



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
01.01.2014 Bulletin 2014/01

(51) Int Cl.:
H05B 6/12 (2006.01)

(21) Application number: **11859439.9**

(86) International application number:
PCT/JP2011/006621

(22) Date of filing: **29.11.2011**

(87) International publication number:
WO 2012/114405 (30.08.2012 Gazette 2012/35)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **21.02.2011 JP 2011035123**

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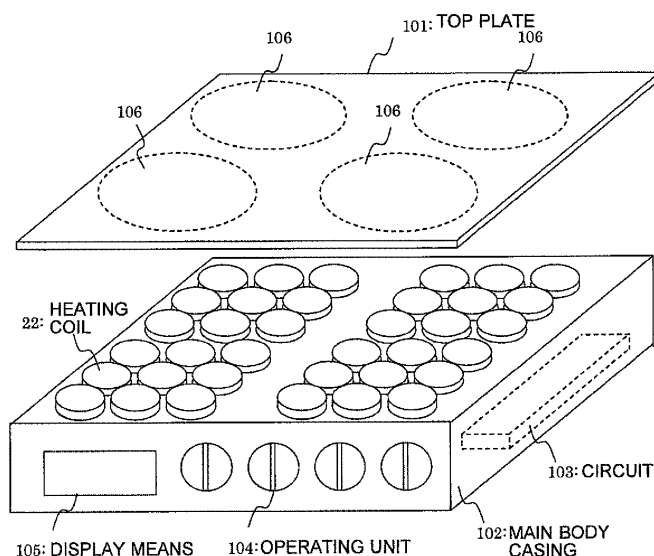
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(54) **INDUCTION-HEATING COOKWARE**

(57) In the case where two or more inverter circuits 9 of a plurality of inverter circuits 9 are driven at the same time, control means 25 drives the inverter circuits 9 at the same driving frequency, acquires output currents of the driven inverter circuits 9, and performs drive control for the inverter circuits 9 in such a manner that the phase

difference between the acquired output currents is reduced. Furthermore, the load determining means 26 performs a load determination on the basis of output currents of the driven inverter circuits 9 detected by output current detecting means 28 and input power or output power detected by power detecting means.

F I G. 1



Description

Technical Field

5 **[0001]** The present invention relates to an induction heating cooker including a plurality of heating coils.

Background Art

10 **[0002]** There has conventionally been proposed induction heating cookers, for example, an induction heating cooker "in which in the case where load detection is based on the input current, as illustrated in Fig. 4(b), it is detected that a suitable load exists when output V_{in} of an input current detecting unit 21 is equal to or greater than a load threshold V_{ond} and it is detected that no load exists when the output V_{in} is smaller than the load threshold V_{ond} . Furthermore, in the case where load detection is based on an inverter current, as illustrated in Fig. 4(c), it is detected that an aluminum pan exists when the output V_{inv} of an inverter current detecting unit 19 is equal to or greater than a load threshold V_{inv} (Vond) and it is detected that a suitable load exists when the output V_{inv} is smaller than the load threshold V_{inv} (Vond). When it is determined that a suitable load exists, then, a set on-time is returned. After a predetermined period T1, a similar operation is repeated. When it is determined that unsuitable load exists, an instruction for stopping heating is sent from a heating stopping unit 16 to an on-time setting unit 14, and heating is stopped" (for example, see Patent Literature 1).

Citation List

Patent Literature

25 **[0003]**

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 6-119968 (paragraph [0017])

Summary of Invention

Technical Problem

30 **[0004]** The above-mentioned technique of Patent Literature 1 performs a determination as to the state of a heating target, detects, in the case where the object is moved or removed, that the object has been moved or removed, and stops driving of an inverter circuit. Thus, a wasteful power consumption and an increase of leakage flux can be avoided. However, in the case where the above-mentioned method is applied to an induction heating cooker that includes a plurality of heating coils and that allows high-frequency current to flow to the plurality of heating coils at the same time, movement of power occurs between the heating coils due to magnetic coupling between the heating coils, and a difference occurs between power input to a heating coil and power for heating an object by the heating coil. Thus, a problem has existed in which it is impossible to perform an accurate determination of whether or not a heating target is placed above a heating coil.

35 **[0005]** The present invention has been designed to overcome the problem mentioned above, and provides an induction heating cooker for which in the case where high-frequency current flows to a plurality of heating coils at the same time, the accuracy of the determination as to whether or not a heating target is placed above the individual heating coils can be increased.

Solution to Problem

40 **[0006]** An induction heating cooker according to the present invention includes a plurality of heating coils; a plurality of inverter circuits that supply a high-frequency current to the heating coils; output current detecting means for detecting an output current of each of the inverter circuits; power detecting means for detecting input power or output power of each of the inverter circuits; load determining means for performing a load determination on the basis of the output current detected by the output current detecting means and the input power or the output power detected by the power detecting means; and control means for performing individual drive control of each of the inverter circuits. The control means drives, in a case where two or more inverter circuits of the plurality of inverter circuits are driven at the same time, the inverter circuits at the same driving frequency, acquires output currents of the driven inverter circuits, and performs drive control for the inverter circuits in such a manner that a phase difference between the acquired output currents is reduced. The load determining means performs the load determination on the basis of the output current

detected by the output current detecting means and the input power or the output power detected by the power detecting means for the driven inverter circuits. Regarding the phases of output currents, being in the same circumferential direction is set as a reference for concentric heating coils, and being in the opposite circumferential directions is set as a reference for heating coils that are arranged to be adjacent with each other (a circumferential direction in which positive mutual inductance is achieved).

Advantageous Effects of Invention

[0007] According to the present invention, in the case where high-frequency current flows to a plurality of heating coils at the same time, power movement occurring between the plurality of heating coils can be suppressed, and the accuracy of the determination as to whether or not a heating target is placed above the individual heating coils can be increased.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a diagram illustrating a configuration of an induction heating cooker according to Embodiment 1.
 [Fig. 2] Fig. 2 is a diagram illustrating a circuit configuration of the induction heating cooker according to Embodiment 1.
 [Fig. 3] Fig. 3 includes diagrams illustrating examples of driving signals and output voltage waveforms of an inverter circuit in the induction heating cooker according to Embodiment 1.
 [Fig. 4] Fig. 4 is a diagram illustrating an example of driving signals and output voltage waveforms of an inverter circuit in the induction heating cooker according to Embodiment 1.
 [Fig. 5] Fig. 5 includes diagrams illustrating an example of positional relationship between heating coils and a load (pan) to be heated in the induction heating cooker according to Embodiment 1.
 [Fig. 6] Fig. 6 is a diagram illustrating an example of heating permission/inhibition conditions at the time when heating starts in the induction heating cooker according to Embodiment 1.
 [Fig. 7] Fig. 7 is a diagram illustrating the state of magnetic coupling between heating coils in the induction heating cooker according to Embodiment 1.
 [Fig. 8] Fig. 8 is a diagram illustrating the flow of power among inverter circuits, heating coils, and a heating target in the induction heating cooker according to Embodiment 1.
 [Fig. 9] Fig. 9 is a diagram illustrating determining conditions as to whether or not a load to be heated is placed in the induction heating cooker according to Embodiment 1.
 [Fig. 10] Fig. 10 is a flowchart illustrating a heating control process by control means in the induction heating cooker according to Embodiment 1.
 [Fig. 11] Fig. 11 is a flowchart illustrating an initial load determining process by the control means in the induction heating cooker according to Embodiment 1.
 [Fig. 12] Fig. 12 is a flowchart illustrating an output control process for an inverter circuit for the peripheral heating coil n by the control means in the induction heating cooker according to Embodiment 1.
 [Fig. 13] Fig. 13 includes diagrams illustrating examples in which the phase difference between output currents is suppressed in the induction heating cooker according to Embodiment 1.
 [Fig. 14] Fig. 14 is a diagram illustrating the circuit configuration of an induction heating cooker according to Embodiment 2.
 [Fig. 15] Fig. 15 includes diagrams illustrating examples of driving signals of an inverter circuit in the induction heating cooker according to Embodiment 2.
 [Fig. 16] Fig. 16 is a flowchart illustrating a heating control process by control means in the induction heating cooker according to Embodiment 2.
 [Fig. 17] Fig. 17 is a flowchart illustrating an output control process for an inverter circuit for the peripheral heating coil n by the control means in the induction heating cooker according to Embodiment 2.
 [Fig. 18] Fig. 18 is a diagram illustrating an example of heating coils including an inner heating coil arranged at a central portion of a heating port and a plurality of peripheral heating coils arranged around the inner heating coil.
 [Fig. 19] Fig. 19 is a diagram illustrating an example of heating coils including an inner heating coil arranged at a central portion of a heating port and an outer heating coil wound so as to surround the inner heating coil.

Description of Embodiments

Embodiment 1.

(Configuration)

[0009] Fig. 1 is a diagram illustrating the configuration of an induction heating cooker according to Embodiment 1. In Fig. 1, 101 denotes a top plate, 102 denotes a main body casing, 103 denotes a circuit that supplies a high-frequency current, 104 denotes an operating unit, 105 denotes display means, and 22 denotes a heating coil.

The top plate 101 is provided so that a heating target such as a pan or the like is placed thereon. Heating ports 106 on which positions where pans are to be placed are indicated are arranged on the top plate 101. The circuit 103, the display means 105, and the heating coils 22 are accommodated inside the main body casing 102. The upper surface of the main body casing 102 is covered with the top plate 101 so that the internal configuration of the main body casing 102 is accommodated.

The circuit 103 has the configuration explained later with reference to Fig. 2 and supplies a high-frequency current to the heating coils 22.

The operating unit 104 is provided for a user to adjust heating output.

The display means 105 is a screen display device including a liquid crystal display device or the like and displays the operation state of the induction heating cooker.

The plurality of heating coils 22 are arranged, for each heating port, in each of a depth direction and a lateral direction.

[0010] Fig. 2 is a diagram illustrating the circuit configuration of the induction heating cooker according to Embodiment 1. The induction heating cooker is connected to an alternating-current power supply 1. Power supplied from the alternating-current power supply 1 is converted into direct-current power by a direct-current power supply circuit 2.

The direct-current power supply circuit 2 includes a rectifying diode bridge 3 that rectifies alternating-current power and a reactor 4 and a smoothing capacitor 5 that are arranged for each of the inverter circuits 9. Input power input to each of the inverter circuits 9 is detected by input voltage detecting means 7 and input current detecting means 6 that is provided for each of the inverter circuits 9. The power converted into direct-current power by the direct-current power supply circuit 2 is supplied to each of the inverter circuits 9-1 to 9-n.

The input current detecting means 6 and the input voltage detecting means 7 constitute "power detecting means" according to the present invention.

[0011] The plurality of inverter circuits 9-1 to 9-n are connected to the direct-current power supply circuit 2. The inverter circuits 9-1 to 9-n have the same configuration. Hereinafter, the inverter circuits 9-1 to 9-n will be referred to as inverter circuits 9 when the inverter circuits 9-1 to 9-n are not distinguished from one another. The inverter circuits 9 are provided in accordance with the number of the heating coils 22.

The inverter circuits 9 are each formed of two sets of arms that are each formed of two switching elements (IGBTs) that are connected in series between the same positive and negative buses of the direct-current power supply circuit 2 and diodes connected in anti-parallel with the switching elements (hereinafter, two sets of arms are referred to as a U-phase arm 10 and a V-phase arm 11, and a switching element on the positive bus side of each of the arms and a switching element on the negative bus side of each of the arms are referred to as an upper switch and a lower switch, respectively).

[0012] The U-phase arm 10 includes an upper switch 12, a lower switch 13, an upper diode 14 connected in anti-parallel with the upper switch 12, and a lower diode 15 connected in anti-parallel with the lower switch 13.

Furthermore, the V-phase arm 11 includes an upper switch 16, a lower switch 17, an upper diode 18 connected in anti-parallel with the upper switch 16, and a lower diode 19 connected in anti-parallel with the lower switch 17.

[0013] The upper switch 12 and the lower switch 13 forming the U-phase arm 10 are on/off driven in accordance with a driving signal output from a U-phase driving circuit 20.

The upper switch 16 and the lower switch 17 forming the V-phase arm 11 are on/off driven in accordance with a driving signal output from a V-phase driving circuit 21.

The U-phase driving circuit 20 outputs a driving signal for alternately turning on and off the upper switch 12 and the lower switch 13 in such a manner that the lower switch 13 is turned off during the period in which the upper switch 12 of the U-phase arm 10 is turned on and the lower switch 13 is turned on during the period in which the upper switch 12 is turned off.

Furthermore, similarly, the V-phase driving circuit 21 outputs a driving signal for alternately turning on and off the upper switch 16 and the lower switch 17 of the V-phase arm 11.

[0014] A load circuit 24 including the heating coil 22 and a resonant capacitor 23 is connected between output points of the two arms in each of the inverter circuits 9. The heating coil 22 and the resonant capacitor 23 form a series resonant circuit and have a resonant frequency. However, since the inverter circuit 9 is driven at a frequency higher than the resonant frequency, the load circuit 24 has inductive characteristics.

[0015] Control means 25 performs drive control of each of the inverter circuits 9-1 to 9-n and performs a function of

controlling the entire induction heating cooker. The control means 25 controls heating output, using detection values from the input current detecting means 6 and the input voltage detecting means 7, on the basis of a heating power instruction set by a user using the operating unit 104, in a full-bridge operation mode in which high-frequency driving signals are output from both the U-phase driving circuit 20 and the V-phase driving circuit 21.

[0016] Output current detecting means 28 detects a current (hereinafter, referred to as an output current) flowing to the load circuit 24 including the heating coil 22 and the resonant capacitor 23.

Load determining means 26 arranged inside the control means 25 performs determination as to whether or not a suitable pan (suitable load) is placed above the heating coils 22 on the basis of the correlation between an output current detected by the output current detecting means 28 and an input current detected by the input current detecting means 6 (hereinafter referred to as "load determination").

Here, suitable pans mean pans that are suitable for induction heating and include objects to be heated other than unsuitable pans. Furthermore, unsuitable pans described here mean low-resistance pans including aluminum pans that are made of a low-efficiency material and that cannot be heated, small articles including forks and spoons that should not be heated, and the state where a heating target is not placed.

In the explanation provided below, the case where the load determining means 26 performs a load determination on the basis of an output current and an input current will be explained. However, the present invention is not limited to this.

For example, load determination may be performed using input power or output power of the inverter circuits 9, instead of the input current, on the basis of the input power or the output power and the output current. In the case where output power is used, output voltage detecting means for detecting a voltage (effective value) output from the inverter circuits 9 to the load circuits 24 can be additionally provided so that output power can be detected on the basis of the output voltage and the output current detected by the output current detecting means 28.

(Power control operation)

[0017] Next, an operation for controlling heating output on the basis of the phase difference between the arms in the inverter circuits 9 will be explained.

Fig. 3 and Fig. 4 are diagrams illustrating examples of driving signals and output voltage waveforms of an inverter circuit in the induction heating cooker according to Embodiment 1:

- (a) illustrates an example of driving signals and output voltage waveforms of individual switches in a high output state;
- (b) illustrates an example of driving signals and output voltage waveforms of individual switches in a medium output state; and
- (c) illustrates an example of driving signals and output voltage waveforms of individual switches in a low output state.

Here, a preceding arm in Fig. 3 and Fig. 4 refers to an arm, of the U-phase arm 10 and the V-phase arm 11, whose change in output potential precedes the other arm, and a following arm refers to an arm, of the U-phase arm 10 and the V-phase arm 11, whose change in output potential follows the other arm.

In the following explanation, the case where the U-phase arms 10 are preceding arms and the V-phase arms 11 are following arms will be explained by way of example.

[0018] The control means 25 controls driving signals output from the U-phase driving circuits 20 and the V-phase driving circuits 21, and drives the inverter circuits 9 at a frequency higher than the resonant frequency of the load circuits 24. At this time, a driving signal output from a U-phase driving circuit 20 to a corresponding upper switch 12 and a corresponding lower switch 13 has the same frequency as that of a driving signal output from a V-phase driving circuit 21 to a corresponding upper switch 16 and a corresponding lower switch 17.

As illustrated in (a) to (c), the phase of a driving signal from a preceding arm (U-phase driving circuit 20) is advanced relative to the phase of a driving signal from a following arm (V-phase driving circuit 21), and thus a phase difference occurs between the output potential of the preceding arm and the output potential of the following arm. Based on this phase difference (hereinafter, also referred to as the phase difference between arms), the time of application of the output voltage of the inverter circuits 9 is controlled, and the magnitude of the output current flowing to the load circuits 24 can be controlled.

As illustrated in (a), in the case of the high output state, the phase difference between the arms is increased, and the voltage application duration in one cycle is thus increased. As illustrated in (b), in the case of the medium output state, the phase difference between the arms is reduced compared to the high output state, and the voltage application duration in one cycle is thus reduced. As illustrated in (c), in the case of the low output state, the phase difference between the arms is further reduced, and the voltage application duration in one cycle is thus further reduced.

The upper limit of the phase difference between the arms is applied to the case of an opposite phase (a phase difference of 180°), and the output voltage waveform at this time is substantially a rectangular wave. Furthermore, the lower limit of the phase difference between the arms is set to, for example, a level that does not cause a situation in which an

excessive current flows to a switching element due to the relation with the phase of a current flowing to the load circuit 24 or the like when the switching element is turned on and the switching element breaks down.

(Load determination)

[0019] Next, a load determination operation by the load determining means 26 will be explained.

[0020] Fig. 5 includes diagrams illustrating an example of the positional relationship between heating coils and load (pan) to be heated in the induction heating cooker according to Embodiment 1.

[0021] Fig. 5(a) is an explanatory diagram illustrating the state when the arrangement of the heating coils 22 is viewed from the above, and Fig. 5(b) is an explanatory diagram illustrating the state when the arrangement of the heating coils 22 is viewed from a side. In Fig. 5(a), neighboring heating coils 22 are wound in opposite circumferential directions. When high-frequency currents that are in phase with each other are output from the inverter circuits 9, high-frequency currents having phases shifted from each other by 180 degrees flow to the neighboring heating coils 22.

[0022] Fig. 6 is a diagram illustrating an example of heating permission/inhibition determining conditions at the time when heating starts in the induction heating cooker according to Embodiment 1.

[0023] Here, as illustrated in Fig. 5, the case where with respect to one heating port 106, nine heating coils 22 are arranged in such a manner that three heating coils 22 are arranged in a lateral direction and three heating coils 22 are arranged in a depth direction will be explained by way of example.

[0024] In the explanation provided below, the heating coil 22 arranged at a central portion of the heating port 106 is referred to as a central heating coil 22a.

[0025] In addition, the heating coils 22 arranged in the lateral direction and the depth direction relative to the central heating coil 22a are referred to as peripheral heating coils 22b-1 to 22b-8. Here, in the case where the peripheral heating coils 22b-1 to 22b-8 are not distinguished from one another, they are referred to as the peripheral heating coils 22b or the peripheral heating coil 22b. The number of the peripheral heating coils 22b is not limited to this. Any number of peripheral heating coils 22b may be arranged.

[0026] Furthermore, in the description provided below, the inverter circuit 9 that drives the central heating coil 22a is also referred to as an inverter circuit 9a for the central heating coil, and the inverter circuits 9 that drive the peripheral heating coils 22b-1 ... 22b-n are also referred to as inverter circuits 9b-1 ... 9b-n for the peripheral heating coil (1 ... n).

[0027] The load determining means 26 acquires an output current detected by the output current detecting means 28 and an input current detected by the input current detecting means 6 at a specific timing (described later) in the heating control. Then, by referring to, for example, information illustrated in Fig. 6, the load determining means 26 determines, on the basis of the acquired output current and input current, whether or not the load placed above each of the heating coils 22 is a suitable load.

For example, in the case where the output current is large as illustrated in Fig. 6, it is determined that a low-resistance pan that cannot be heated and that is made of a low-efficiency material, such as an aluminum pan, is placed. In the case where the input current is small, it is determined that it is in the state where no load is placed or that a small article that should not be heated, such as a fork or a spoon, is placed. Meanwhile, in the case where input current and output current are within a specific range, it is determined that suitable load, which is a load suitable for heating, is placed.

[0028] In the example illustrated in Fig. 5, since a pan 200 (suitable diameter) is placed above the entire central heating coil 22a and part of the peripheral heating coil 22b-2, the load determining means 26 determines that the suitable pan is placed above the central heating coil 22a and the peripheral heating coil 22b-2.

Then, the control means 25 drives the inverter circuit 9a for the central heating coil and the inverter circuit 9b-2 for the peripheral heating coil 2 above which the suitable pan is mounted. A heating control operation will be described later.

As described above, in this embodiment, the plurality of heating coils 22 are arranged in adjacent to one another, and in cooking by heating, the plurality of heating coils 22 may be driven at the same time.

(Principle of movement of power)

[0029] Next, the principle of the movement of power in the case where a plurality of heating coils 22 are driven at the same time will be explained.

Fig. 7 is a diagram illustrating the state of magnetic coupling between heating coils in the induction heating cooker according to Embodiment 1.

Here, two heating coils 22 between which power movement occurs are represented by heating coils A and B.

As described above, a determination as to whether or not a heating target is placed above each of heating coil is made on the basis of an output current flowing to the heating coil and power (equivalent to input current) input to or output from the heating coil.

In the case where a pan, which is a heating target, is placed above the heating coils A and B and the pan is magnetically coupled to the heating coils A and B, an eddy current is induced to the bottom of the pan above the heating coils due

to high-frequency magnetic fields generated by high-frequency currents flowing to the heating coils, and power is consumed. Thus, output power is large compared to the state where no load is placed.
Here, the case where the following currents flow to the heating coil A and the heating coil B will be discussed:

$$\text{Heating coil A: } i_a(t) = (\sqrt{2})I_a \cdot \sin(\omega t);$$

and

$$\text{Heating coil B: } i_b(t) = (\sqrt{2})I_b \cdot \sin(\omega t + \theta)$$

[0030] When the self-inductance and the resistance of the heating coil A are represented by L_a and r_a , respectively, the self-inductance and the resistance of the heating coil B are represented by L_b and r_b , respectively, and the mutual inductance is represented by M , power P_a and P_b output from the inverter circuits 9 to the heating coil A and the heating coil B, respectively, are represented as follows:

$$P_a = r_a \cdot I_a^2 + M \cdot I_a \cdot I_b \cdot \omega \cdot \sin\theta;$$

and

$$P_b = r_b \cdot I_b^2 - M \cdot I_a \cdot I_b \cdot \omega \cdot \sin\theta$$

[0031] That is, power movement occurs between neighboring heating coils, and the magnitude of the moving power depends on the phase difference θ between currents flowing to the heating coils.

Thus, in the case where the phase difference θ between currents flowing to the heating coil A and the heating coil B is large, the amount of power movement between the heating coils is large. In the case where the amount of the power movement between the heating coils is large, the load determining means 26 cannot correctly perform load determination. Meanwhile, when the phase difference θ is set to 0, power does not move between the heating coils. Thus, the accuracy of the determination regarding the load determination can be increased.

[0032] Fig. 8 is a diagram illustrating the flow of power among inverter circuits, heating coils, and a heating target in the induction heating cooker according to Embodiment 1.

Fig. 9 is a diagram illustrating determining conditions as to whether or not load to be heated is placed in the induction heating cooker according to Embodiment 1.

The movement of power between heating coils and the influence on load determination will further be explained with reference to Figs. 8 and 9.

Referring to Fig. 8, the measurement value of power (detection value of the power detecting means) output from the inverter circuit 9a to the heating coil A is represented by P_a , and the measurement value of an output current (detection value of the output current detecting means 28) flowing to the heating coil A is represented by I_a . Furthermore, the measurement value of power (detection value of the power detecting means) output from the inverter circuit 9b to the heating coil B is represented by P_b , and the measurement value of an output current (detection value of the output current detecting means 28) flowing to the heating coil B is represented by I_b .

Furthermore, the power moved from the heating coil A to the heating coil B is represented by P_{ab} .

[0033] As illustrated in Fig. 8, when the pan 200, which is a suitable pan, is placed above the heating coils A and B, the pan 200 is magnetically coupled to the heating coils A and B.

In this case, the load resistance that can be observed from the inverter circuit 9a and the resistance determined on the basis of magnetic coupling between the heating coil A and the pan 200 (object to be heated) are represented as follows:

Load resistance that can be observed from the inverter circuit 9a = $P_a / (I_a \times I_a)$;

and

Resistance determined on the basis of magnetic coupling between heating coil A and pan 200 = $(P_a - P_{ab}) / (I_a \times I_a)$

and

That is, the load resistance that can be observed from the inverter circuit 9a is greater than the resistance determined on the basis of the magnetic coupling between the heating coil A and the pan 200.

In this case, as represented by a point A in Fig. 9, due to power movement, the input current (equivalent to P_a) is detected as a large value by the input current detecting means 6 for the inverter circuit 9a.

[0034] Furthermore, the load resistance that can be observed from the inverter circuit 9b and the resistance determined on the basis of magnetic coupling between the heating coil B and the pan 200 (object to be heated) are represented as follows:

Load resistance that can be observed from the inverter circuit 9b = $P_b / (I_b \times I_b)$;

Resistance determined on the basis of magnetic coupling between heating coil

B and pan 200 = $(P_b + P_{ab}) / (I_b \times I_b)$

That is, the load resistance that can be observed from the inverter circuit 9b is smaller than the resistance determined on the basis of the magnetic coupling between the heating coil B and the pan 200.

In this case, as represented by a point B in Fig. 9, due to power movement, the input current (equivalent to P_b) is detected as a small value by the input current detecting means 6 for the inverter circuit 9b.

As described above, when the detection value of input current is detected as a small value, a false result of determination may be obtained as absence of load, a small article, or a low-resistance pan, in the load determination for the heating coil B (see Fig. 6).

[0035] By suppressing power movement occurring between heating coils, the accuracy of the load determination can be increased. An operation in this embodiment will now be explained.

(Operation)

[0036] Fig. 10 is a flowchart illustrating a heating control process by the control means in the induction heating cooker according to Embodiment 1.

The flow of the heating control process will be explained with reference to Fig. 10.

First, the control means 25 determines whether or not a heating start request, such as setting of a heating power using the operating unit 104, has been input (S101).

In the case where a heating start request has been issued, an initial load determining process starts (S200).

The details of the initial load determining process will be explained with reference to Fig. 11.

[0037] Fig. 11 is a flowchart illustrating an initial load determining process by the control means in the induction heating cooker according to Embodiment 1.

The control means 25 causes the inverter circuit 9a for the central heating coil to be driven at a specific output (specific frequency specific phase difference between arms) (S201).

The control means 25 acquires, for the inverter circuit 9 being driven, an output current detected by the output current detecting means 28 and an input current detected by the input current detecting means 6 (S202).

The control means 25 causes the output of the inverter circuit 9a for the central heating coil to be stopped after a certain period of time has passed (S203).

As described above, the load determining means 26 determines, on the basis of the acquired output current and input

current and heating permission/inhibition determining conditions (for example, Fig. 6), whether or not a suitable load is placed above the central heating coil 22a. Then, the load determining means 26 sets (stores) a result of load determination (S204).

[0038] In the case where it is determined that no suitable load is placed above the central heating coil 22a, the initial load determining process is terminated. Meanwhile, in the case where it is determined that a suitable load is placed above the central heating coil 22a, the process proceeds to load determining processing for the peripheral heating coil 22b-1 (S205).

[0039] In the initial loading determining processing (S206-1) for the peripheral heating coil 22b-1, the following processing is performed:

- (1) the control means 25 causes the inverter circuit 9-1 for the peripheral heating coil 1 to be driven at a specific output (specific frequency specific phase difference between arms);
- (2) the control means 25 acquires, for the inverter circuit 9 being driven, an output current detected by the output current detecting means 28 and an input current detected by the input current detecting means 6;
- (3) the control means 25 causes the output of the inverter circuit 9b-1 for the peripheral heating coil 1 to be stopped after a certain period of time has passed; and
- (4) the load determining means 26 determines, on the basis of the acquired output current and input current and heating permission/inhibition conditions (for example, Fig. 6), whether or not a suitable load is placed above the peripheral heating coil 22b-1. Then, the load determining means 26 sets (stores) a load result of determination.

[0040] In the following processing, similarly to the above description, in the initial load determining processing (S206-2, S206-3, ... S206-8) for the peripheral heating coils 22b-2, 22b-3, ... 22b-8, the processing of (1) to (4) described above is performed.

Although the case where eight peripheral heating coils 22b are arranged is described in this embodiment, the present invention is not limited to this. Furthermore, the above-described initial load determining processing is performed in an appropriate manner in accordance with the number of the peripheral heating coils 22b.

[0041] Referring back to Fig. 10, the control means 25 determines whether or not it is determined that suitable load is placed above the central heating coil 22a (S102). In the case where no suitable load is placed above the central heating coil 22a, the process returns to step S101 to repeat the above-described operation.

[0042] Meanwhile, in the case where a suitable load is placed above the central heating coil 22a, the control means 25 starts driving of the inverter circuit 9a for the central heating coil and the peripheral heating coil inverter circuit 9b for which it is determined that the suitable load is placed above the inverter circuit 9a for the central heating coil and the peripheral heating coil inverter circuit 9b in step S200 (S103). In the case where two or more inverter circuits 9 are driven, the inverter circuits 9 are driven at the same driving frequency.

Next, the control means 25 acquires, for each of the inverter circuits 9 being driven, the output current detected by the output current detecting means 28 and the input current detected by the input current detecting means 6 (S104).

The load determining means 26 determines, on the basis of the output current and the input current of the central heating coil 22a and heating permission/inhibition conditions (Fig. 6), whether or not a suitable load is placed above the central heating coil 22a (S105).

In the case where no suitable load is placed above the central heating coil 22a, the process proceeds to step S112, in which the control means 25 stops the driving of all the inverter circuits, and then returns to step S101.

[0043] Meanwhile, in the case where suitable load is placed above the central heating coil 22a, the control means 25 compares set power (heating power) set by a user using the operating unit 104 with an input power calculated on the basis of the detection values detected by the input current detecting means 6 and the input voltage detecting means 7 (S106).

[0044] In the case where the input power is smaller than the set power (step S106; >), it is determined whether or not the phase difference between the arms of the inverter circuit 9a for the central heating coil is smaller than the upper limit (180 degrees (half-cycle) (S107).

In the case where the phase difference between the arms has reached the upper limit, the process proceeds to an output control process for the peripheral heating coils 22b.

Meanwhile, in the case where the phase difference between the arms is smaller than the upper limit, the control means 25 increases the phase difference between the arms of the inverter circuit 9a for the central heating coil (S108), and the process proceeds to the output control process for the peripheral heating coils 22b.

[0045] In the case where the input power is greater than the set power (step S106; <), it is determined whether or not the phase difference between the arms of the inverter circuit 9a for the central heating coil is greater than a lower limit value (S109). The lower limit value of the phase difference between the arms is set to, for example, a level that does not cause a situation where excessive current flows to a switching element due to the relation with the phase of the current flowing to the load circuit 24 or the like when the switching element is turned on and the switching element breaks

down.

In the case where the phase difference between the arms has reached the lower limit value, the process proceeds to the output control process for the peripheral heating coils 22b.

Meanwhile, in the case where the phase difference between the arms is greater than the lower limit value, the control means 25 reduces the phase difference between the arms of the inverter circuit 9a for the central heating coil (S110), and the process proceeds to the output control process for the peripheral heating coils 22b.

[0046] In the case where the set power and the input power are approximately the same (step S106; $\approx$), the process proceeds to the output control process for the heating coils 22b.

[0047] The control means 25 performs the output control process for the peripheral heating coils 22b-1, 22b-2, ..., 22b-8 (S300-1 to 300-8). The details of the control will be explained with reference to Fig. 12.

Here, the same output control process is performed for the individual peripheral heating coils 22b. In the explanation with reference to Fig. 12, a peripheral heating coil 22b for which an output control process is performed is referred to as a peripheral heating coil n, and an inverter circuit 9 that drives the peripheral heating coil n is referred to as an inverter circuit 9b-n for the peripheral heating coil n.

[0048] Fig. 12 is a flowchart illustrating an output control process for an inverter circuit for the peripheral heating coil n by the control means in the induction heating cooker according to Embodiment 1.

The control means 25 determines whether or not an inverter circuit 9b-n for the peripheral heating coil n is being driven (S301). In the case where the inverter circuit 9b-n for the peripheral heating coil n is not being driven, the output processing for the peripheral heating coil n is terminated.

In the case where the inverter circuit 9b-n for the peripheral heating coil n is being driven, the control means 25 acquires, for the inverter circuit 9b-n for the peripheral heating coil n, the output current detected by the output current detecting means 28 and the input current detected by the input current detecting means 6 (S302).

[0049] The control means 25 determines whether or not the acquired output current is greater than a specific overcurrent value (S303). In the case where the output current is greater than the specific overcurrent value, the control means 25 stops the driving of the inverter circuit 9b-n for the peripheral heating coil n (S304), and terminates the output processing for the inverter circuit 9b-n for the peripheral heating coil n.

Meanwhile, in the case where the output current is not greater than the specific overcurrent value, a determination as to the phase of the output current of the inverter circuit 9b-n for the peripheral heating coil n is performed on the basis of the output current of the inverter circuit 9a for the central heating coil (S305).

[0050] In the case where the phase of the output current of the peripheral heating coil n is delayed, the control means 25 causes the phase of a driving signal of the inverter circuit 9b-n for the peripheral heating coil n to be advanced, so that the phase of the output voltage of the peripheral heating coil n is advanced (shift correction for delayed current). Accordingly, the phase difference from the phase of the output current of the central heating coil is reduced (S306).

Meanwhile, in the case where the phase of the output current of the peripheral heating coil n is advanced, the control means 25 causes the phase of a driving signal of the inverter circuit 9b-n for the peripheral heating coil n to be delayed, so that the phase of the output voltage of the peripheral heating coil n is delayed (shift correction for advanced current). Accordingly, the phase difference from the phase of the output current of the central heating coil is reduced (S307).

[0051] The phase of a driving signal may be advanced (or delayed) by a specific amount of time. Alternatively, the phase difference between output currents is detected, and the phase may be advanced (or delayed) by the time corresponding to the phase difference. Even in the case where the phase of the driving signal is advanced (or delayed) by a specific amount of time, since the output processing is repeatedly performed as described later, the output currents are made substantially in phase with each other eventually.

Furthermore, by repeatedly performing the output processing for the individual peripheral heating coils n, output currents of all the peripheral heating coils being driven are made substantially in phase with one another eventually.

[0052] Shift correction for a delayed current and shift correction for an advanced current for suppressing the phase difference between output currents will be explained with reference to Fig. 13.

[0053] Fig. 13 includes diagrams illustrating examples in which the phase difference between output currents is reduced in the induction heating cooker according to Embodiment 1:

- (a) illustrates an example of output voltage waveforms and output current waveforms in the shift correction for delayed current; and
- (b) illustrates an example of output voltage waveforms and output current waveforms in the shift correction for advanced current.

In Fig. 13, for the sake of easier understanding, individual output voltage waveforms are expressed by rectangular waves. However, it is noted that as explained above with reference to Figs. 3 and 4, an output voltage wave is changed by performing phase control between arms in accordance with heating output.

[0054] In (a), before phase correction, the output current of the peripheral heating coil n has a delayed phase ($\theta 1$)

relative to the output current of the central heating coil 22a. In this case, by causing the output voltage of the peripheral heating coil n to be advanced relative to the output voltage of the central heating coil (t1), the output currents can be made substantially in phase with each other after the phase correction.

In (b), before phase correction, the output current of the peripheral heating coil n has an advanced phase (θ_2) relative to the output current of the central heating coil. In this case, by causing the output voltage of the peripheral heating coil n to be delayed relative to the output voltage of the central heating coil (t2), the output currents can be made substantially in phase with each other after the phase correction.

[0055] As described above, by reducing the phase difference between the output current of the peripheral heating coil n and the output current of the central heating coil 22a (substantially in phase with each other), power movement between the peripheral heating coil n and the central heating coil 22a can be suppressed.

[0056] Referring back to Fig. 12, in the case where the output current of the peripheral heating coil n is substantially in phase with the output current of the central heating coil in step S305, the load determining means 26 determines whether or not suitable load is placed above the peripheral heating coil n (S308).

In the case where suitable load is not placed above the peripheral heating coil n, the control means 25 stops driving of the inverter circuit 9b-n for the peripheral heating coil n (S309), and terminates the output processing for the peripheral heating coil n.

As described above, by reducing the phase difference between output currents and performing load determination in the state where power movement between heating coils is suppressed, the accuracy of the determination can be improved.

[0057] After step S306 or S307 described above is performed or in the case where a suitable load is placed in step S308, the control means 25 compares the output current of the central heating coil 22a with the output current of the peripheral heating coil n (S310).

[0058] In the case where the output current of the peripheral heating coil n is smaller than the output current of the central heating coil 22a (step S310; >), it is determined whether the phase difference between the arms of the inverter circuit 9b-n for the peripheral heating coil n is smaller than the upper limit (180 degrees (half cycle)) (S311).

In the case where the phase difference between the arms has reached the upper limit value, the output processing for the peripheral heating coil n is terminated.

Meanwhile, in the case where the phase difference between the arms is smaller than the upper limit, the control means 25 increases the phase difference between the arms of the inverter circuit 9b-n for the peripheral heating coil n (S312), and terminates the output processing for the peripheral heating coil n.

[0059] In the case where the output current of the peripheral heating coil n is greater than the output current of the central heating coil 22a (step S310; <), it is determined whether the phase difference between the arms of the inverter circuit 9b-n for the peripheral heating coil n is greater than a lower limit value (S313). The lower limit value of the phase difference between the arms is set to, for example, a level that does not cause a situation where excessive current flows to a switching element due to the relation with the phase of the current flowing to the load circuit 24 or the like when the switching element is turned on and the switching element breaks down.

In the case where the phase difference between the arms has reached the lower limit value, the output processing for the peripheral heating coil n is terminated.

Meanwhile, in the case where the phase difference between the arms is greater than the lower limit value, the control means 25 reduces the phase difference between the arms of the inverter circuit 9b-n for the peripheral heating coil n (S314), and terminates the output processing for the peripheral heating coil n.

[0060] In the case where the output current of the central heating coil 22a and the output current of the peripheral heating coil n are substantially the same (step S310; $\approx$), the output processing for the peripheral heating coil n is terminated.

[0061] Referring back to Fig. 10, after the output control process for all the peripheral heating coils is terminated, the control means 25 determines whether or not an operation for a heating stop request to be set by a user using the operating unit 104 has been performed (S111).

In the case where a heating stop request has not been issued, the process returns to step S104 to repeat the above-described operation.

Meanwhile, in the case where a heating stop request has been issued, the process proceeds to step S112, in which the control means 25 causes the driving of all the inverter circuits 9 to be stopped. Then, the process returns to step S101.

[0062] As the operation described above, the example has been described in which the phase difference from a driving signal of the inverter circuit 9a for the central heating coil is controlled as required in the output control processing (S300-1 to S300-8) for the peripheral heating coils n. However, the present invention is not limited to this. For example, in the initial load determining processing (S200) at the time when heating starts, the load state of the individual heating coils 22 may be determined, and the phase of the driving signal of each of the inverter circuits 9 may be moved (corrected) so that the high-frequency currents flowing to the heating coils 22 can be made substantially in phase with one another.

[0063] The above description is directed to the case where the operation for sequentially reducing the phase difference

between the output current of the central heating coil 22a and the output current of each of the peripheral heating coils n. However, the present invention is not limited to this. Any operation can be employed as long as it reduces the phase difference between the output currents of a plurality of heating coils 22 that are being driven at the same time.

For example, the phase of the output voltage of the central heating coil 22a may be controlled. Furthermore, control may be performed such that, on the basis of the output current of a reference heating coil 22 being driven, the phase difference of the output current of another heating coil 22 from the reference heating coil 22 is reduced, without distinction between the central heating coil 22a and a peripheral heating coil n.

(Effects)

[0064] As described above, in this embodiment, in the case where two or more inverter circuits 9 of the plurality of inverter circuits 9 are driven at the same time, the inverter circuits 9 are driven at the same driving frequency. Furthermore, the output currents of the driven inverter circuits 9 are acquired, and drive control for the inverter circuits 9 is performed in such a manner that the phase difference between the acquired output currents is reduced. Then, load determination is performed on the basis of the output currents detected by the output current detecting means 28 for the driven inverter circuits 9 and the input power or output power detected by the power detecting means.

Thus, power movement occurring between the plurality of heating coils 22 can be suppressed, and the determination as to a heating target that is magnetically coupled to the individual heating coils 22 can be accurately performed on the basis of the output currents flowing to the individual heating coils 22 and the power (input currents) output to the heating coils 22. Therefore, the accuracy of the determination as to whether or not the heating target is placed above the individual heating coils can be increased.

In this embodiment, neighboring heating coils 22 are wound in opposite circumferential directions, and power movement between the heating coils 22 is suppressed by reducing the phase difference between output currents from the inverter circuits 9 to the heating coils 22. However, winding neighboring heating coils 22 in the same circumferential directions and causing the phase difference between currents output from the inverter circuits 9 to the neighboring heating coils 22 to approach a difference of 180 degrees is also equivalent operation for suppressing power movement between the heating coils 22.

[0065] Furthermore, in this embodiment, in the case where two or more inverter circuits 9 of the plurality of inverter circuits 9 are driven at the same time, the phases of the output voltage of the inverter circuits 9 are controlled such that the phase difference between the output currents is reduced.

Thus, the phase difference between currents flowing to the heating coils 22 that are being driven can be reduced, and power movement occurring between neighboring heating coils 22 can be suppressed. Therefore, the accuracy of the load determination based on the output current and the input power or output power (input current) can be increased.

[0066] Furthermore, in this embodiment, in the case where two or more inverter circuits 9 of the plurality of inverter circuits 9 are driven at the same time, driving signals output to the switching elements of the inverter circuits 9 are controlled such that the phase difference between output currents is reduced.

Thus, the phase difference between the currents flowing to the heating coils 22 that are being driven can be reduced, and power movement occurring between neighboring heating coils 22 can be suppressed. Therefore, the accuracy of the load determination based on the output current and the input power or output power (input power) can be increased.

[0067] Furthermore, in this embodiment, the load determining means 26 determines whether or not a suitable load is placed above heating coils 22 on the basis of the correlation between output currents detected by the output current detecting means 28 and input power or output power detected by the power detecting means. Then, the control means 25 stops driving of inverter circuits 9 for heating coils 22 above which no suitable load is placed, on the basis of the result of determination by the load determining means 26.

Thus, the determination as to whether or not suitable load is placed can be accurately performed. In addition, heating of an object (load) that is not suitable for being heated can be prevented. Furthermore, the heating coils 22 can be prevented from being driven in the no-load state where no load is placed above heating coils 22.

Embodiment 2.

[0068] In Embodiment 2, an embodiment in which the inverter circuits 9 each have a half-bridge configuration will be explained.

[0069] Fig. 14 is a diagram illustrating the circuit configuration of an induction heating cooker according to Embodiment 2.

Hereinafter, explanations will be provided with emphasis on differences from Embodiment 1 described above. In Fig. 14, configurations similar to that in Embodiment 1 (Fig. 2) described above are referred to with the same reference signs.

[0070] Individual inverter circuits 9' in Embodiment 2 each have a half-bridge configuration and each include a switching element (upper switch 12') on a higher potential side, a switching element (lower switch 13') on a lower potential side,

an upper diode 14' connected in anti-parallel with the upper switch 12', and a lower diode 15' connected in anti-parallel with the lower switch 13'.

A load circuit 24' is connected between output points of each of the inverter circuits 9'. The load circuit 24' includes a heating coil 22, a resonant capacitor 23, and a clamp diode 27 connected in parallel to the resonant capacitor 23.

The clamp diode 27 clamps the potential of the connection point between the heating coil 22 and the resonant capacitor 23 at the potential of a bus on a lower potential side of a direct-current power supply. Due to the operation of the clamp diode 27, communication of the current flowing to the heating coil 22 does not take place in the state where the lower switch 13' is connected.

[0071] The upper switch 12' and the lower switch 13' are on/off driven in accordance with a driving signal output from a driving circuit 20'.

When the control means 25 according to this embodiment alternately turns on and off the switching element on the higher potential side (upper switch 12') and the switching element on the lower potential side (lower switch 13'), a high-frequency voltage is generated between: the connection point therebetween; and one end of the direct-current bus. The control means 25 thus supplies the high-frequency voltage to the load circuit 24'.

[0072] Fig. 15 includes diagrams illustrating examples of driving signals of an inverter circuit in the induction heating cooker according to Embodiment 2:

- (a) illustrates examples of driving signals and output voltage waveforms of individual switches in a high output state;
- (b) illustrates examples of driving signals and output voltage waveforms of individual switches in a medium output state; and
- (c) illustrates examples of driving signals and output voltage waveforms of individual switches in a low output state.

The control means 25 controls driving signals output from the driving circuits 20', and drives the inverter circuits 9' at a frequency higher than the resonant frequency of the load circuits 24'.

As illustrated in (a) to (c), when the control means 25 in this embodiment controls the duty ratio of a switching element on the higher potential side (upper switch 12') and a switching element on the lower potential side (lower switch 13'), the application time of the output voltage of the inverter circuit 9' is controlled. Thus, the control means 25 is capable of controlling the magnitude of the output current flowing to the load circuit 24'.

As illustrated in (a), in the case of the high output state, the duty ratio (on-duty ratio) of the upper switch 12' is increased, and the voltage application duration in one cycle is thus increased. Furthermore, as illustrated in (b), in the case of the medium output state, the duty ratio (on-duty ratio) of the upper switch 12' is reduced compared to the high output state, and the voltage application duration in one cycle is thus reduced. Furthermore, in the case of the low output state illustrated in (c), the duty ratio (on-duty ratio) of the upper switch 12' is further reduced, and the voltage application duration in one cycle is further reduced.

[0073] Fig. 16 is a flowchart illustrating a heating control process by the control means in the induction heating cooker according to Embodiment 2.

Fig. 17 is a flowchart illustrating an output control process for an inverter circuit for the peripheral heating coil n by the control means in the induction heating cooker according to Embodiment 2.

With reference to Fig. 16 and Fig. 17, differences from Embodiment 1 described above (Fig. 10 and Fig. 12) will be explained.

Operations similar to those in Embodiment 1 described above are referred to with the same step numbers. Furthermore, operations of an initial load determining process are similar to those in Embodiment 1 described above (Fig. 11).

In the explanation provided below, an inverter circuit 9' that drives the central heating coil 22a is referred to as an inverter circuit 9'a for the central heating coil, and inverter circuits 9' that drive the peripheral heating coils 22b-1 ... 22b-n are referred to as inverter circuits 9'b-1 ... 9'b-n for the peripheral heating coil (1 ... n).

[0074] First, regarding the heating control process in Fig. 16, differences from Embodiment 1 described above will be explained.

In the case where input power is smaller than set power in step S106 (step S106; >), it is determined whether the duty ratio of the upper switch 12' of the inverter circuit 9'a for the central heating coil is smaller than the upper limit (S401).

In the case where the duty ratio of the upper switch 12' has reached the upper limit value, the process proceeds to an output control process for the peripheral heating coils 22b.

Meanwhile, in the case where the duty ratio of the upper switch 12' is smaller than the upper limit, the control means 25 increases the duty ratio of the upper switch 12' of the inverter circuit 9'a for the central heating coil (S402), and the process proceeds to the output control process for the peripheral heating coils 22b.

[0075] In the case where the input power is greater than the set power in step S106 (step S106; <), it is determined whether the duty ratio of the upper switch 12' of the inverter circuit 9'a for the central heating coil is greater than a lower limit value (S403).

In the case where the duty ratio of the upper switch 12' has reached the lower limit value, the process proceeds to the

output control process for the peripheral heating coils 22b.

Meanwhile, in the case where the duty ratio of the upper switch 12' is greater than the lower limit value, the control means 25 reduces the duty ratio of the upper switch 12' of the inverter circuit 9'a for the central heating coil (S404), and the process proceeds to the output control process for the peripheral heating coils 22b.

[0076] In the case where the set power and the input power are substantially the same in step S106 (step S106; $\approx$), the process proceeds to the output control process for the peripheral heating coils 22b.

[0077] Next, regarding the output control process in Fig. 17, differences from Embodiment 1 described above will be explained.

In the case where the output current of the peripheral heating coil n is smaller than the output current of the central heating coil 22a in step S310 (step S310; $>$), it is determined whether the duty ratio of the upper switch 12' of an inverter circuit 9'b-n for the peripheral heating coil n is smaller than the upper limit (S501).

In the case where the duty ratio of the upper switch 12' has reached the upper limit, the output processing for the peripheral heating coil n is terminated.

Meanwhile, in the case where the duty ratio of the upper switch 12' is smaller than the upper limit, the control means 25 increases the duty ratio of the upper switch 12' of the inverter circuit 9'b-n for the peripheral heating coil n (S502), and terminates the output processing for the peripheral heating coil n.

[0078] In the case where the output current of the peripheral heating coil n is greater than the output current of the central heating coil 22a in step S310 (step S310; $<$), it is determined whether the duty ratio of the upper switch 12' of the inverter circuit 9'b-n for the peripheral heating coil n is greater than a lower limit value (S503).

In the case where the duty ratio of the upper switch 12' has reached the lower limit value, the output processing for the peripheral heating coil n is terminated.

Meanwhile, in the case where the duty ratio of the upper switch 12' is greater than the lower limit value, the control means 25 reduces the duty ratio of the upper switch 12' of the inverter circuit 9'b-n for the peripheral heating coil n (S504), and terminates the output processing for the peripheral heating coil n.

[0079] In the case where the output current of the central heating coil 22a and the output current of the peripheral heating coil n are substantially the same in step S310 (step S310; $\approx$), the output processing for the peripheral heating coil n is terminated.

(Effects)

[0080] As described above, in this embodiment, the inverter circuits 9' each have a half-bridge configuration. Even with this configuration, effects similar to those in Embodiment 1 described above can be achieved.

[0081] A circuit configuration may be employed in which both the inverter circuit 9' having a half-bridge configuration in Embodiment 2 and the inverter circuit 9 having a full-bridge configuration in Embodiment 1 exist.

[0082] Although the case has been explained in Embodiments 1 and 2 described above in which the plurality of heating coils 22 include the central heating coil 22a arranged at a central portion of each of the heating ports 106 arranged on the top plate 101 and the plurality of peripheral heating coils 22b arranged in each of the lateral direction and the depth direction of the central heating coil 22a, the present invention is not limited to this.

For example, as illustrated in Fig. 18, the plurality of heating coils 22 may include a central heating coil 22a arranged at a central portion of each of the heating ports 106 arranged on the top plate 101 and a plurality of peripheral heating coils 22b arranged in a circumferential direction of the central heating coil 22a.

Even with this configuration, effects similar to those in Embodiment 1 described above can be achieved.

[0083] Furthermore, for example, as illustrated in Fig. 19, the plurality of heating coils 22 may include an inner heating coil 22' arranged at a central portion of each of the heating ports 106 arranged on the top plate 101 and an outer heating coil 22' wound so as to surround the inner heating coil 22'. In this case, the central heating coil 22a in the operation explanation described above corresponds to the inner heating coil 22' and the peripheral heating coil 22b corresponds to the outer heating coil 22'.

Even with this configuration, effects similar to those in Embodiment 1 described above can be achieved.

Reference Signs List

[0084] 1 alternating-current power supply, 2 direct-current power supply circuit, 3 rectifying diode bridge, 4 reactor, 5 smoothing capacitor, 6 input current detecting means, 7 input voltage detecting means, 9 inverter circuit, 10 U-phase arm, 11 V-phase arm, 12 upper switch, 13 lower switch, 14 upper diode, 15 lower diode, 16 upper switch, 17 lower switch, 18 upper diode, 19 lower diode, 20 U-phase driving circuit, 21 V-phase driving circuit, 22 heating coil, 23 resonant capacitor, 24 load circuit, 25 control means, 26 load determining means, 27 clamp diode, 28 output current detecting means, 101 top plate, 102 main body casing, 103 circuit, 104 operating unit, 105 display means, 106 heating port, 200 pan

Claims

1. An induction heating cooker comprising:

5 a plurality of heating coils;
 a plurality of inverter circuits that supply a high-frequency current to the heating coils;
 output current detecting means for detecting an output current of each of the inverter circuits;
 power detecting means for detecting input power or output power of each of the inverter circuits;
 10 load determining means for performing a load determination on a basis of the output current detected by the
 output current detecting means and the input power or the output power detected by the power detecting means;
 and
 control means for performing individual drive control of each of the inverter circuits,
 wherein the control means
 15 drives, in a case where two or more inverter circuits of the plurality of inverter circuits are driven at the same
 time, the inverter circuits at the same driving frequency,
 acquires output currents of the driven inverter circuits, and
 performs drive control for the inverter circuits in such a manner that a phase difference between the acquired
 output currents is reduced, and
 20 wherein the load determining means
 performs the load determination on a basis of the output current detected by the output current detecting means
 and the input power or the output power detected by the power detecting means for the driven inverter circuits.

2. The Induction heating cooker of claim 1,
wherein the control means

25 controls, in the case where two or more inverter circuits of the plurality of inverter circuits are driven at the same time,
 the phases of output voltages of the inverter circuits in such a manner that the phase difference between the output
 currents is reduced.

3. The induction heating cooker of claim 1 or 2,

30 wherein the inverter circuits each include a plurality of switching elements and each supply a high-frequency current
 to the heating coils when the switching elements are driven at high frequency, and
 wherein the control means
 controls, in the case where two or more inverter circuits of the plurality of inverter circuits are driven at the same
 35 time, driving signals output to the switching elements of the inverter circuits in such a manner that the phase difference
 between the output currents is reduced.

4. The induction heating cooker of any one of claims 1 to 3,

wherein the load determining means
 40 determines, on the basis of correlation between the output current detected by the output current detecting means
 and the input power or the output power detected by the power detecting means, whether or not a suitable load is
 placed above the heating coils, and
 wherein the control means
 causes, on the basis of a result of determination by the load determining means, driving of an inverter circuit for a
 45 heating coil, above which suitable load is not placed, of the heating coils, to be stopped.

5. The induction heating cooker of any one of claims 1 to 4, further comprising input current detecting means for
detecting input current of each of the inverter circuits,

wherein the load determining means
 50 performs, using the input current detected by the input current detecting means, instead of the input power or the
 output power detected by the power detecting means, the load determination.

6. The induction heating cooker of any one of claims 1 to 5, further comprising a top plate arranged above the plurality
of heating coils,

55 wherein the plurality of heating coils include
 a central heating coil arranged in a central portion of a heating port arranged on the top plate and a plurality of
 peripheral heating coils arranged in a lateral direction of the central heating coil and a plurality of peripheral heating
 coils arranged in a depth direction of the central heating coil.

7. The induction heating cooker of any one of claims 1 to 5, further comprising a top plate arranged above the plurality of heating coils,
wherein the plurality of heating coils include
a central heating coil arranged in a central portion of a heating port arranged on the top plate and a plurality of
peripheral heating coils arranged in a circumferential direction around the central heating coil.

8. The induction heating cooker of any one of claims 1 to 5, further comprising a top plate arranged above the plurality of heating coils,
wherein the plurality of heating coils include
an inner heating coil arranged in a central portion of a heating port arranged on the top plate and an outer heating coil wound so as to surround the inner heating coil.

FIG. 1

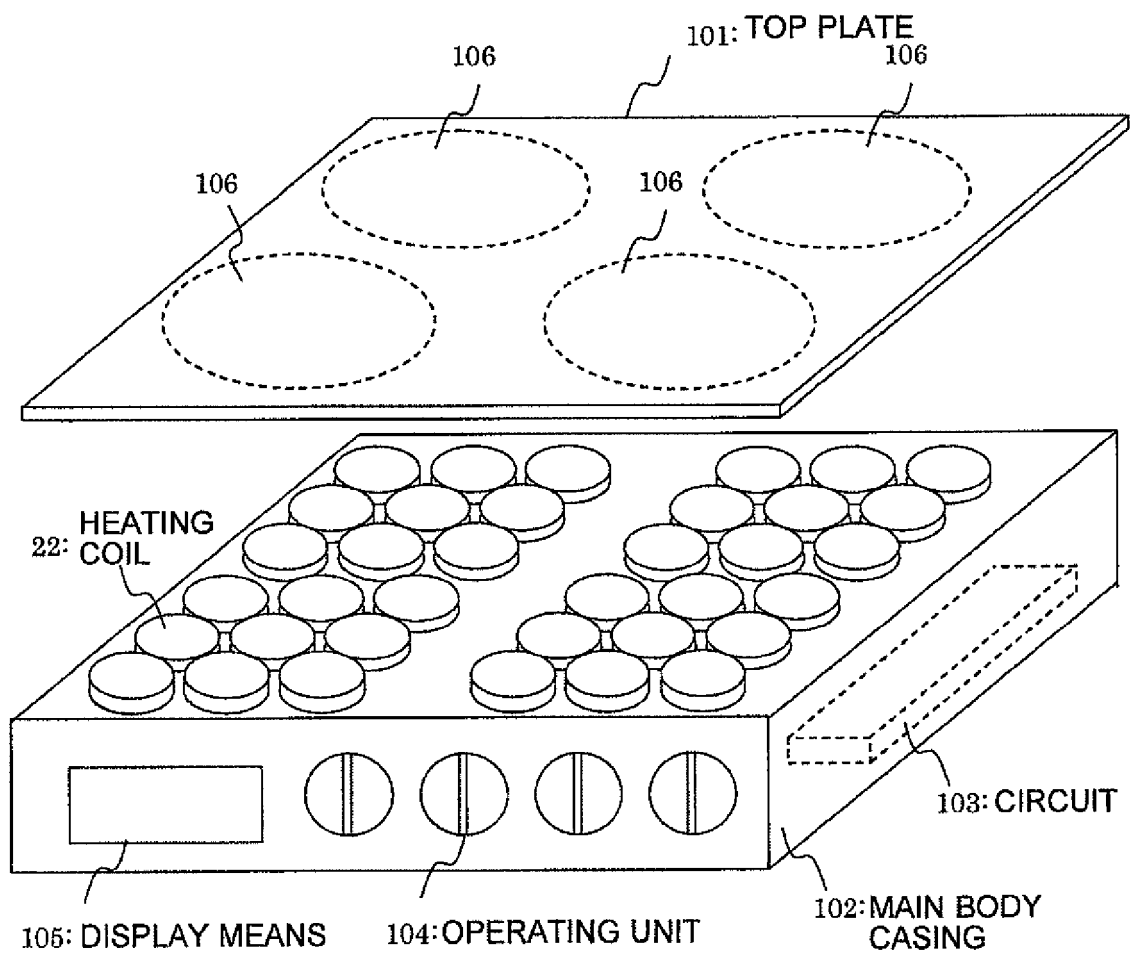


FIG. 2

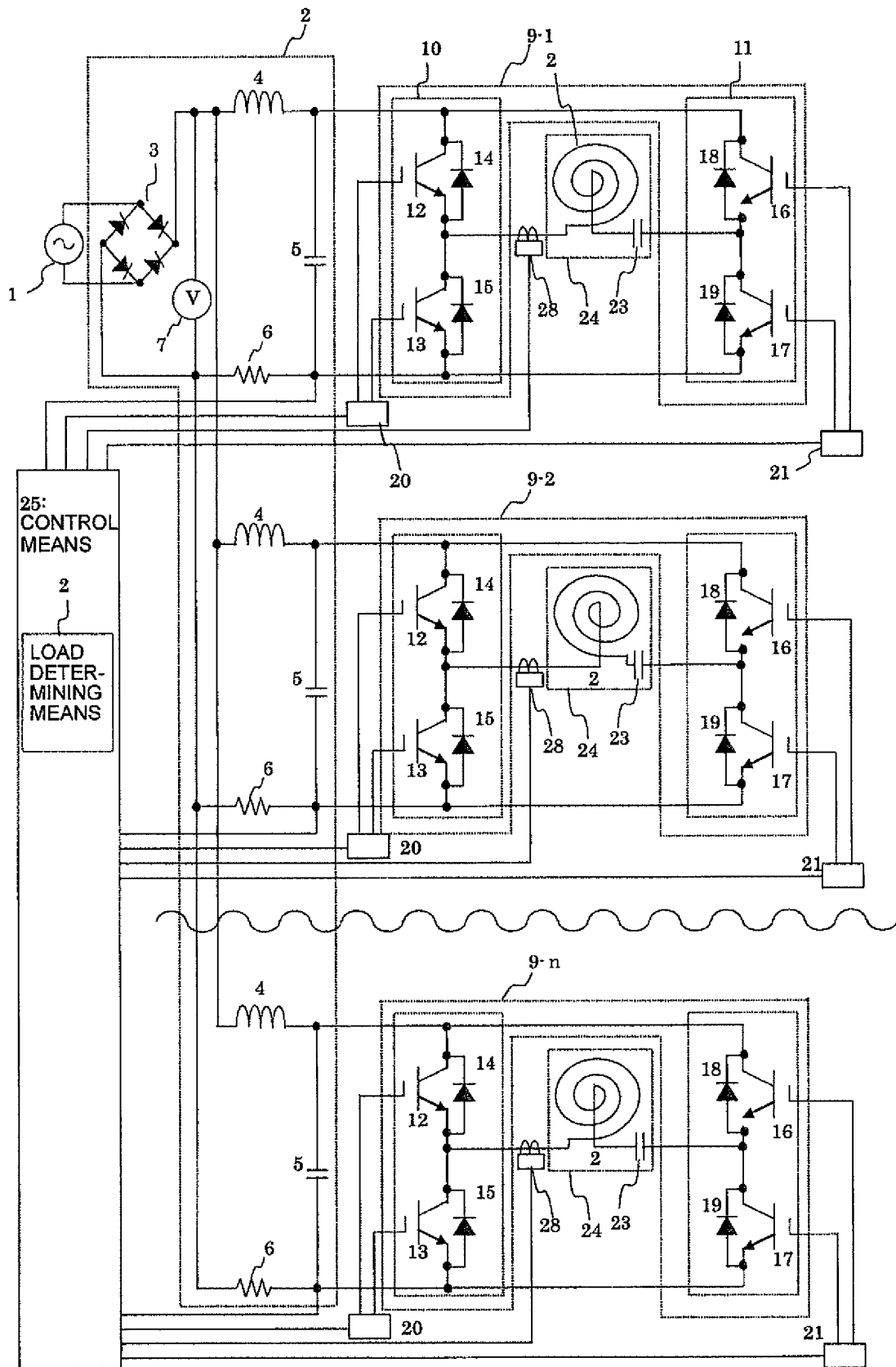
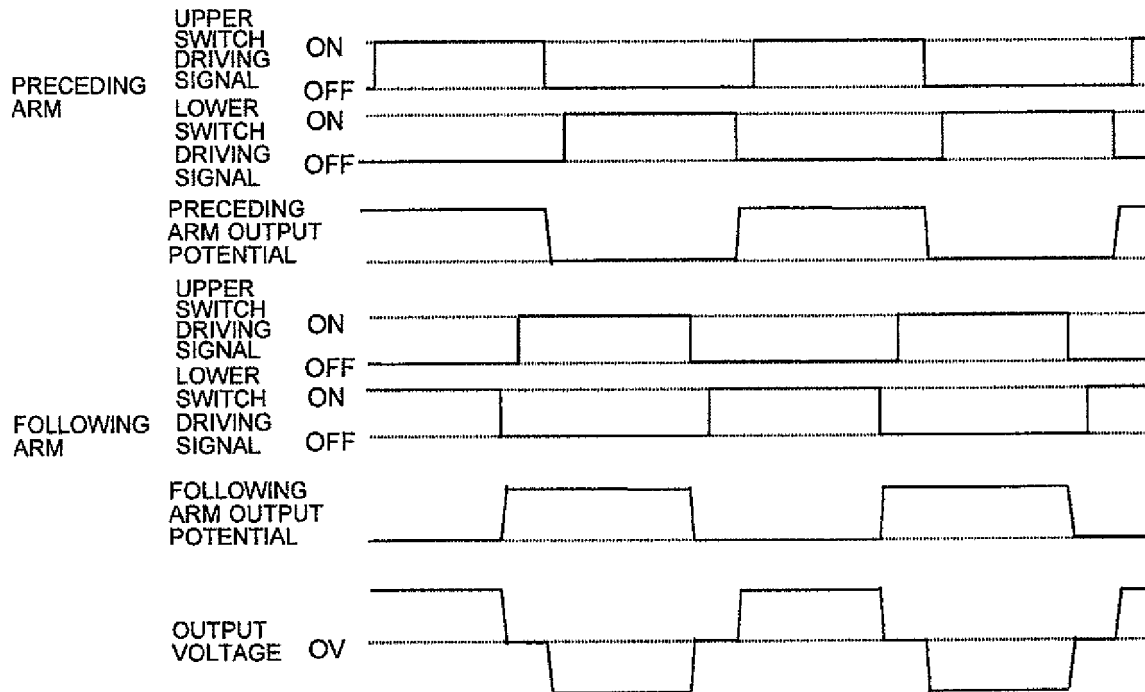


FIG. 3

(a) HIGH OUTPUT STATE



(b) MEDIUM OUTPUT STATE

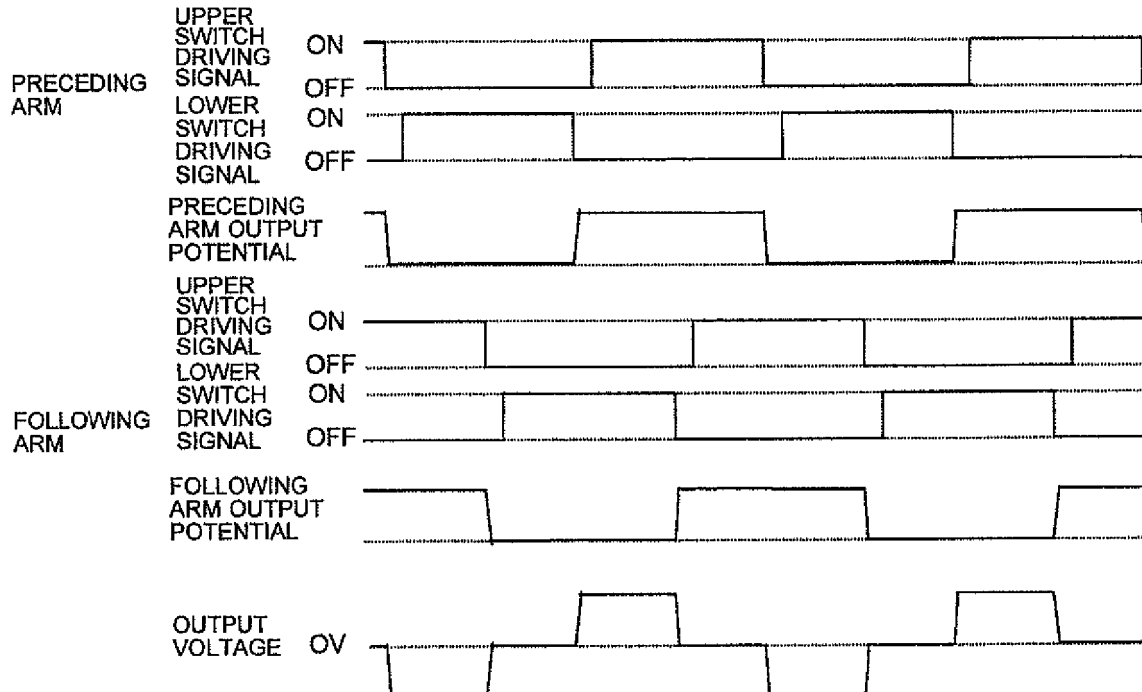


FIG. 4

(c) LOW OUTPUT STATE

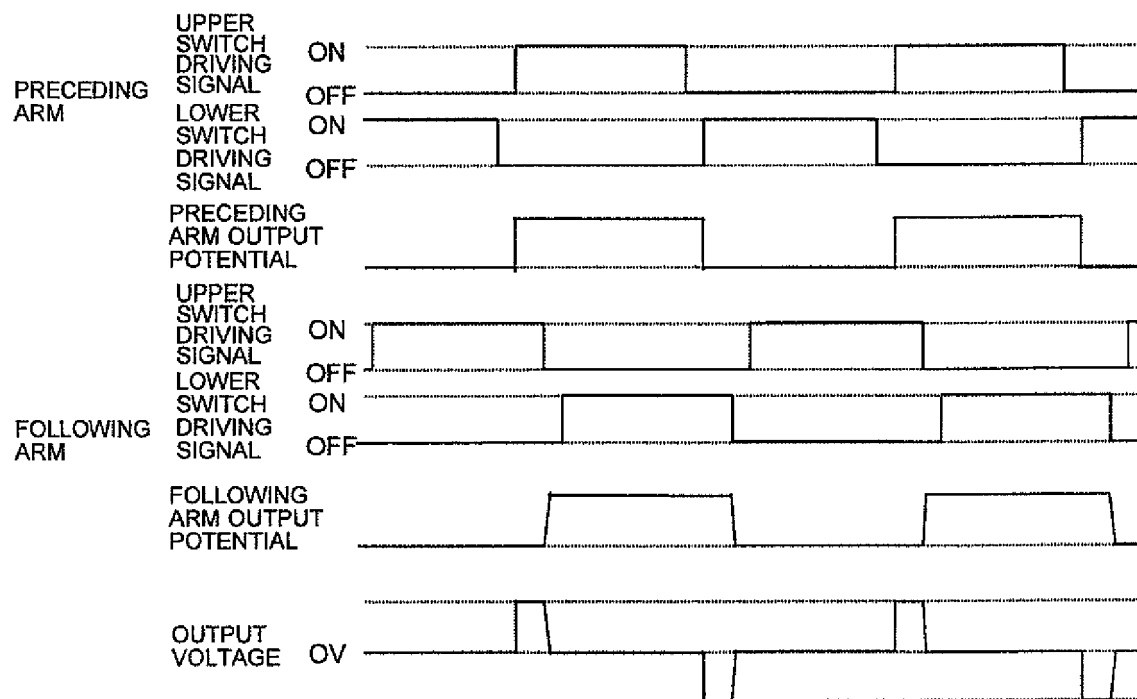
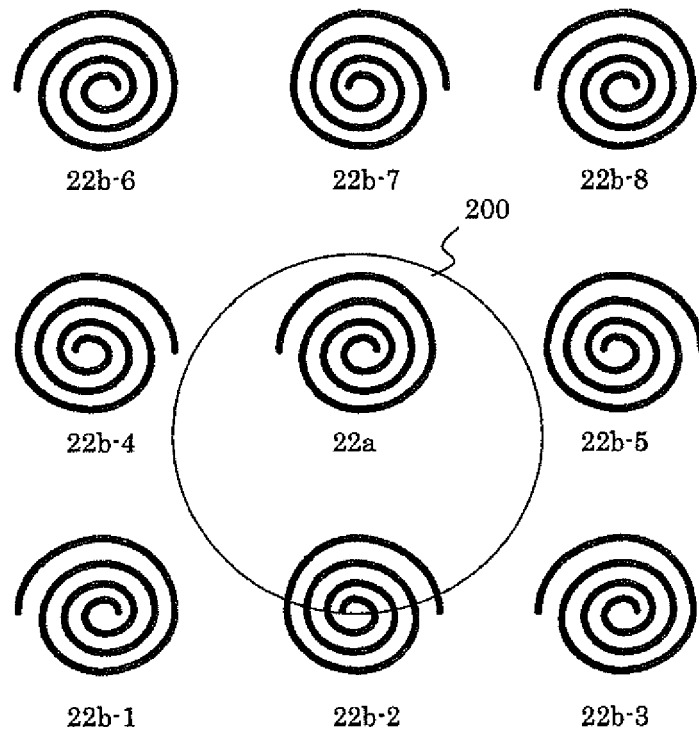


FIG. 5

(a)



(b)

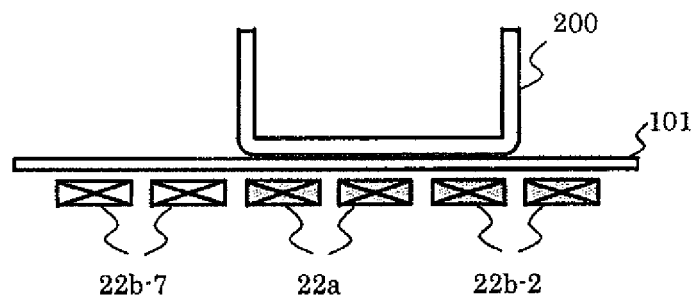


FIG. 6

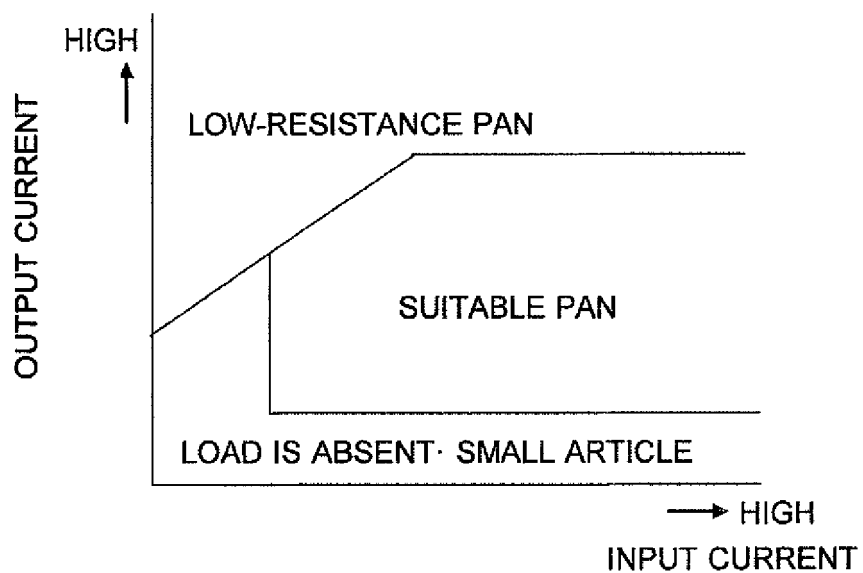


FIG. 7

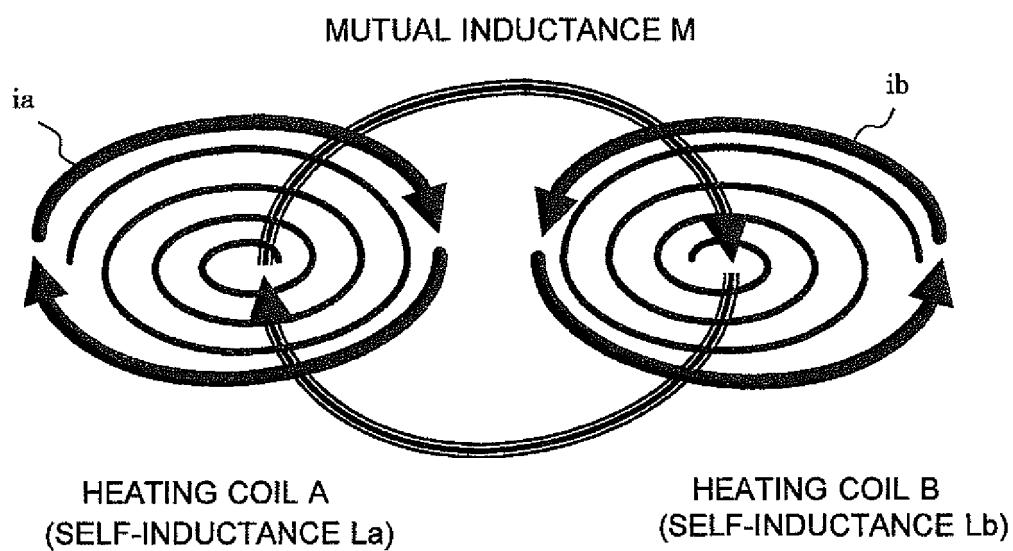


FIG. 8

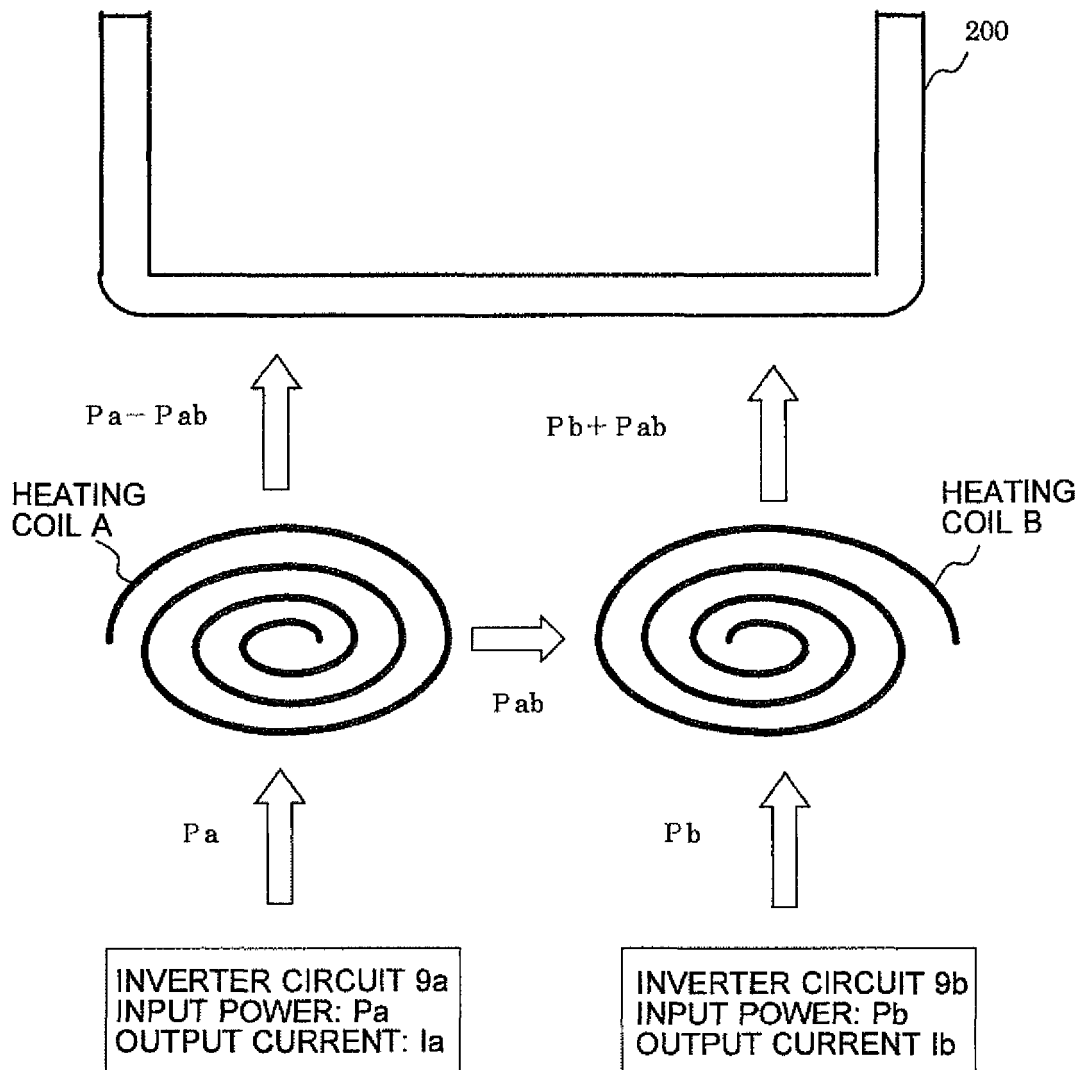


FIG. 9

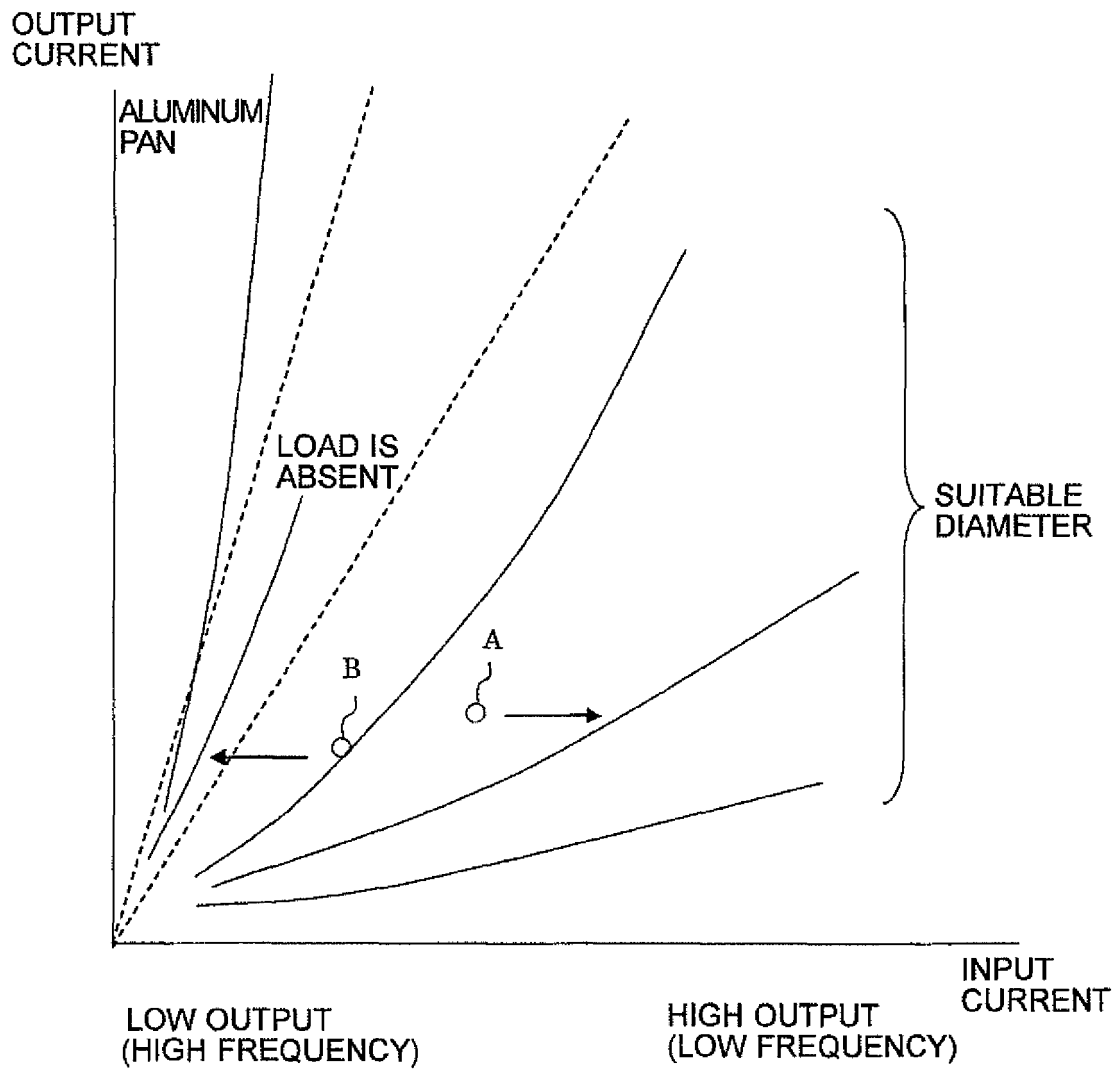


FIG. 10

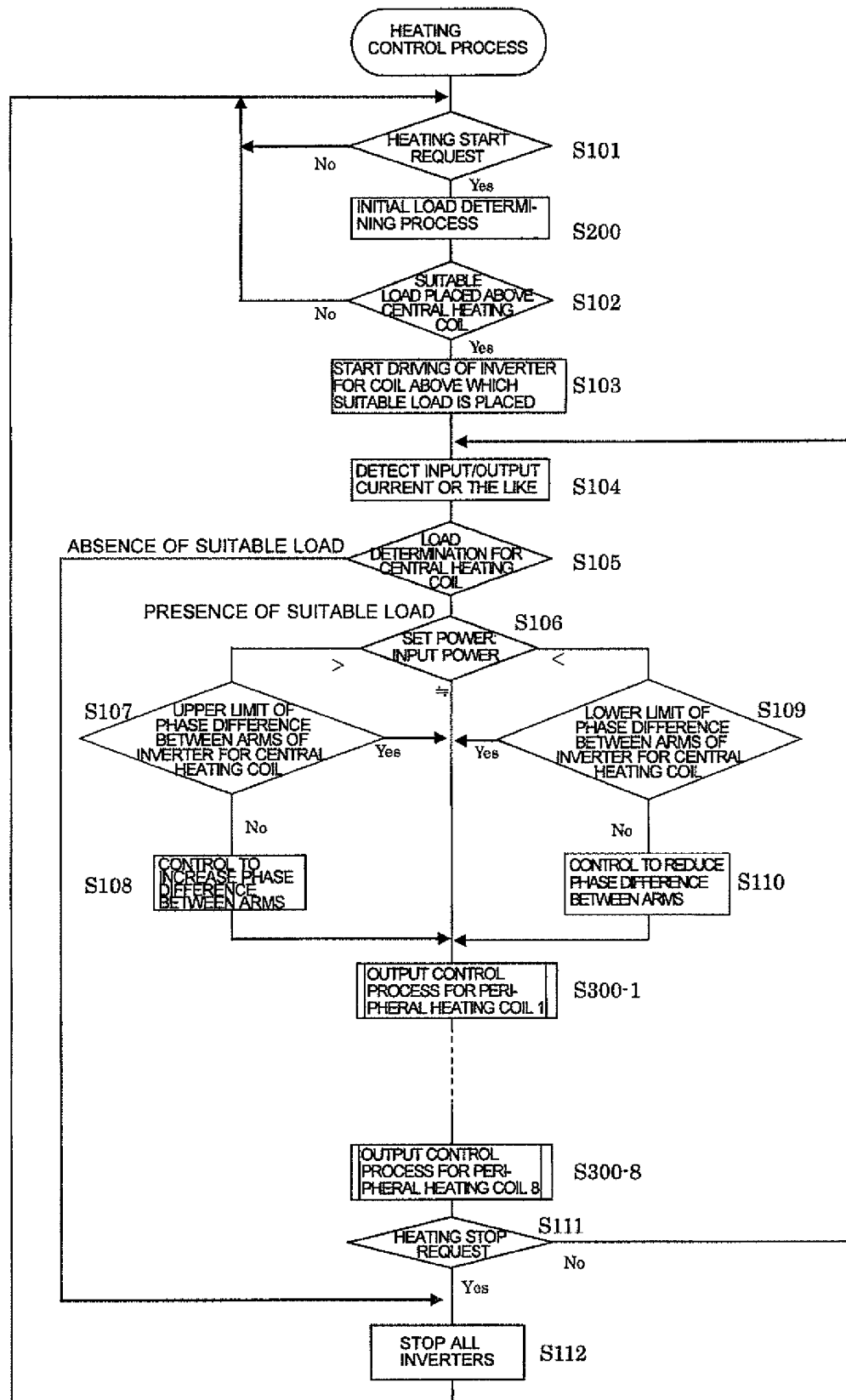


FIG. 11

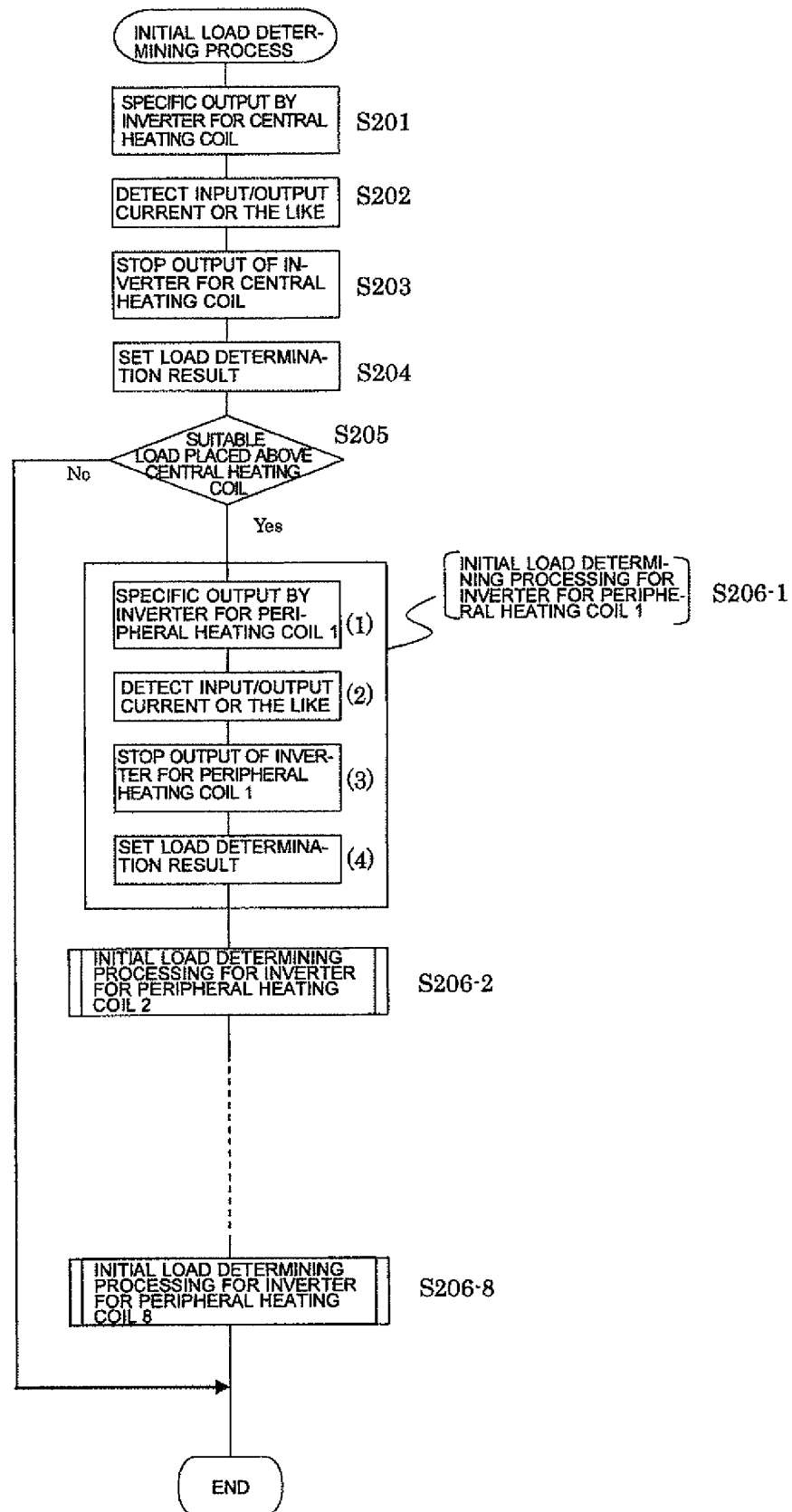


FIG. 12

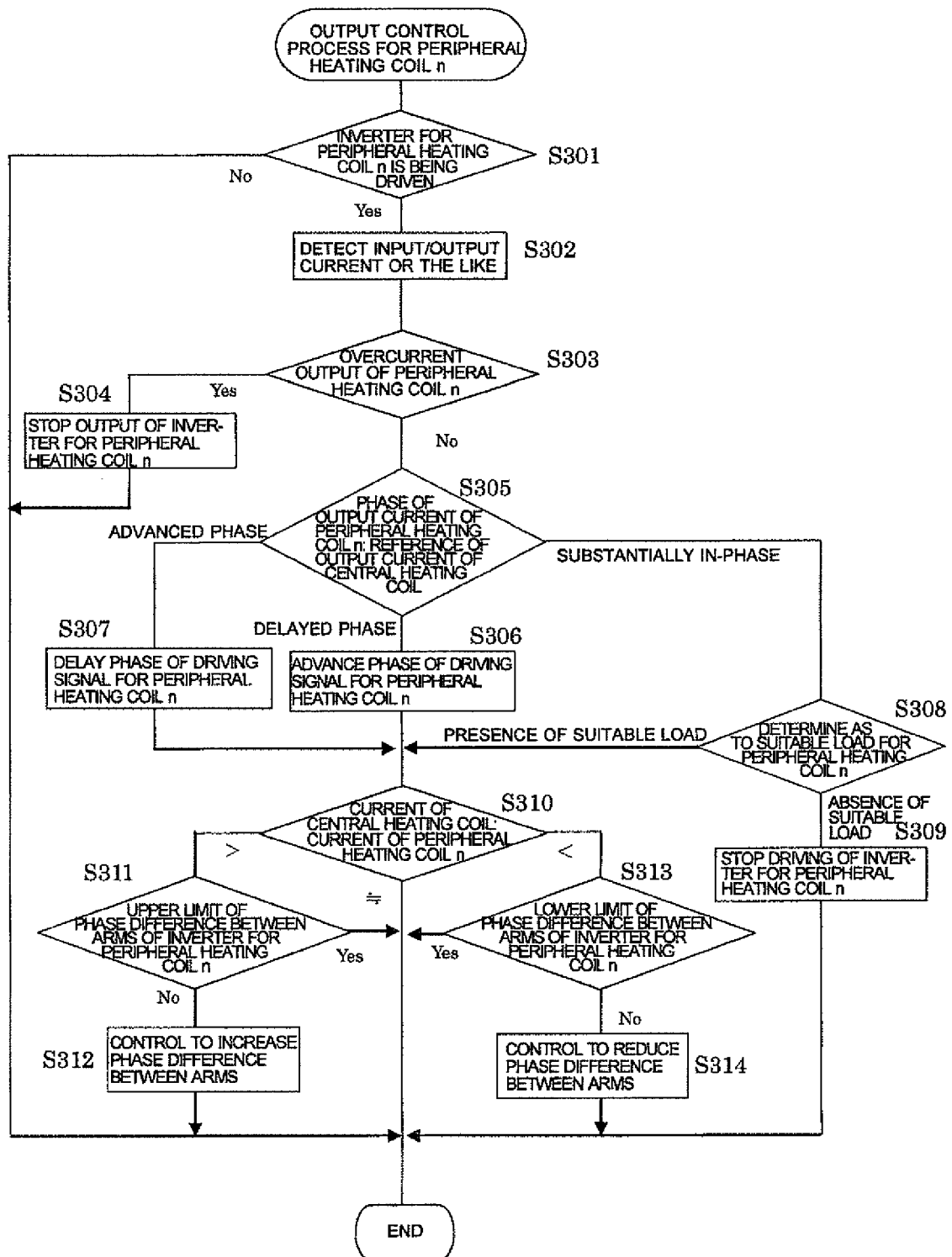
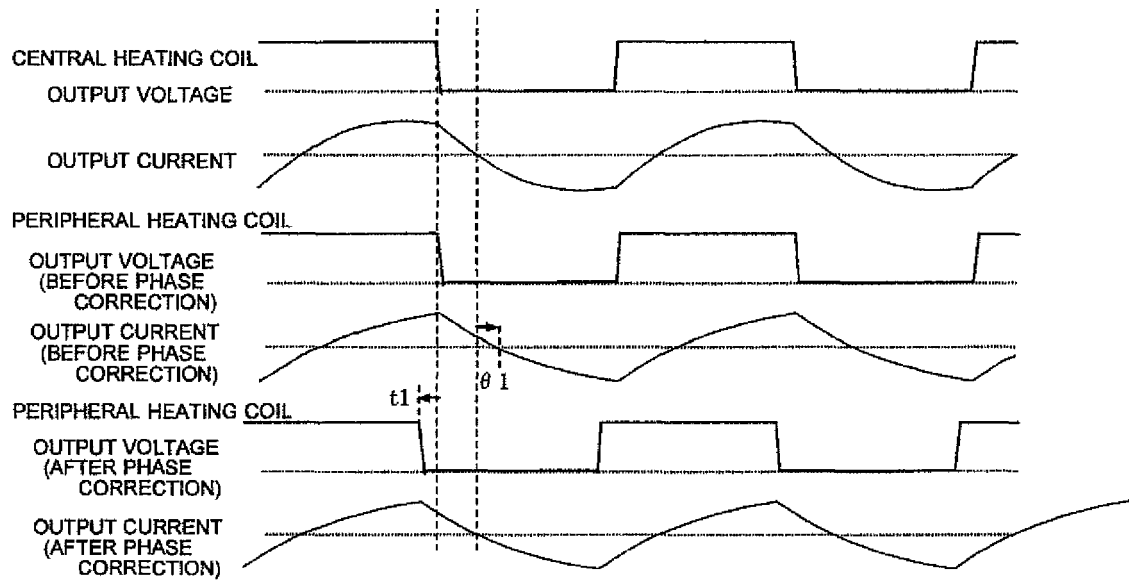


FIG. 13

(a) SHIFT CORRECTION FOR DELAYED CURRENT



(b) SHIFT CORRECTION FOR ADVANCED CURRENT

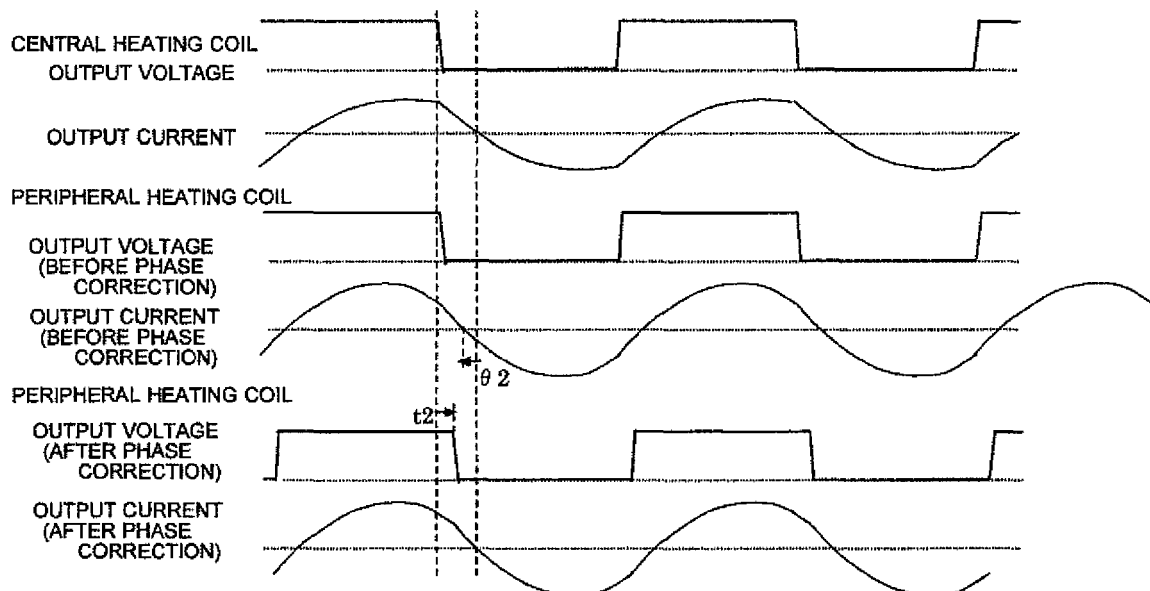


FIG. 14

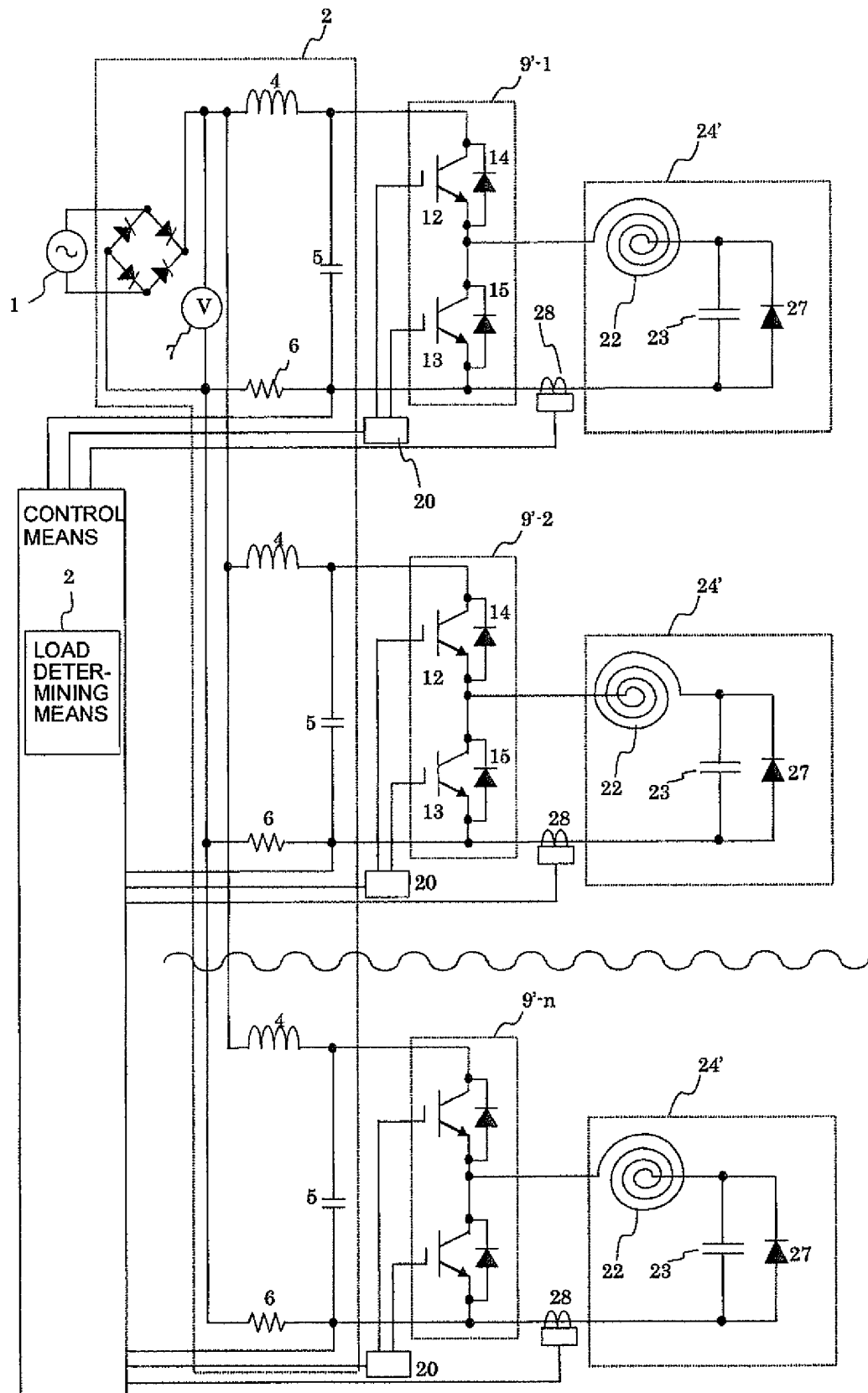
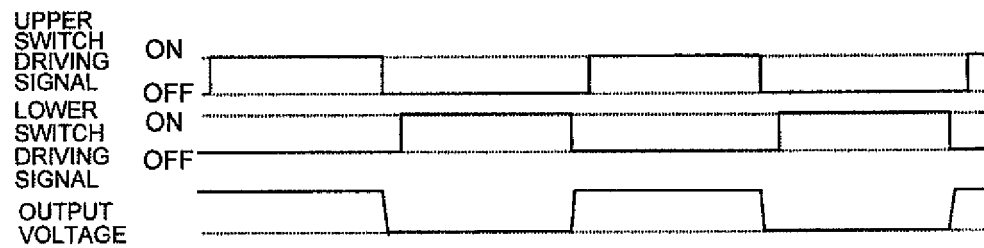
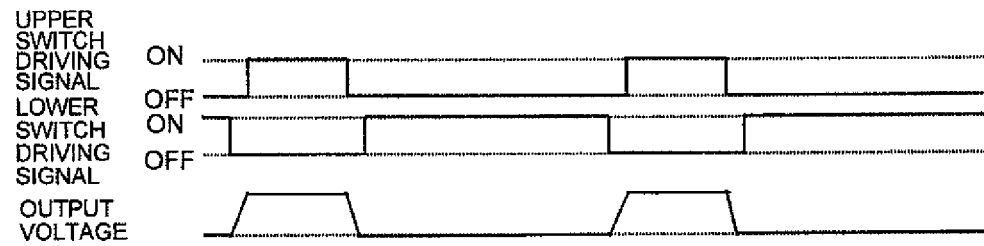


FIG. 15

(a) HIGH OUTPUT STATE



(b) MEDIUM OUTPUT STATE



(c) LOW OUTPUT STATE

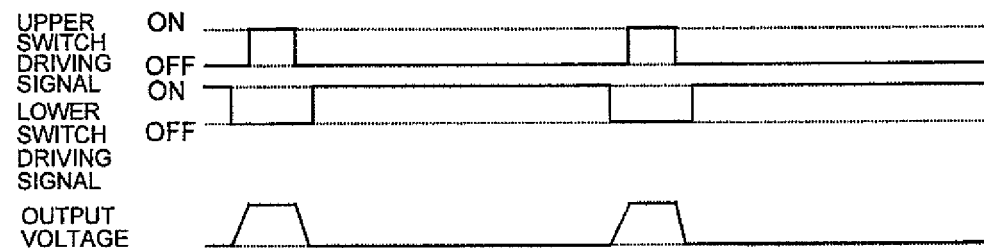


FIG. 16

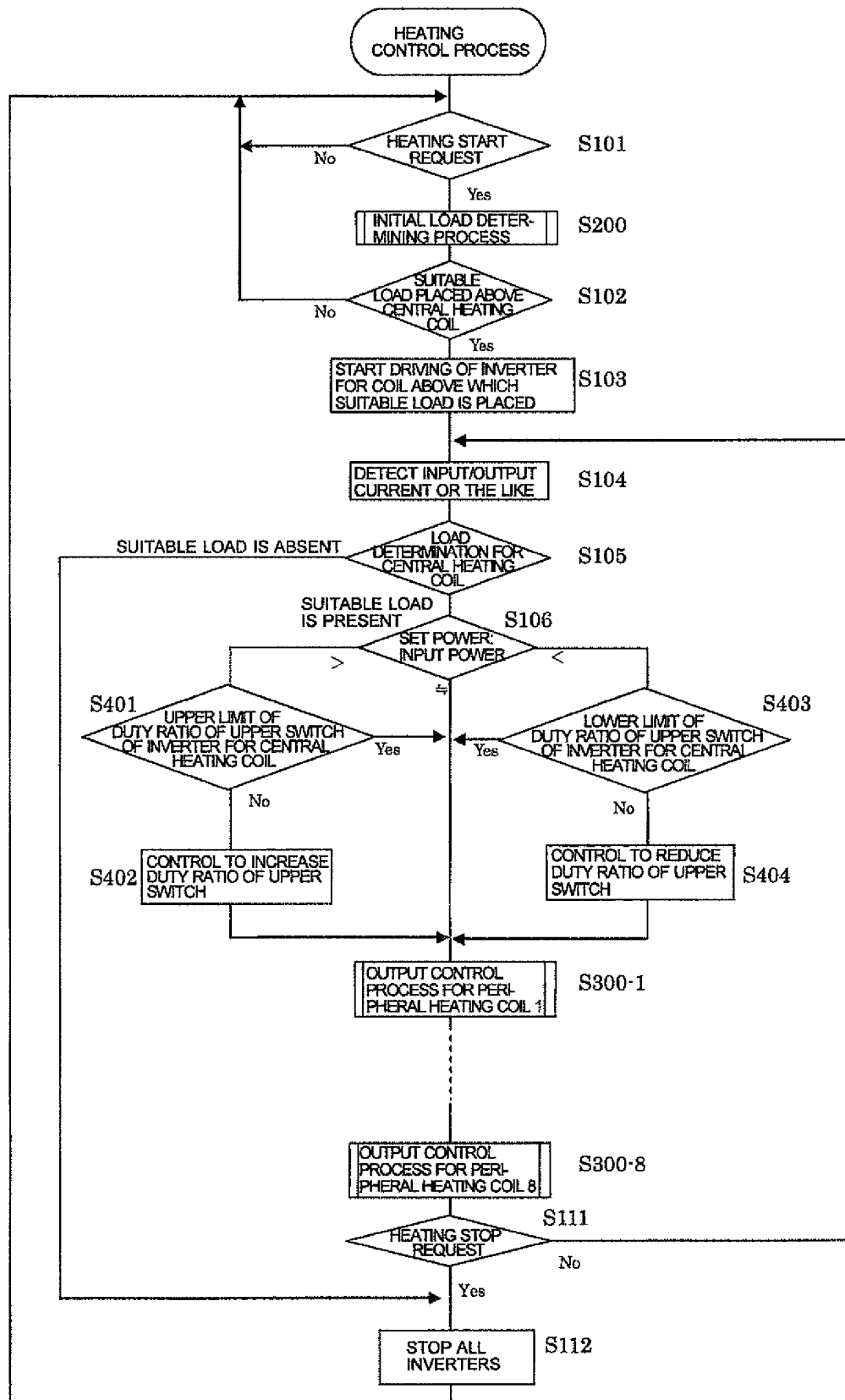


FIG. 17

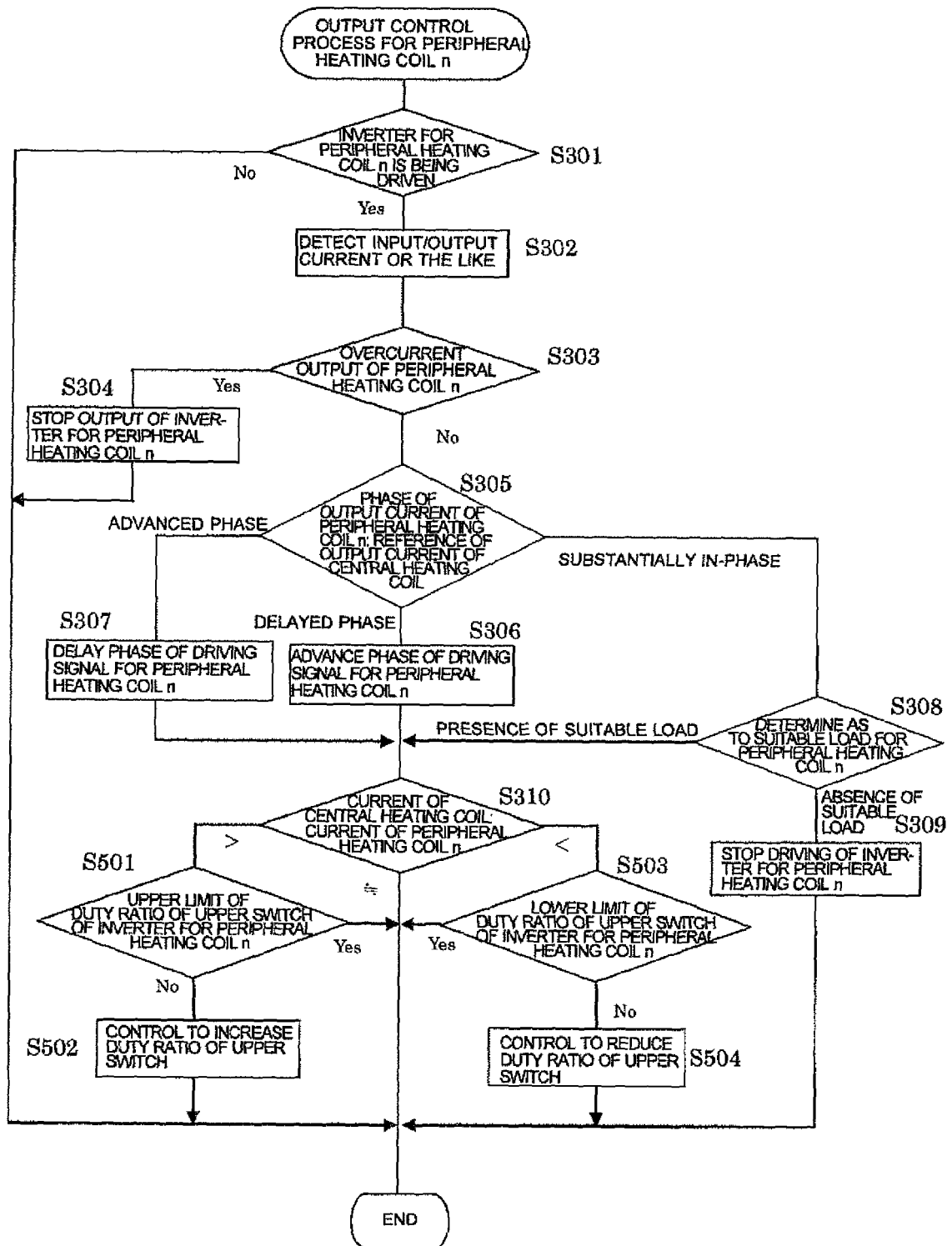


FIG. 18

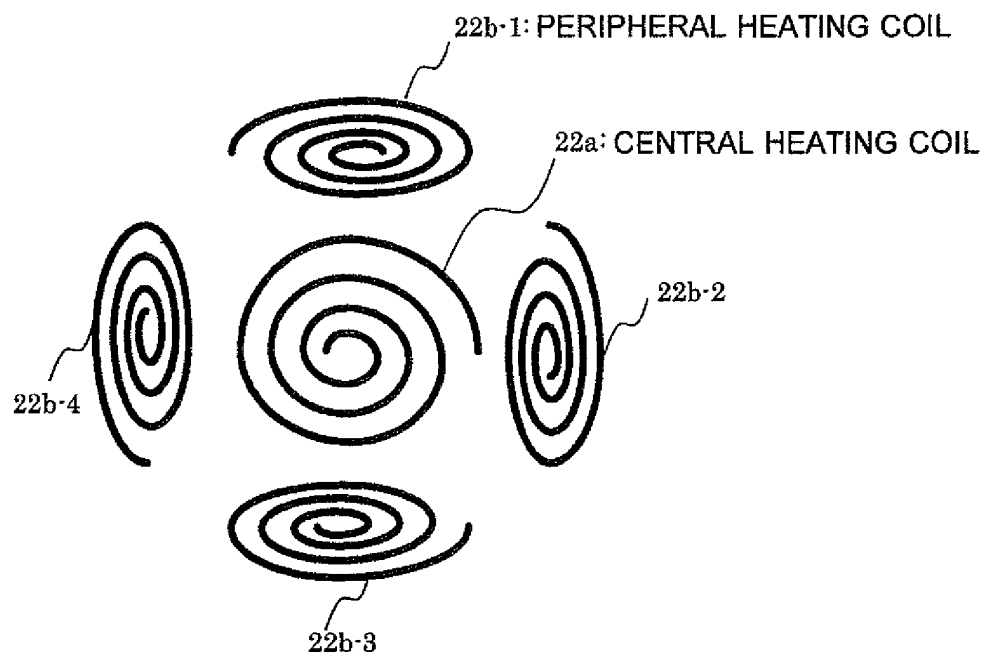
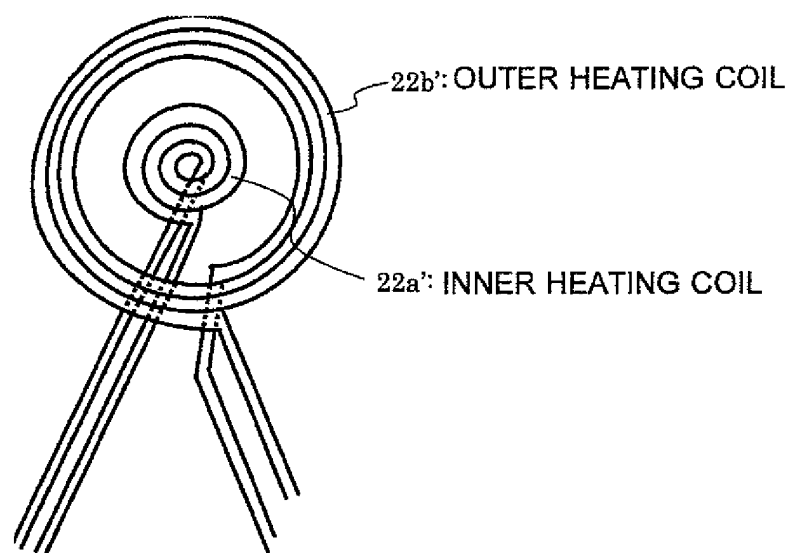


FIG. 19



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/006621

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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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.
Y	JP 2008-293871 A (Mitsubishi Electric Corp.), 04 December 2008 (04.12.2008), paragraphs [0008] to [0036]; fig. 1 to 4 (Family: none)	1-8
Y	JP 2007-317465 A (Mitsubishi Electric Corp.), 06 December 2007 (06.12.2007), claims 1 to 3; paragraphs [0009], [0013], [0020] to [0028]; fig. 1 to 10 (Family: none)	1-8
Y	JP 2005-353362 A (Toshiba Corp.), 22 December 2005 (22.12.2005), paragraph [0016] (Family: none)	1-8

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

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Date of the actual completion of the international search
24 February, 2012 (24.02.12)Date of mailing of the international search report
06 March, 2012 (06.03.12)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/006621

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2009-94028 A (Mitsubishi Electric Corp.), 30 April 2009 (30.04.2009), paragraphs [0012], [0015] (Family: none)	1-8
Y	JP 2006-202705 A (Mitsubishi Electric Corp.), 03 August 2006 (03.08.2006), paragraphs [0066], [0067]; fig. 11 (Family: none)	4-8
Y	WO 2010/101202 A1 (Mitsubishi Electric Corp.), 10 September 2010 (10.09.2010), paragraph [0022]; fig. 3(a) & EP 2405715 A1 & CN 102342177 A	7

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6119968 A [0003]