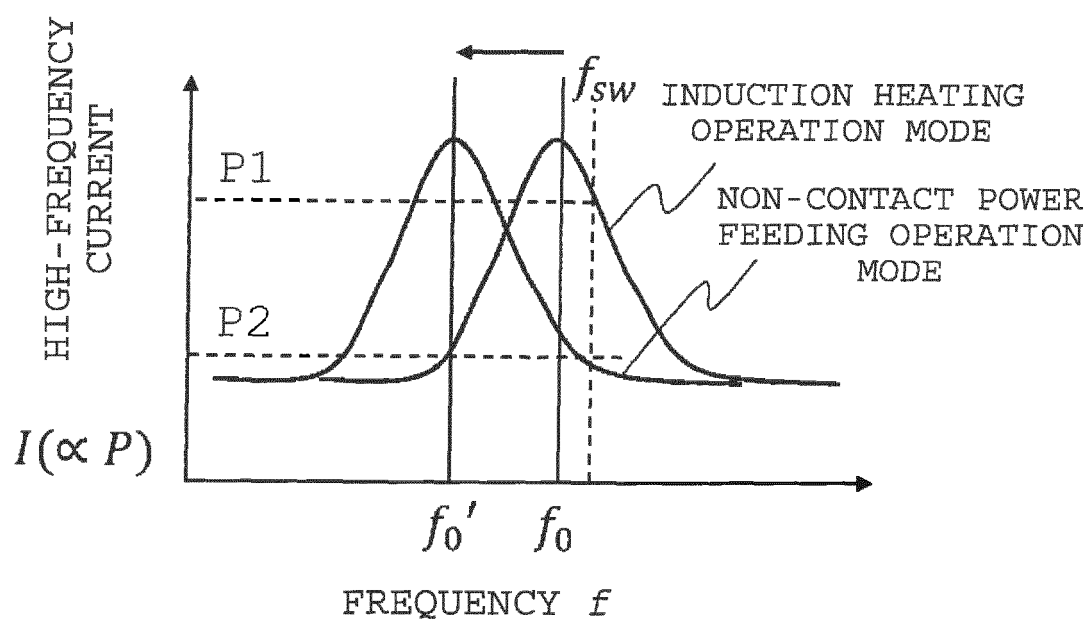


FIG. 19



(a)



RESONANCE FREQUENCY

$$f_0 = \frac{1}{2\pi\sqrt{(L \times C)}}$$

DRIVE FREQUENCY

$$f_{sw} = f_0 + \Delta f$$

POWER DUE TO
HIGH-FREQUENCY MAGNETIC
FIELD

$$P \propto (NI)^2$$

(b)

FIG. 20

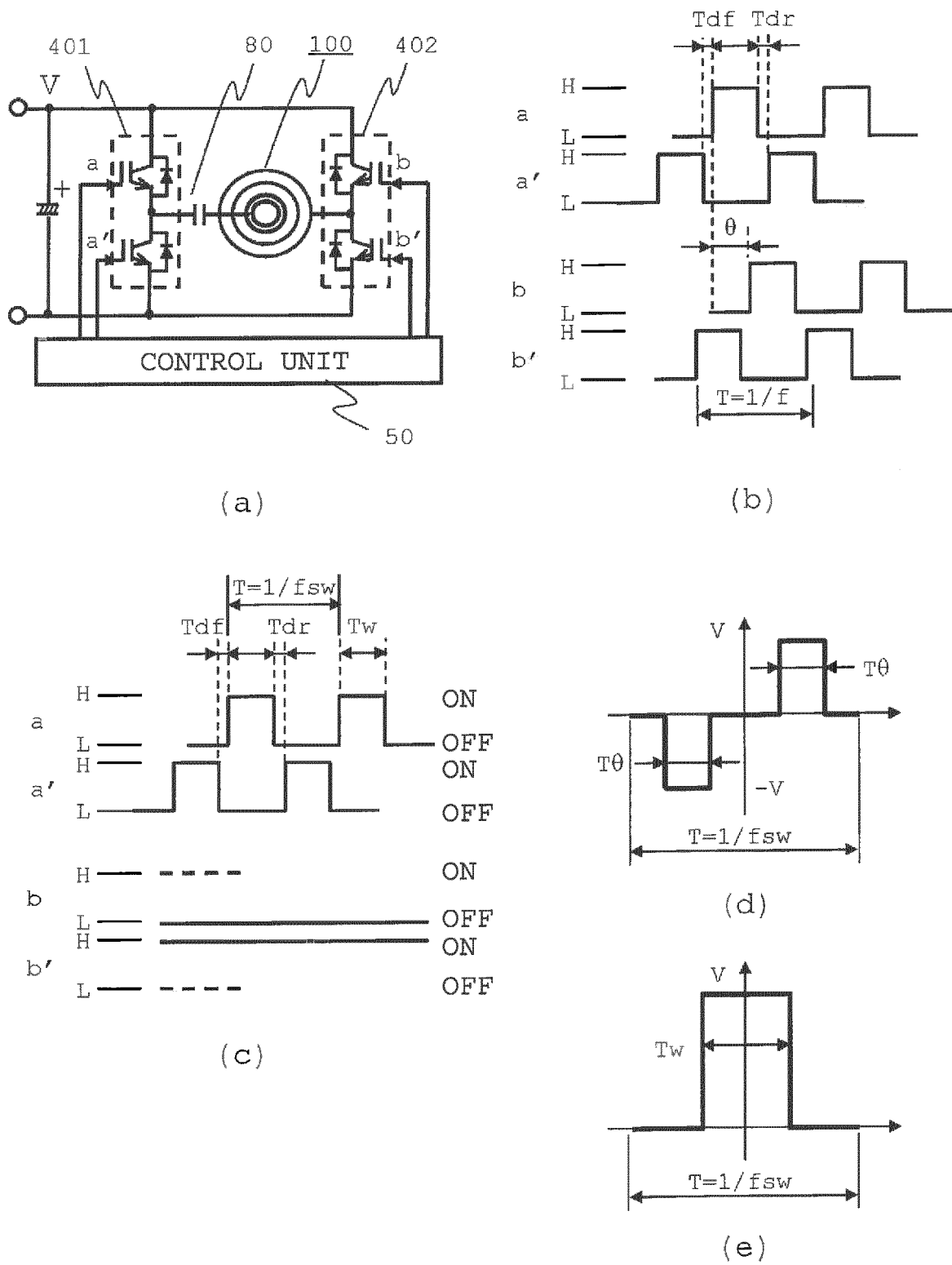
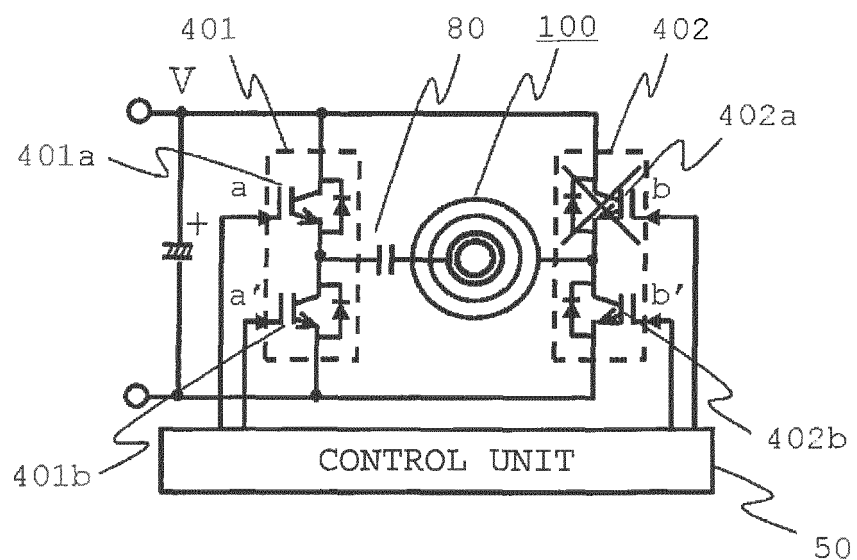


FIG. 21



DRIVING OF 402a IS STOPPED
402b IS CONSTANTLY ON

(a)

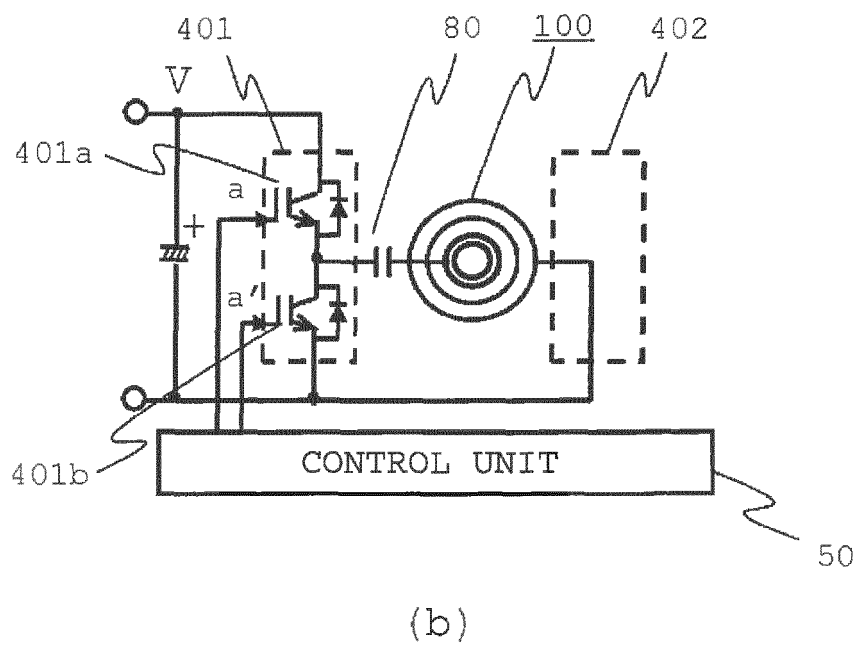
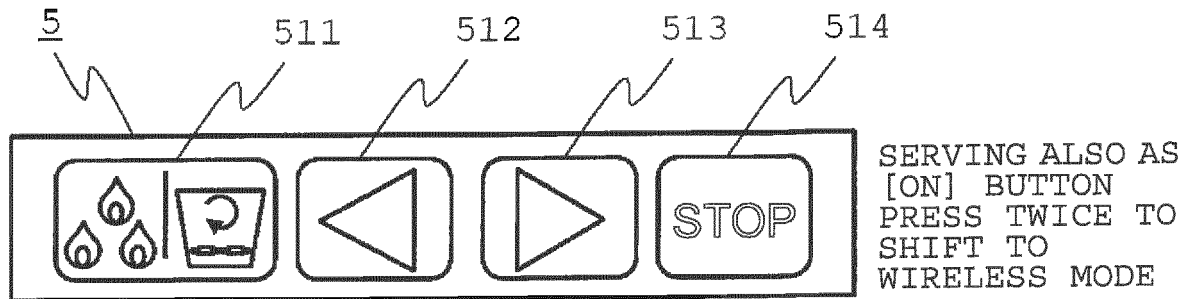
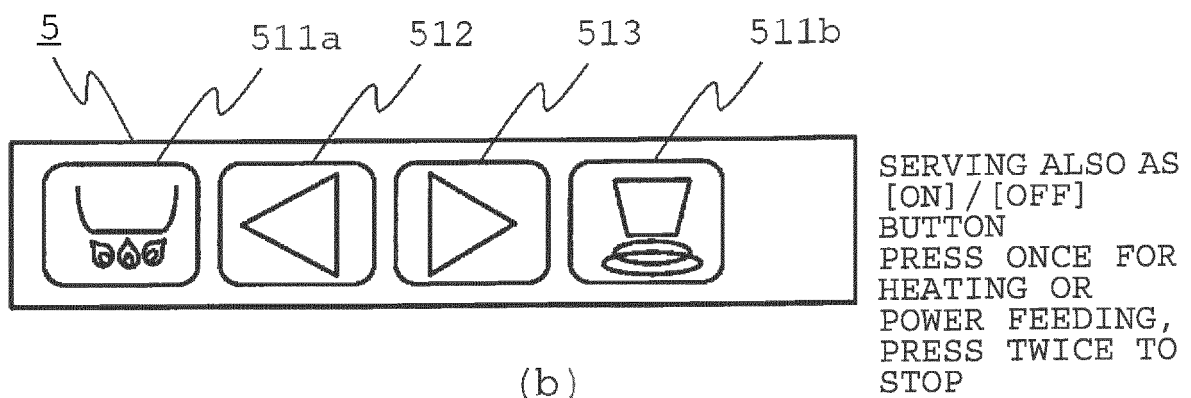


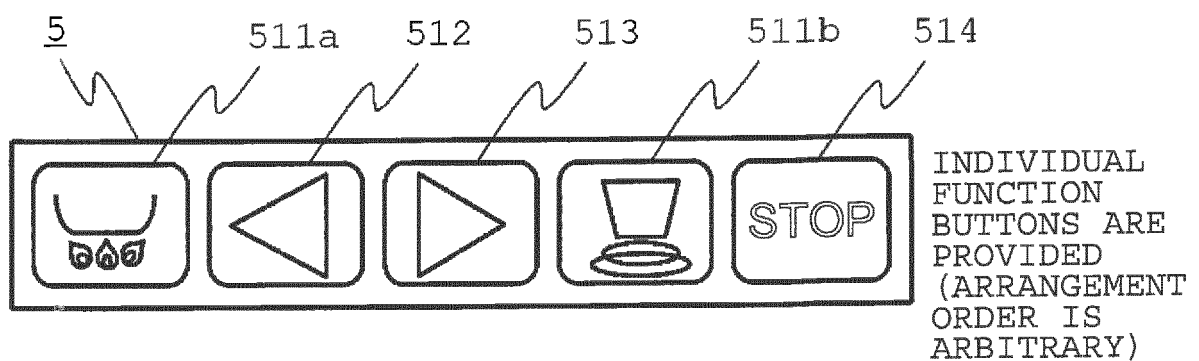
FIG. 22



(a)



(b)



(c)

FIG. 23

	OUTPUT POWER VALUE P	
	INDUCTION HEATING OPERATION MODE	NON-CONTACT POWER FEEDING OPERATION MODE
ADJUSTMENT VALUE α (SETTING LEVEL)		
1	200W	100W
2	400W	200W
3	600W	300W
⋮	⋮	⋮
8	2,000W	1,000W
9	2,500W	1,250W
10	3,000W	1,500W

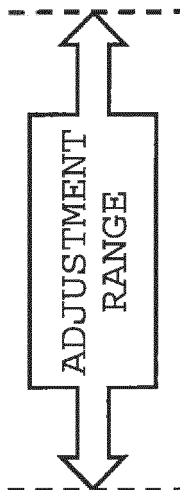


FIG. 24

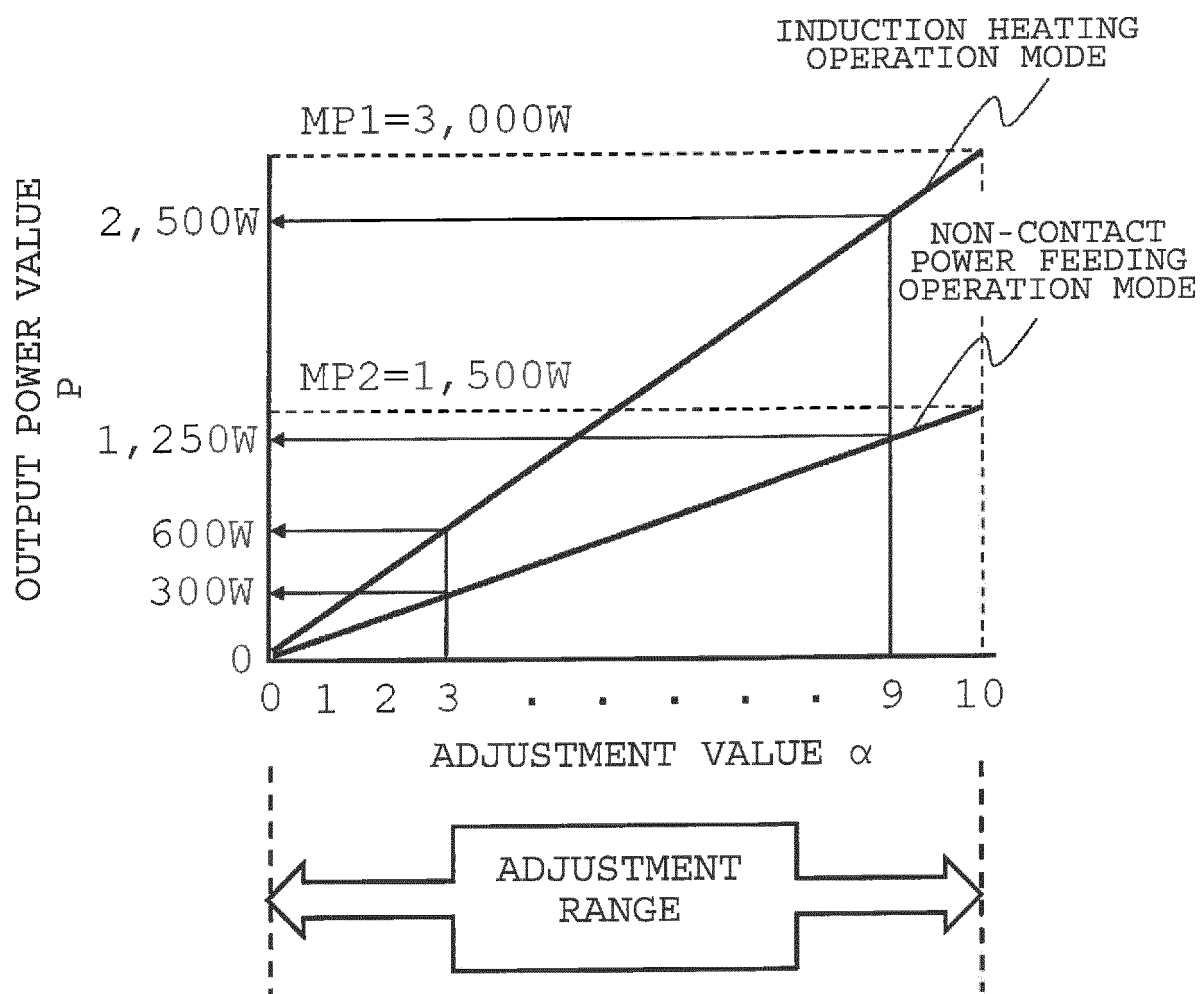


FIG.25

ADJUSTMENT VALUE α (SETTING LEVEL)	OUTPUT POWER VALUE P	
	INDUCTION HEATING OPERATION MODE	NON-CONTACT POWER FEEDING OPERATION MODE
LOW	1,000W	400W
MIDDLE	2,000W	750W
HIGH	3,000W	1,500W

FIG. 26

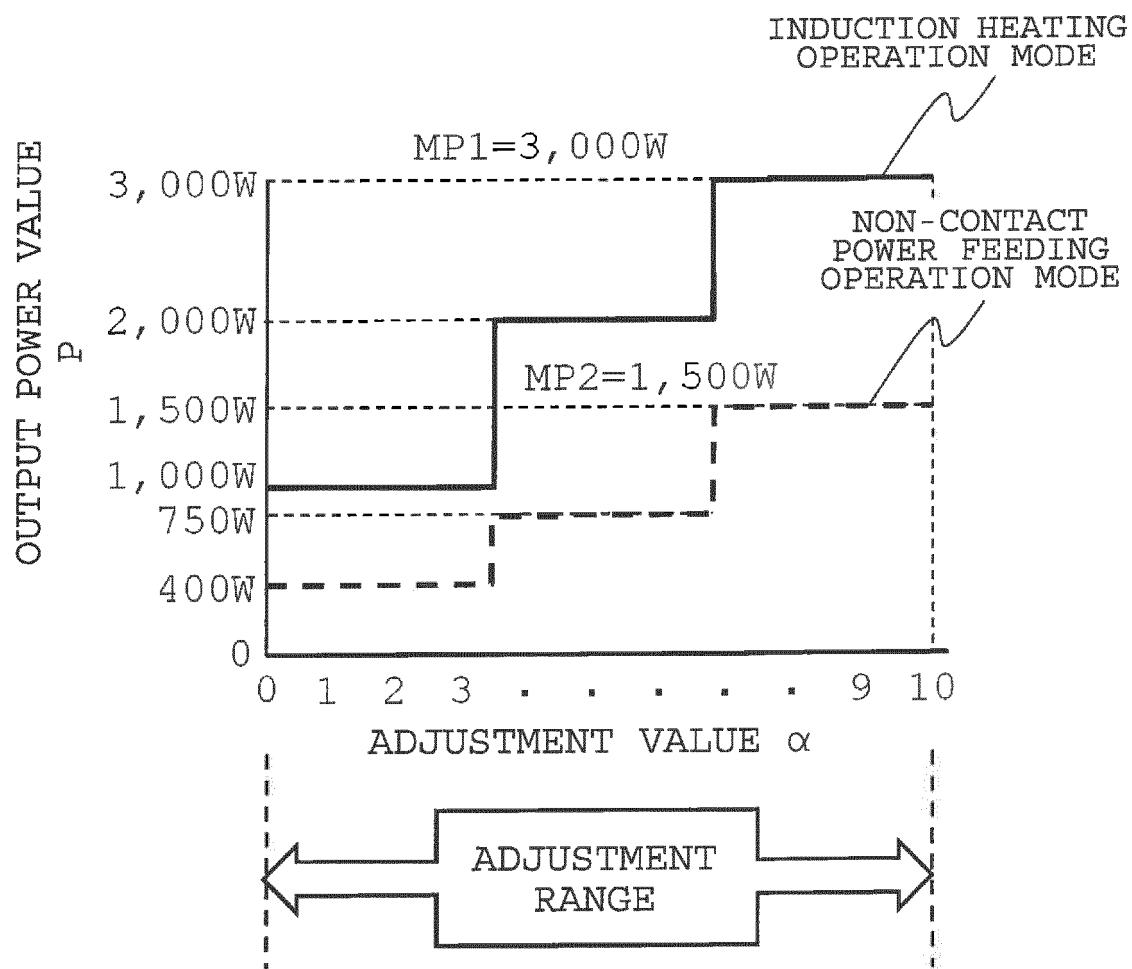
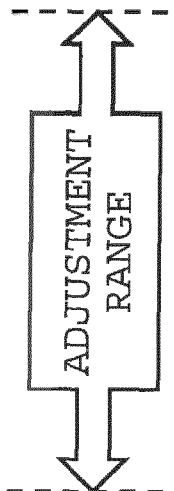


FIG. 27



ADJUSTMENT VALUE α (SETTING LEVEL)	OUTPUT POWER VALUE SETTING (PROPORTION ka) TABLE		
	INITIAL SETTING VALUE	INDUCTION HEATING OPERATION MODE	NON-CONTACT POWER FEEDING OPERATION MODE
1	200W	1	$ka=0.5$
2	400W	1	0.5
3	600W	1	0.5
•	•	•	•
•	•	•	•
•	•	•	•
8	2,000W	1	0.5
9	2,500W	1	0.5
10	3,000W	1	0.5

FIG. 28

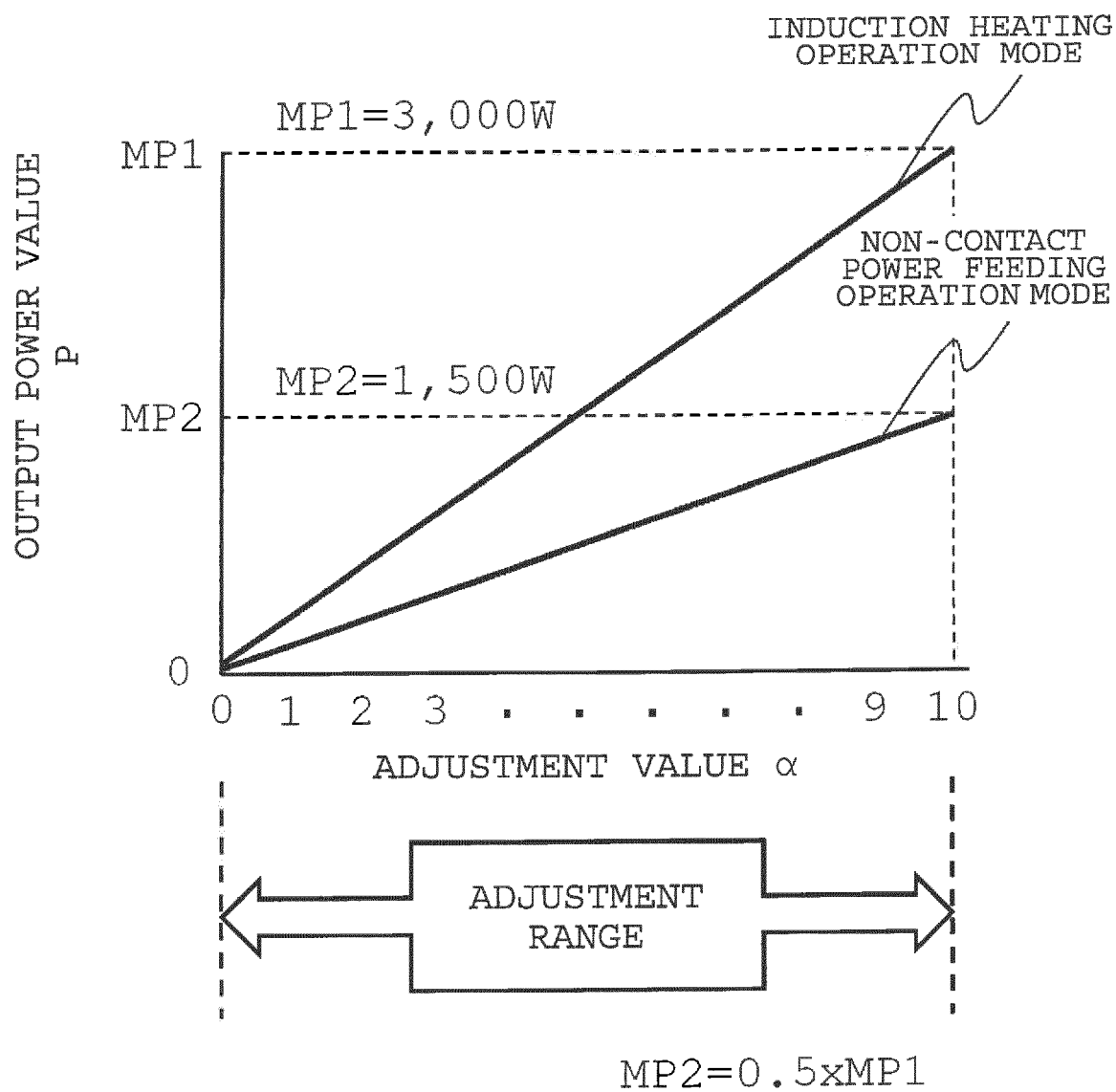


FIG. 29

OUTPUT POWER VALUE SETTING (PROPORTION kc) TABLE			
ADJUSTMENT VALUE α (SETTING LEVEL)	INITIAL SETTING VALUE	INDUCTION HEATING OPERATION MODE	NON-CONTACT POWER FEEDING OPERATION MODE
1	200W	1	$kc=0.9$
2	400W	1	0.45
3	600W	1	0.3
•	•	•	•
•	•	•	•
•	•	•	•
8	2,000W	1	0.4
9	2,500W	1	0.5
10	3,000W	1	0.5

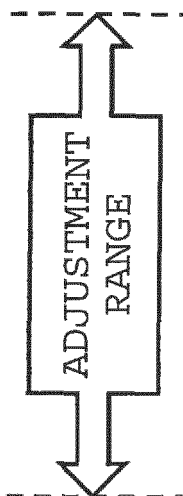


FIG. 30

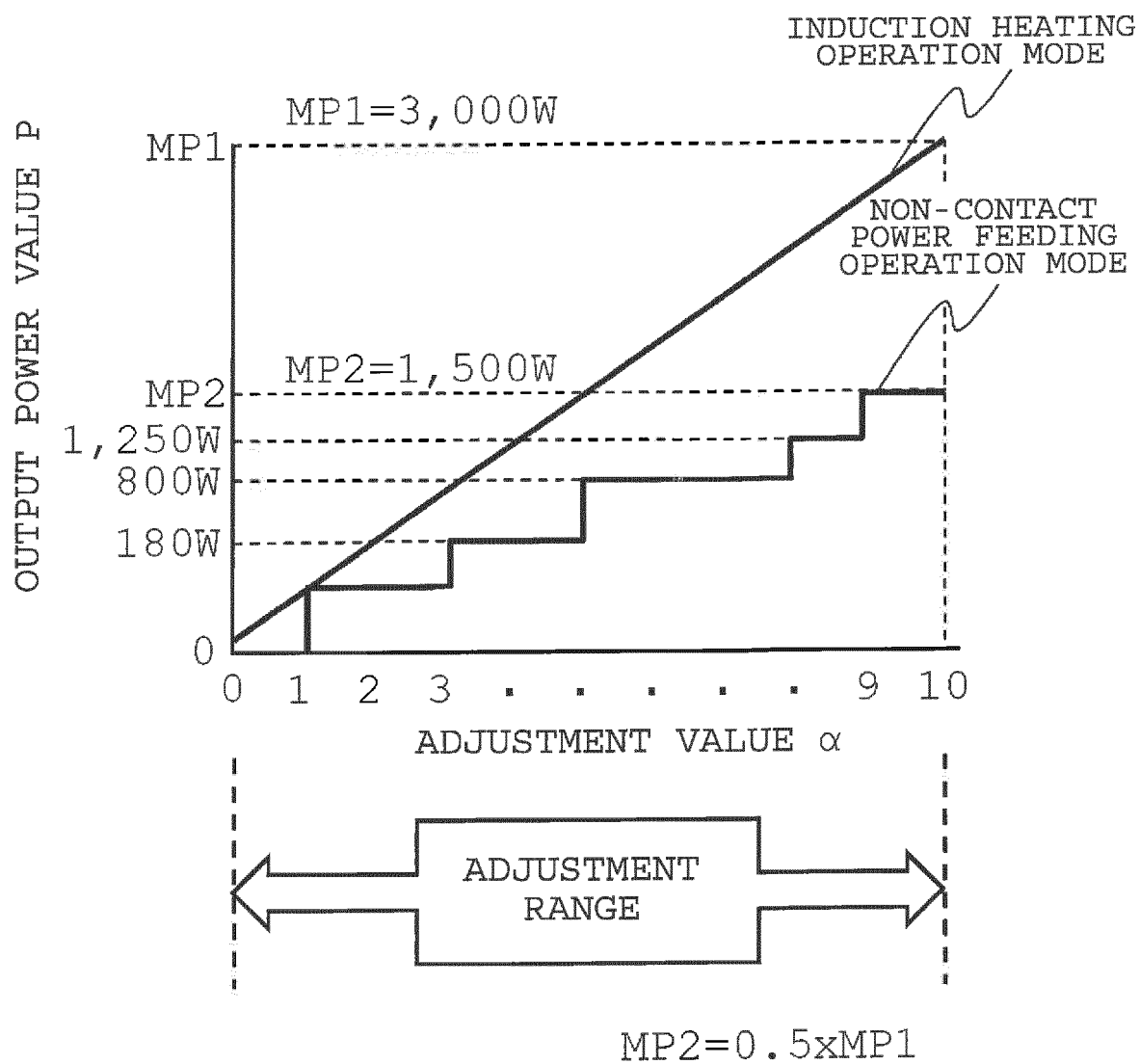
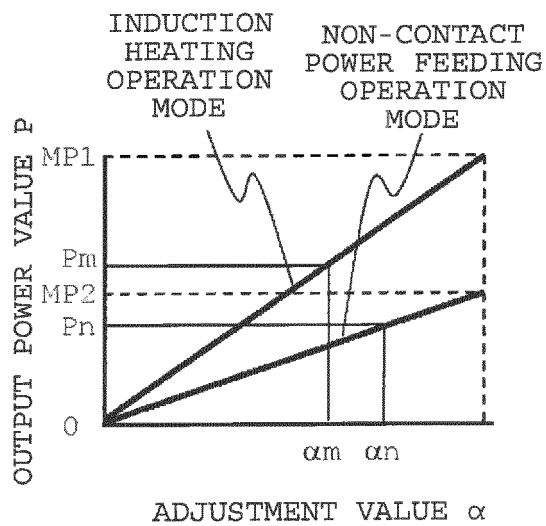
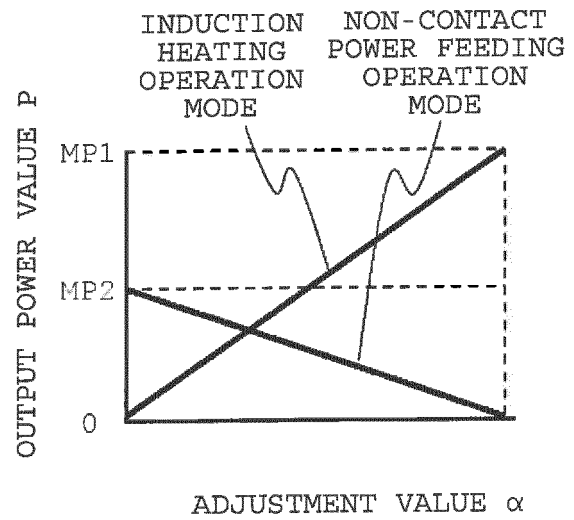


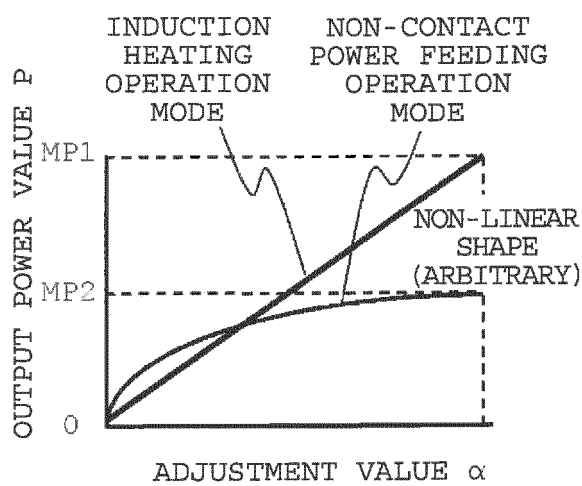
FIG. 31



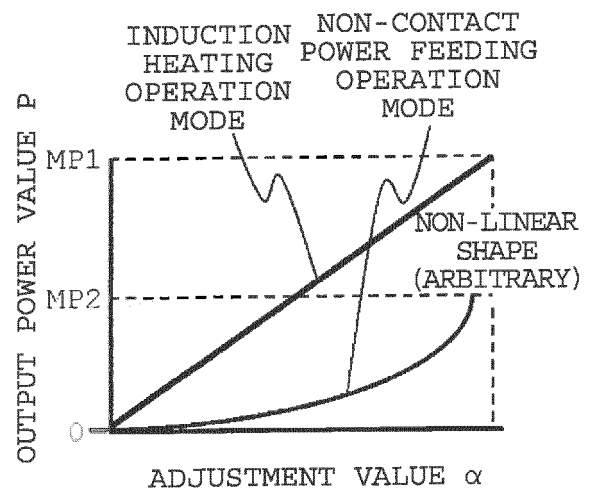
(a)



(b)



(c)



(d)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/071527

A. CLASSIFICATION OF SUBJECT MATTER

H05B6/12(2006.01) i

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)

H05B6/12

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016
 Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2013/094174 A1 (Panasonic Corp.), 27 June 2013 (27.06.2013), claims 1, 2; paragraphs [0022] to [0055], [0059]; all drawings & US 2014/0158680 A1 paragraphs [0030] to [0063], [0067]; all drawings & EP 2797384 A1 & CN 103262647 A & JP 2013-894174 A	1-4, 8, 9, 13, 15, 16, 18, 19 5-7, 10-12, 14, 17
Y	JP 2007-012490 A (Hitachi Appliances, Inc.), 18 January 2007 (18.01.2007), abstract; fig. 5, 6 (Family: none)	5-7, 10-12, 14, 17

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 Date of the actual completion of the international search
 13 October 2016 (13.10.16)

 Date of mailing of the international search report
 25 October 2016 (25.10.16)

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 3-4-3, Kasumigaseki, Chiyoda-ku,
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/071527

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2010/101202 A1 (Mitsubishi Electric Corp.), 10 September 2010 (10.09.2010), fig. 6, 7 & EP 2405715 A1 fig. 6, 7 & CN 102342177 A & ES 2547559 T & JP 5358673 B	10-12, 14, 17
Y	JP 2009-165291 A (Mitsubishi Electric Corp.), 23 July 2009 (23.07.2009), claim 28; fig. 4 (Family: none)	17

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REFERENCES CITED IN THE DESCRIPTION

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- WO 2013094174 A1 **[0022]**
- WO 2013038694 A1 **[0022]**
- JP H05184471 A **[0022]**
- JP H0629082 A **[0022]**
- JP 2013115893 A **[0022]**
- JP 2012054179 A **[0119]**