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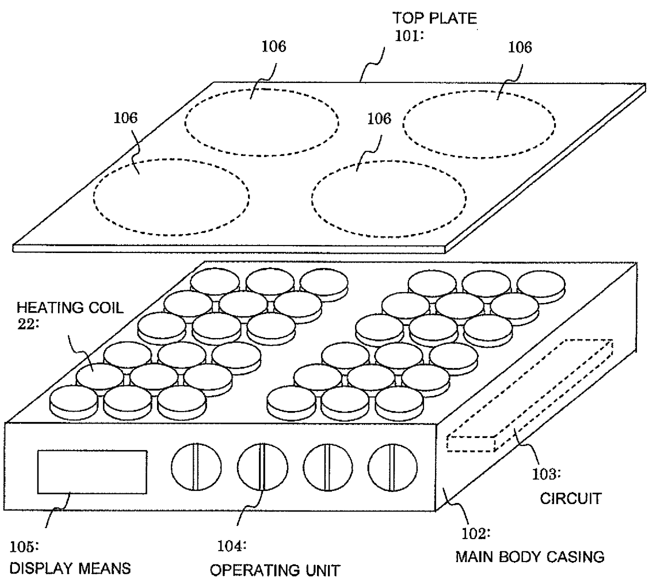
(54) **INDUCTIVE HEATING COOKER**

(57) During performance of heating operation for applying set power to a heating target, control means 25 controls an inverter circuit 9 to output power corresponding to the set power to a heating coil 22 above which a heating target is placed, on the basis of a determination result by load determining means 26. In the case where the heating target is not placed above the heating coil 22 to which the power corresponding to the set power is being output, the control means 25 controls the inverter circuit 9 to output a specific power that is smaller than or equal to the set power to the heating coil 22.

F I G. 1



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Description

Technical Field

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

Background Art

[0002] As a conventional induction heating cooker, for example, an induction heating cooker "including load detecting means for detecting that a heating target is placed on the top plate, wherein the load detecting means detects, for each of the heating coils, that a heating target is placed above the heating coil, and wherein the circuit supplies high-frequency current only to the heating coil for which the load detecting means detects that a heating target is placed above the heating coil" is suggested (for example, see Patent Literature 1).

Citation List

Patent Literature

[0003]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2008-293871 (claim 2)

Summary of Invention

Technical Problem

[0004] In the technology of Patent Literature 1 mentioned above, by supplying a high-frequency current only to a heating coil for which a heating target is detected, a reduction in the heating efficiency and an increase of leakage flux according to the size of a pan and the place where the pan is placed can be suppressed.
However, there is a problem in which in the case where after a load is detected and heating starts, when heating operation is being performed, the position where a heating target is placed is moved and the heating target is not positioned above a heating coil to which high-frequency current is being supplied, the current flowing to the heating coil does not work on the heating of the heating target, which reduces the heating efficiency as loss and increases leakage flux.
Furthermore, there is also a problem in which since the position where a heating target is placed is moved, a part of the heating target that has been moved to a position above a heating coil to which high-frequency current is not being supplied is not heated, which increases uneven heating.

[0005] The present invention has been designed to solve the above-mentioned problems, and provides an induction heating cooker that is capable of suppressing a reduction in the heating efficiency and an increase of leakage flux in the case where a heating target is moved when heating operation is being performed.
Furthermore, an induction heating cooker that is capable of reducing the occurrence of uneven heating in the case where a heating target is moved after heating starts.

Solution to Problem

[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; control means for performing individual drive control of each of the inverter circuits; and load determining means for performing a load determination as to whether, on a basis of the output current and the input power or the output power of an inverter circuit of the inverter circuits that is being driven, a heating target is placed above a corresponding heating coil of the heating coils, wherein the control means, during performance of a heating operation for applying set power to a heating target, controls, on a basis of a determination result by the load determining means, an inverter circuit of the inverter circuits to output power corresponding to the set power to a heating coil of the heating coils above which a heating target is placed, and controls the inverter circuit to output specific power that is smaller than or equal to the set power to the heating coil, in a case where the heating target is not placed above the heating coil to which the power corresponding to the set power is being output.

Advantageous Effects of Invention

[0007] In the present invention, in the case where a heating target is not placed above a heating coil, a specific power that is smaller than or equal to set power is output to the heating coil. Thus, in the case where the heating target is moved during performance of the heating operation, a reduction in the heating efficiency and an increase of leakage flux can be suppressed.

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 is a diagram illustrating an example of the 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 load state and a driving signal control range for an inverter circuit in the induction heating cooker according to Embodiment 1.

[Fig. 8] Fig. 8 is a diagram illustrating determining conditions for a load state when heating operation is being performed in the induction heating cooker according to Embodiment 1.

[Fig. 9] Fig. 9 is a diagram illustrating an example of detecting conditions for load to be heated in a driving signal limited state 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 peripheral heating coil n by the control means in the induction heating cooker according to Embodiment 1.

[Fig. 13] Fig. 13 is a diagram illustrating the circuit configuration of an induction heating cooker according to Embodiment 2.

[Fig. 14] Fig. 14 includes diagrams illustrating examples of driving signals of an inverter circuit in the induction heating cooker according to Embodiment 2.

[Fig. 15] Fig. 15 is a flowchart illustrating a heating control process by control means in the induction heating cooker according to Embodiment 2.

[Fig. 16] Fig. 16 is a flowchart illustrating an output control process for an inverter circuit for peripheral heating coil n by the control means in the induction heating cooker according to Embodiment 2.

[Fig. 17] Fig. 17 is a diagram illustrating an example of heating coils including an inner heating coil arranged in the central part of a heating port and a plurality of peripheral heating coils arranged around the inner heating coil.

[Fig. 18] Fig. 18 is a diagram illustrating an example of heating coils including an inner heating coil arranged in the central part 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 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 on the top plate 101. 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 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 (or inverter circuit 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 driving 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 pan or the like, which is a heating target, 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 (hereafter referred to as "load determination").

In the explanation provided below, the state where no object to be heated such as a pan or the like is placed is referred to as "load is absent" or pan is absent".

[0017] Furthermore, the load determining means 26 performs a load determination as to whether or not unsuitable 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.

Here, unsuitable load (unsuitable pans) refers to a load that is not suitable for induction heating, such as, low-resistance pans including aluminum pans that are made of a low-efficiency material and that cannot be induction heated or small items including forks and spoons that should not be heated. Furthermore, suitable load (suitable pans) refers to a load that is suitable for being induction heated and includes objects to be heated other than unsuitable load.

[0018] 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)

[0019] Next, an operation for controlling a 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.
[0020] 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 have 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 degrees), 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)

[0021] Next, a load determination operation by the load determining means 26 will be explained.
Fig. 5 is a diagram illustrating an example of the positional relationship between heating coils and a load (pan) to be heated in the induction heating cooker according to Embodiment 1.
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.
Here, as illustrated in Fig. 5, the case will be explained by way of example, in which 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.
In the explanation provided below, the heating coil 22 arranged in the central part of the heating port 106 is referred to as a central heating coil 22a.
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.
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-10 ··· 22b-n are also referred to as inverter circuits 9b-1 ··· 9b-n for peripheral heating coils (1 ··· n).
[0022] The control means 25 causes a specific high-frequency current (specific frequency) to be supplied to the individual heating coils 22 at the time when heating starts.
Then, the load determining means 26 acquires an output current detected by the output current detecting means 28 and input current detected by the input current detecting means 6. 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 a pan is placed above each of the heating coils 22 and whether or not the placed

pan is an unsuitable 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 is made of a low-efficiency material, such as an aluminum pan, and that cannot be heated is placed. In this case, the driving of the inverter circuit 9 is stopped. In addition, in the case where the output 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. In this case, the output of the inverter circuit 9 is limited to a specific power. Here, the specific power is a value that is smaller than or equal to power corresponding to the set power and is, for example, a lower limit value of power that the inverter circuit 9 can output.

Here, in the explanation provided below, the specific power is referred to as a limited output, and the state where the output of the inverter circuit 9 is limited to the specific power is referred to as an output limited state.

Meanwhile, in the case where the input current and the output current are within a specific range, it is determined that a suitable load, which is a load suitable for heating, is placed. In this case, the output of the inverter circuit 9 is controlled to power corresponding to set power (feedback control). That is, the output of the inverter circuit 9 is controlled to be within a range from the lower limit value to the upper limit value, in accordance with set power.

[0023] In the example illustrated in Fig. 5, in the case where a pan 200 (suitable diameter) is placed at a position represented by a solid line at the time when heating starts, the load determining means 26 determines that a suitable load is placed above the central heating coil 22a, the peripheral heating coils 22b-5, 22b-7, and 22b-8, and determines that no pan is placed above the peripheral heating coils 22b-1 to 22b-4 and 22b-6.

Then, the control means 25 controls output of the inverter circuit 9a for the central heating coil 22a and the inverter circuits 9b-5, 9b-7, and 9b-8 for the peripheral heating coils 22b-5, 22b-7, and 22b-8 above which a suitable load is placed, in accordance with set power. Furthermore, the control means 25 controls the output of the inverter circuits 9b-1 to 9b-4 and 9b-6 for the peripheral heating coils 22b-1 to 22b-4 and 22b-6 for which no pan is placed to a limited output.

The details of the heating control operation will be explained later.

[0024] As described above, a load determination is performed at the time when heating starts, and a heating operation for applying set power to a pan by the heating coils 22 above which the pan is placed. Furthermore, by controlling the output of the heating coils 22 above which the pan is not placed to a limited output, which is for example, a lower limit value, a reduction in the heating efficiency and leakage flux can be suppressed.

[0025] The case where a load determination is performed by referring to, for example, the information illustrated in Fig. 6, on the basis of the relationship between the output current and the input current and power to be output to the heating coils 22 is set has been explained above. However, the present invention is not limited to this. For example, the output of the inverter circuits 9 may be set in accordance with the resistance of the load circuits 24 calculated on the basis of input current and output current. One such example will be explained with reference to Fig. 7.

[0026] Fig. 7 is a diagram illustrating the load state and a driving signal control range for an inverter circuit in the induction heating cooker according to Embodiment 1.

In Fig. 7, the lateral axis represents the resistance of a load circuit 24 calculated on the basis of input current and output current of an inverter circuit 9, and the vertical axis represents the magnitude of output (level of a driving signal) of the inverter circuit 9.

Here, in the case where a heating coil 22 and a pan are magnetically coupled to each other, eddy current flows to the pan due to an output current flowing to the heating coil 22. Thus, the pan is caused to be heated, and power is consumed. The eddy current flowing to the pan depends on (substantially proportional to) the degree of magnetic coupling between the heating coil 22 and the pan and the output current flowing to the heating coil 22. Furthermore, the power consumed for the pan is that generated by the eddy current flowing to the pan; is approximately the same as that obtained by multiplying the square of the output current flowing to the heating coil 22 with a load resistance; and is substantially proportional to the input power (input current). Thus, a load determination is performed using the resistance obtained on the basis of the input current (equivalent to power) and the output current.

For example, as illustrated in Fig. 7, in the case where the resistance is high and the power applied to the pan is equal to or greater than a certain value, it is determined that suitable load is placed. Thus, the output of the inverter circuit 9 is controlled to be power corresponding to set power (feedback control). That is, the output of the inverter circuit 9 is controlled within a range from the lower limit value to the upper limit value in accordance with set power.

Furthermore, in the case where the resistance is within a specific range that is smaller than that for a suitable load, it is determined that no pan is placed or a small article such as a fork is placed. Thus, the output of the inverter circuit 9 is controlled to a limited power, which is for example, a lower limit value.

Furthermore, in the case where the resistance is a value that is smaller than the limited output range, it is determined that unsuitable load whose output current is excessive, such as a nonmagnetic pan made of aluminum or the like, is placed, and the driving of the inverter circuit 9 is stopped.

[0027] Next, the case where after the above-described load determination at the time when heating starts is performed, the place of a pan is moved when heating operation is being performed will be explained.

[0028] Fig. 8 is a diagram illustrating determining conditions for a load state when heating operation is being performed in the induction heating cooker according to Embodiment 1.

Fig. 9 is a diagram illustrating an example of detecting conditions for load to be heated in a driving signal limited state in the induction heating cooker according to Embodiment 1.

When heating operation is being performed, the control means 25 acquires an output current detected by the output current detecting means 28 of an inverter circuit 9 being driven and an input current detected by the input current detecting means 6.

Then, the load determining means 26 determines, by referring to, for example, information illustrated in Fig. 8, whether or not a pan is placed above a heating coil that is controlled to output power corresponding to set power (feedback control) and whether or not the placed pan is unsuitable load.

Furthermore, the load determining means 26 determines, by referring to, for example, information illustrated in Fig. 9, whether or not a pan is placed above a heating coil that is outputting a limited output and whether or not the placed pan is unsuitable load.

[0029] For example, in the case where the pan 200 is moved from a position represented by a solid line to a position represented by a dotted line as illustrated in Fig. 5 when heating operation is being performed, the peripheral heating coils 22b-5 and 22b-8, which are under feedback control, change from the state where a pan is placed to the state where no pan is placed. Here, as illustrated in Fig. 8, the values of the output current and the input current of the peripheral heating coils 22b-5 and 22b-8 that are outputting power corresponding to set power are moved from a region where a suitable load is present (pan is present) to a region where the load is absent (pan is absent). Thus, the load determining means 26 determines that the peripheral heating coils 22b-5 and 22b-8 are in the state where no pan is placed. The control means 25 controls the output of the inverter circuits 9b-5 and 9b-8 for peripheral heating coils for the peripheral heating coils 22b-5 and 22b-8 above which no pan is placed to a limited output.

[0030] Meanwhile, the peripheral heating coils 22b-4 and 22b-6 change from the state where no pan is placed to the state where a pan is placed. At this time, as illustrated in Fig. 9, the values of the output current and the input current of the peripheral heating coils 22b-4 and 22b-6, which are set to a limited output, are moved from the region of the output limited state (absence of a pan) to the region of feedback control (presence of a pan). Thus, the load determining means 26 determines that the peripheral heating coils 22b-4 and 22b-6 are in the state where a pan is placed. The control means 25 controls the output of the inverter circuits 9b-4 and 9b-6 for the peripheral heating coils 22b-4 and 22b-6 above which a pan is placed to power corresponding to set power (recover feedback control).

Also in the load determination performed when heating operation is being performed, as illustrated in Fig. 7 described above, the output of the inverter circuits 9 may be set in accordance with the resistance of the load circuits 24 calculated on the basis of input current and output current.

[0031] As described above, in the case where the position at which a pan is placed is moved and the pan is thus not positioned above a heating coil 22 that is outputting set power when heat operation is being performed, the output of the heating coil 22 is limited (for example, to a lower limit value). Thus, a reduction in the heating efficiency is suppressed, and leakage flux is reduced.

Furthermore, in the case where a pan is moved to a position above a heating coil 22 whose output is limited, by causing the heating coil 22 to output power corresponding to set power, uneven heating of the pan can be reduced.

[0032] An operation in this embodiment for suppressing a reduction in the heating efficiency and an increase of leakage flux and reducing the occurrence of uneven heating in the case where a heating target is moved when such a heating operation is being performed will now be explained.

(Operation)

[0033] 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, has been input, such as by setting of a heating power using the operating unit 104, (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.

[0034] 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, output current detected by the output current detecting means 28 and 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 pan is placed above the central heating coil 22a and whether the placed pan is suitable load or unsuitable load,. Then, the load determining means 26 sets (stores) a load determination result (S204).

[0035] In the case where it is determined that suitable load is not placed above the central heating coil 22a, the initial load determining process is terminated. Meanwhile, in the case where it is determined that 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).

[0036] 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 peripheral heating coil 1 inverter circuit 9-1 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 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 pan is placed above the peripheral heating coil 22b-1 and whether the placed pan is a suitable load or an unsuitable load, as described above. Then, the load determining means 26 sets (stores) a load determination result.

[0037] In the following processing, the processing of (1) to (4) described above is performed 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,.

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.

[0038] Referring back to Fig. 10, the control means 25 determines whether or not it is determined that a 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.

[0039] 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 inverter circuits for peripheral heating coils 9b for peripheral heating coils other than peripheral heating coils 22b for which it is determined that unsuitable load is placed above the peripheral heating coils 22b in step S200, and sets the output to limited power (lower limit value) (S103).

That is, among the plurality of peripheral heating coils 22b, peripheral heating coils 22b in the state where no pan (no load) is placed and peripheral heating coils 22b above which a suitable load is placed are driven at a limited output.

In the case where two or more inverter circuits 9 are driven, the inverter circuits 9 are driven at the same driving frequency.

[0040] 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 (for example, Fig. 8), whether or not 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.

[0041] Meanwhile, in the case where a 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 by the input current detecting means 6 and the input voltage detecting means 7 (S106).

[0042] 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 haring coils 22b.

[0043] 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 in which an 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.

[0044] In the case where the set power and the input power are approximately the same (step S106; ≈), the process proceeds to the output control process for the heating coils 22b.

[0045] 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 peripheral heating coil n.

[0046] Fig. 12 is a flowchart illustrating an output control process for an inverter circuit for a peripheral heating coil n by the control means in the induction heating cooker according to Embodiment 1.

The control means 25 determines whether the output state of an inverter circuit 9b-n for peripheral heating coil n is a state where driving is stopped (hereinafter, referred to as an output stop state), a controlled state where a power corresponding to set power is set (hereinafter, referred to as a normal output state), or an output limited state (S301).

In the case where it is determined in step S301 that it is in the output stop state, the output processing for the peripheral heating coil n is terminated.

[0047] In the case where it is determined in step S301 that it is in the normal output state, the control means 25 acquires, for the inverter circuit 9b-n for the peripheral heating coil n, an output current detected by the output current detecting means 28 and an input current detected by the input current detecting means 6. Then, as described above, 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. 8), whether a pan is placed above the peripheral heating coil n and whether the placed pan is a suitable load or an unsuitable load (S302).

[0048] In the case of an unsuitable pan (step S302; unsuitable load is present), the driving of the inverter circuit 9b-n for the peripheral heating coil n is stopped (S303), and the output processing for the peripheral heating coil n is terminated.

In the case where no pan is placed (step S302; load is absent), the driving of the inverter circuit 9b-n for the peripheral heating coil n is set to the output limited state (S304), and then the output processing for the peripheral heating coil n is terminated. Accordingly, in the case where a pan is not positioned above a peripheral heating coil n by moving the pan or the like, output to the peripheral heating coil n is limited to a specific power, and a reduction in the heating efficiency and an increase of leakage flux can thus be suppressed.

[0049] In the case of a suitable load (step S302; suitable load is present), the control means 25 compares the output current of the central heating coil 22a with the output current of the peripheral heating coil n (S305).

[0050] 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 S305; >), it is determined whether the phase difference between the arms of the inverter circuit 9b-n for peripheral heating coil n is smaller than the upper limit (180 degrees (half cycle) (S306).

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 peripheral heating coil n (S307), and terminates the output processing for the peripheral heating coil n.

[0051] 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 S305; <), it is determined whether the phase difference between the arms of the inverter circuit 9b-n for peripheral heating coil n is greater than a lower limit value (S308). The lower limit value 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 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 peripheral heating coil n (S309), and terminates the output processing for the peripheral heating coil n.

[0052] 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 S305; ≈), the output processing for the peripheral heating coil n is terminated.

[0053] In the case where of the output limited state in step S301 described above, the control means 25 acquires, for the inverter circuit 9b-n for the peripheral heating coil n, an output current detected by the output current detecting means 28 and an input current detected by the input current detecting means 6. Then, as described above, the load determining means 26 determines, on the basis of the acquired input current and output current and heating permission/inhibition conditions (for example, Fig. 9), whether or not a pan is placed above the peripheral heating coil n and whether the placed pan is a suitable load or an unsuitable load, (S310).

[0054] In the case of an unsuitable pan (step S390; unsuitable load is present), the driving of the inverter circuit 9b-n for the peripheral heating coil n is stopped (S311), and the output processing for the peripheral heating coil n is terminated.

In the case where no pan is placed (step S310; load is absent), the output processing for the peripheral heating coil n is terminated.

In the case of a suitable load (step S310; suitable load is present), the driving of the inverter circuit 9b-n for the peripheral heating coil n is set to the normal output state, and then the output processing for the peripheral heating coil n is terminated. Accordingly, in the case where a pan is placed above a peripheral heating coil n by moving the pan or the like, output to the peripheral heating coil n is set to an output corresponding to set power, and the occurrence of uneven heating can thus be reduced.

[0055] 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.

[0056] As above, the operation for causing the heating control process to be stopped in the case where no suitable load is placed above the central heating coil 22a has been described. However, the present invention is not limited to this. In accordance with the operation state of a desired heating coil 22 and a load determination result, the heating coil 22 above which a pan is not placed may be set to the output limited state and the heating coil 22 above which a pan is placed may be set to the normal output state, without distinction of the central heating coil 22a and a peripheral heating coil n from each other.

In the above-described operation, it is determined whether a placed pan is a suitable load or an unsuitable load and a heating coil 22 above which the unsuitable load is placed is set to the output stop state. However, the present invention is not limited to this. For example, the load determining means 26 may only determine whether or not a pan is placed and perform setting for the normal output state and the output limited state.

[0057] As above, the case where heating output is controlled on the basis of the phase difference between arms of an inverter circuit 9 has been explained.

However, the present invention is not limited to this. For example, the heating output may be controlled by changing the duty ratio of the output voltage of the inverter circuit 9.

(Effects)

[0058] In this embodiment, as described above, when a heating operation for applying set power to a heating target is being performed, power corresponding to the set power is output to a heating coil 22 above which the heating target is placed, on the basis of a determination result by the load determining means 26, and in the case where the heating target is not placed above the heating coil 22, a specific power (limited power) is output.

Accordingly, high-frequency output to the heating coil 22 above which the heating target (load) is not placed is limited, and high-frequency current flowing to the heating coil 22 can be suppressed.

Consequently, a high-frequency magnetic field leaking from the heating coil 22 can be reduced. Furthermore, a loss in the heating coil 22 and an inverter circuit 9 or the like that supplies high-frequency power to the heating coil 22 can be suppressed.

Therefore, a reduction in the heating efficiency and an increase of leakage flux can be suppressed.

[0059] Furthermore, in this embodiment, when a heating operation for applying set power to a heating target is being performed, a specific power (limited power) is output to a heating coil 22 above which the heating target is not placed, on the basis of a determination result by the load determining means 26, and in the case where the heating target is placed above the heating coil 22, power corresponding to the set power is output to the heating coil 22.

Thus, in the case where the heating target (load) is moved to a position above the heating coil 22 above which no object to be heated is placed, heating can be performed with an output corresponding to the set power by the heating coil 22.

Consequently, in the case where the position where a heating target is placed is moved, the occurrence of uneven heating can be reduced.

[0060] Furthermore, since the load determining means 26 performs a load determination on the basis of the output current and the input current (input power or output power) of an inverter circuit 9 that is operating in the output limited state, the load determining means 26 is capable of promptly determining that a heating target is placed above the heating coil 22 in the output limited state.

[0061] Furthermore, in this embodiment, on the basis

of a determination result by the load determining means 26, the driving of the inverter circuit 9 for a heating coil 22 above which unsuitable load is placed is stopped.
Thus, in the case where a heating target that is not suitable for induction heating is placed, excessive current can be prevented from flowing to the inverter circuit 9, the load circuit 24, and the like.

[0062] Furthermore, in this embodiment, a specific power in the output limited state is set to, for example, a lower limit value of power that the inverter circuits 9 can output.
Thus, the loss caused by high-frequency current flowing to a heating coil 22 above which a heating target (load) is not placed and leakage flux from the heating coil 22 can be reduced as much as possible.

Embodiment 2.

[0063] In Embodiment 2, a form in which the inverter circuits 9 each have a half-bridge configuration will be explained.

[0064] Fig. 13 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. 13, configuration similar to that in Embodiment 1 (Fig. 2) described above is referred to with the same reference sign.

[0065] 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.

[0066] 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 between the switching element on the higher potential side and the switching element on the lower potential side and one end of the direct-current bus, and the control means 25 supplies the high-frequency voltage to the load circuit 24'.

[0067] Fig. 14 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.

[0068] Fig. 15 is a flowchart illustrating a heating control process by the control means in the induction heating cooker according to Embodiment 2.
Fig. 16 is a flowchart illustrating an output control process for an inverter circuit for peripheral heating coil n by the control means in the induction heating cooker according to Embodiment 2.
With reference to Fig. 15 and Fig. 16, 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 coils (1 ··· n).

[0069] First, regarding the heating control process in Fig. 15, differences from Embodiment 1 described above will be explained.
In the case where the 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 proceeds to the output control process for the peripheral heating coils 22b.

[0070] 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 proceeds to the output control process for the peripheral heating coils 22b.

[0071] In the case where the set power and the input power are substantially the same in step S106 (step S106; ≈), the process proceeds to the output control process for the peripheral heating coils 22b.

[0072] Next, regarding the output control process in Fig. 16, 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 S305 (step S305; >), 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.

[0073] 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 S305 (step S305; <), 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.

[0074] 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 S305 (step S305; ≈), the output processing for the peripheral heating coil n is terminated.

(Effects)

[0075] 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.

[0076] A circuit configuration 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 may be provided.

[0077] Although the above descriptions on Embodiments 1 and 2 are directed to the case where the plurality of heating coils 22 include the central heating coil 22a arranged in the central part 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. 17, the plurality of heating coils 22 may include a central heating coil 22a arranged in the central part 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.

[0078] Furthermore, for example, as illustrated in Fig. 18, the plurality of heating coils 22 may include an inner heating coil 22a' arranged in the central part of each of the heating ports 106 arranged on the top plate 101 and an outer heating coil 22b' wound so as to surround the inner heating coil 22a'. In this case, the central heating coil 22a in the operation explanation described above corresponds to the inner heating coil 22a' and the peripheral heating coil 22b corresponds to the outer heating coil 22b'.

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

Reference Signs List

[0079] 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:

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;
control means for performing individual drive control of each of the inverter circuits; and
load determining means for performing a load determination as to whether, on a basis of the output current and the input power or the output power of an inverter circuit of the inverter circuits that is being driven, a heating target is placed above a corresponding heating coil of the heating coils,
wherein the control means,
during performance of a heating operation for applying set power to a heating target, on a basis of a determination result by the load determining means,
controls an inverter circuit of the inverter circuits to output power corresponding to the set power to a heating coil of the heating coils above which a heating target is placed, and
controls the inverter circuit to output a specific power that is smaller than or equal to the set power to the heating coil, in a case where the heating target is not placed above the heating coil to which the power corresponding to the set power is being output.

2. The Induction heating cooker of claim 1,
wherein the control means,
during performance of the heating operation for applying the set power to the heating target,
controls, on the basis of the determination result by the load determining means, the inverter circuit to output the specific power that is smaller than or equal to the set power to a heating coil of the heating coils above which the heating target is not placed, and
controls the inverter circuit to output the power corresponding to the set power to the heating coil, in the case where the heating target is placed above the heating coil to which the specific power is being output.

3. The induction heating cooker of claim 1 or 2,
wherein the load determining means performs,
on a basis of correlation between the output current and the input power or the output power of the inverter circuit being driven, a load determination as to whether the heating target placed above the heating coil is an unsuitable load that is not suitable for induction heating, and
wherein the control means causes,
on a basis of a determination result by the load determining means, driving of the inverter circuit for the heating coil above which unsuitable load is placed to stop.

4. The induction heating cooker of any one of claims 1 to 3, wherein the specific power is a lower limit value of power that the inverter circuit can output.

5. The induction heating cooker of any one of claims 1 to 4, further comprising input current detecting means for detecting an input current of each of the inverter circuits,
wherein the load determining means performs the load determination by 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.

6. The induction heating cooker of any one of claims 1 to 5,
wherein an inverter circuit of the inverter circuits includes at least two arms each including two switching elements that are connected in series and each have a full-bridge inverter circuit configuration, and
wherein the control means controls power output from the inverter circuit by varying a driving phase difference of the switching elements between the two arms.

7. The induction heating cooker of any one of claims 1 to 5,
wherein an inverter circuit of the inverter circuits includes two switching elements that are connected in series and has a half-bridge inverter circuit configuration, and

wherein the control means controls power output from the inverter circuit by varying a duty ratio of the switching elements.

8. The induction heating cooker of any one of claims 1 to 7, 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 part 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.

9. The induction heating cooker of any one of claims 1 to 7, 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 part 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.

10. The induction heating cooker of any one of claims 1 to 7, 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 part of a heating port arranged on the top plate and an outer heating coil wound so as to surround the inner heating coil.

F I G. 1

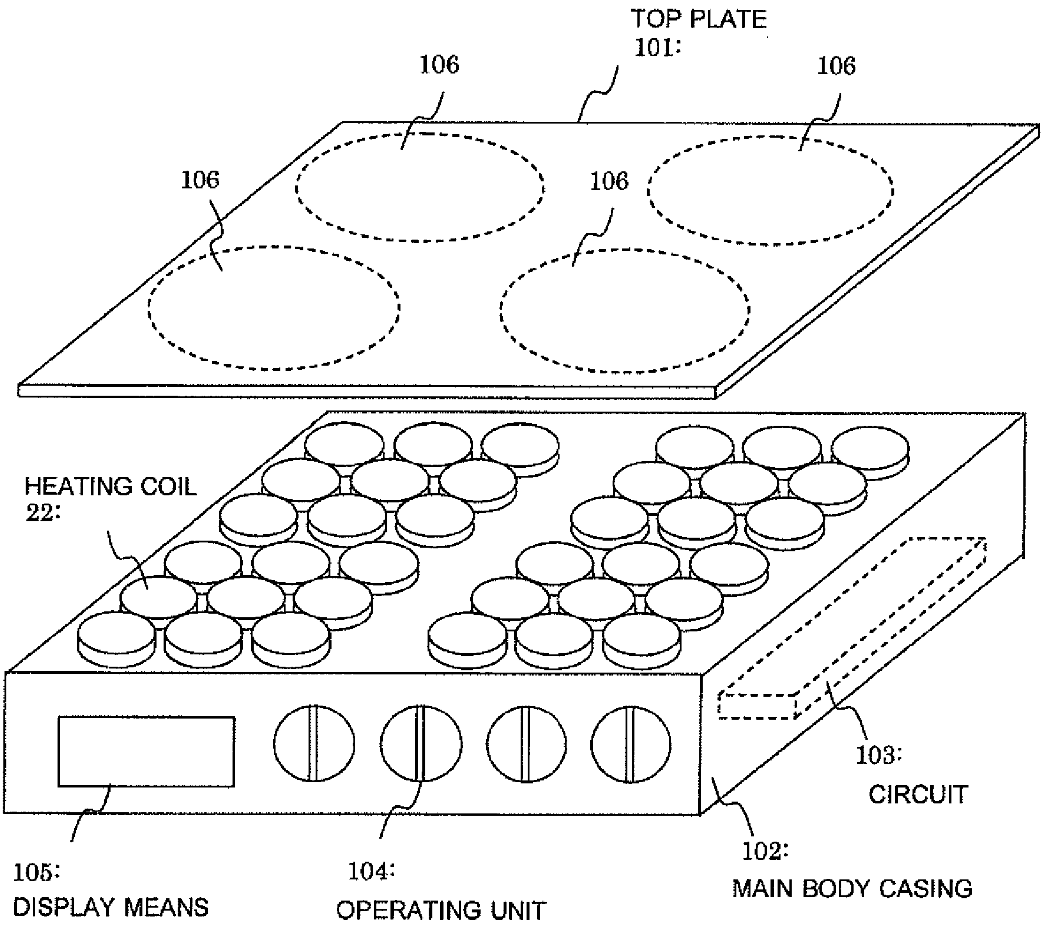
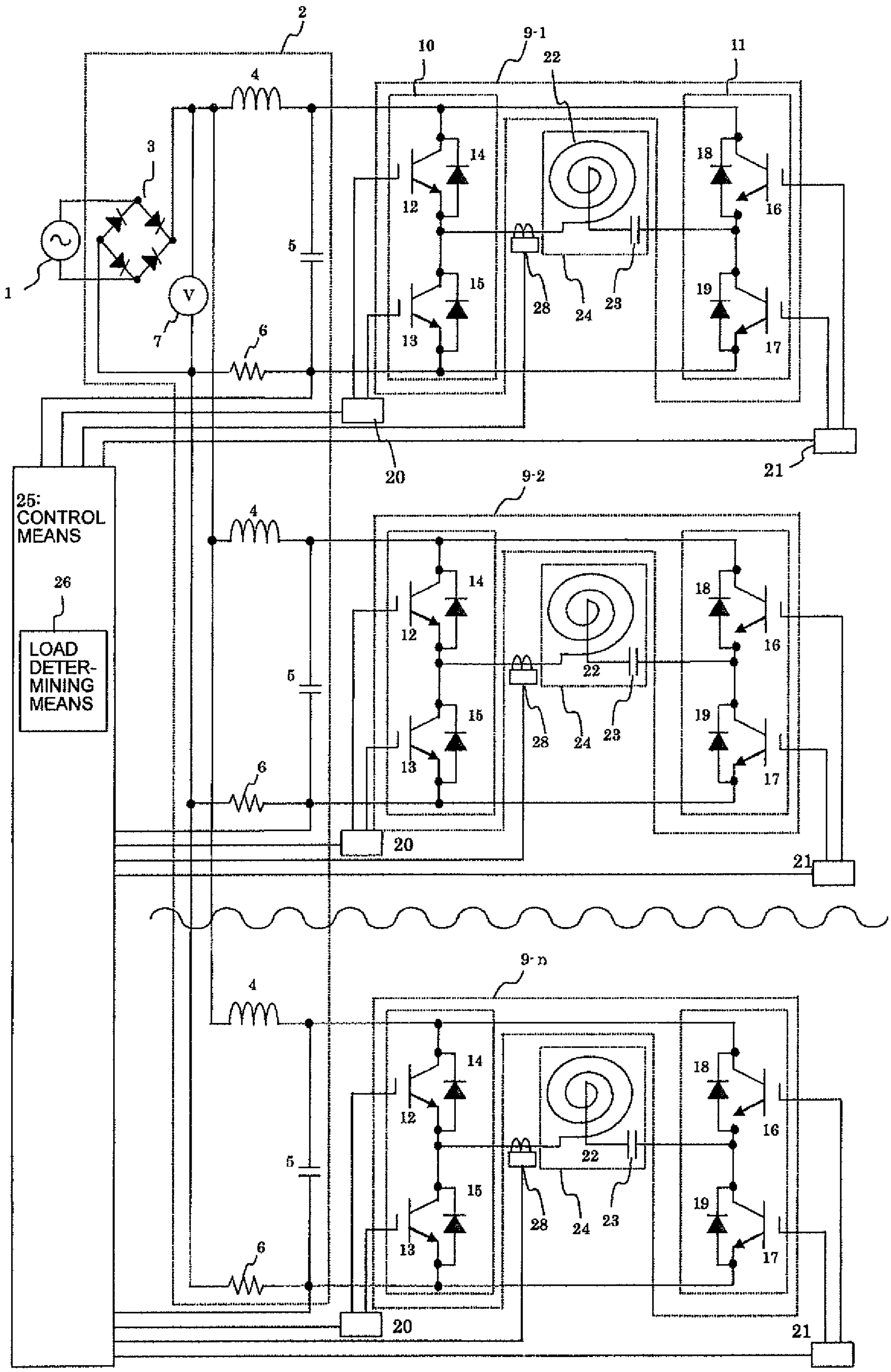
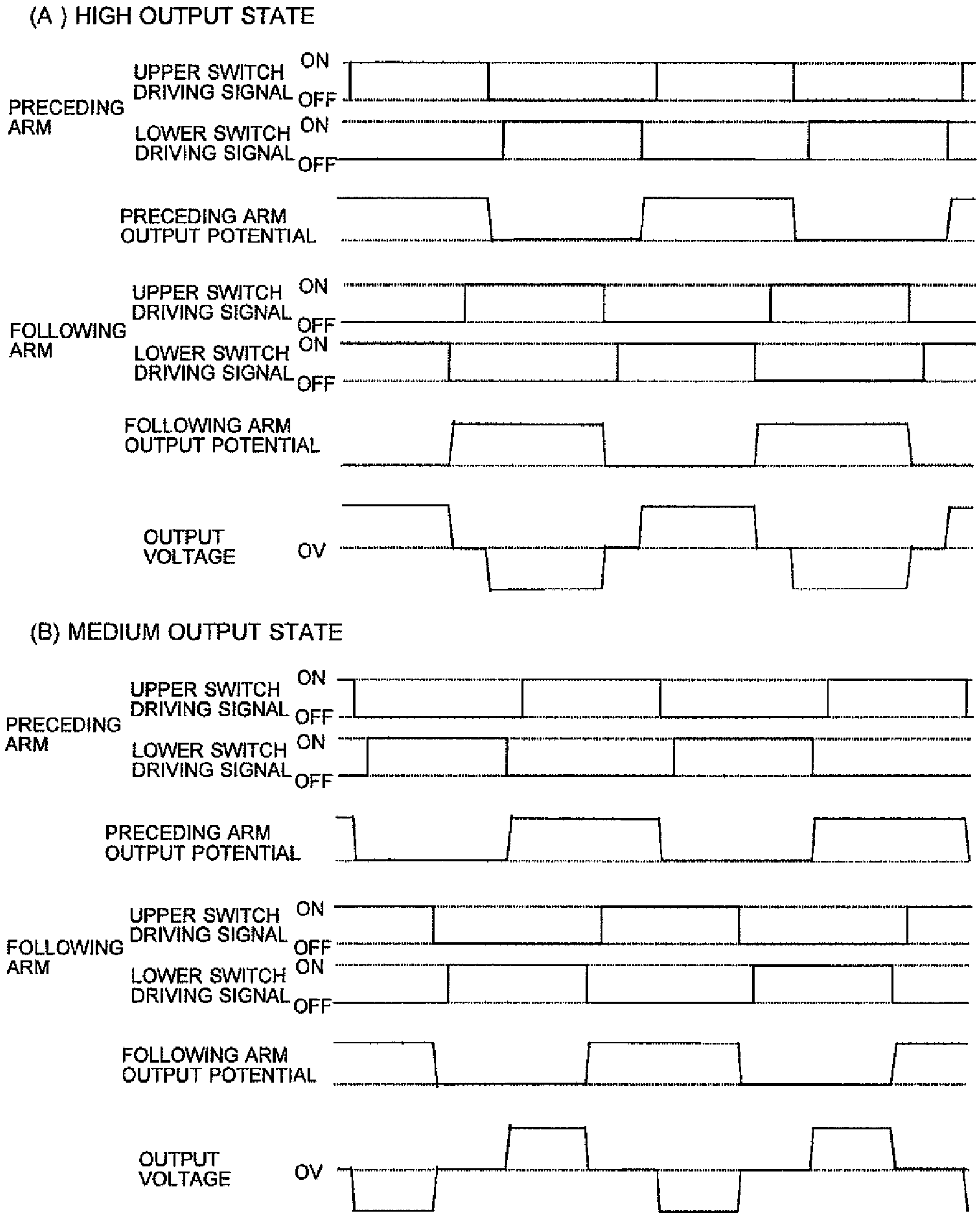

TOP PLATE
101:
106
106
106
106
HEATING COIL
22:
103:
CIRCUIT
102:
MAIN BODY CASING
105:
DISPLAY MEANS
104:
OPERATING UNIT

FIG. 2

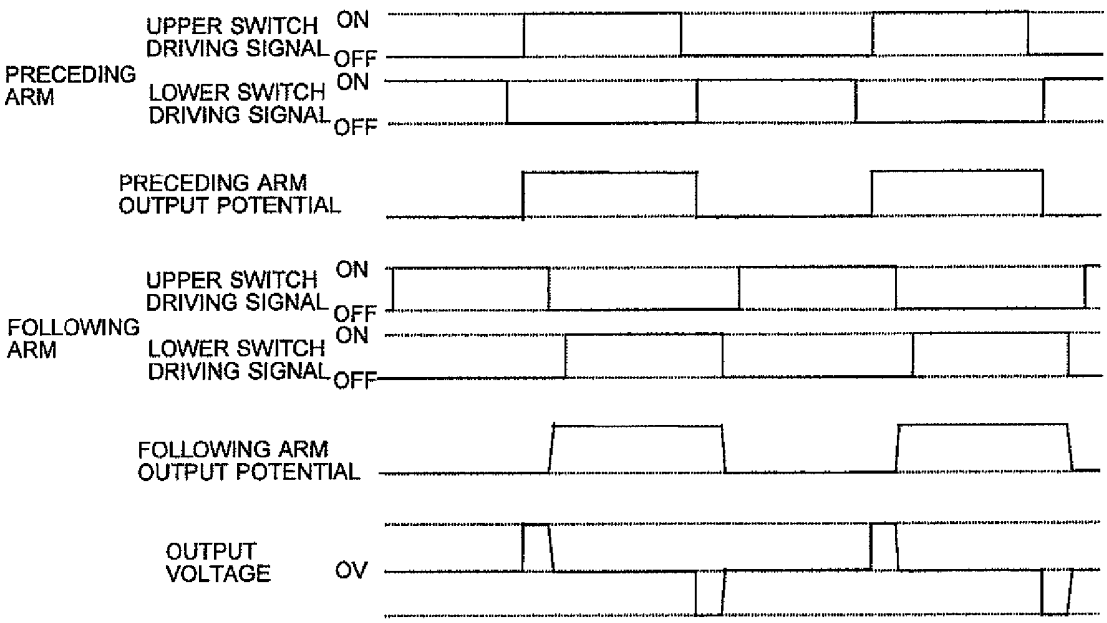


F I G. 3

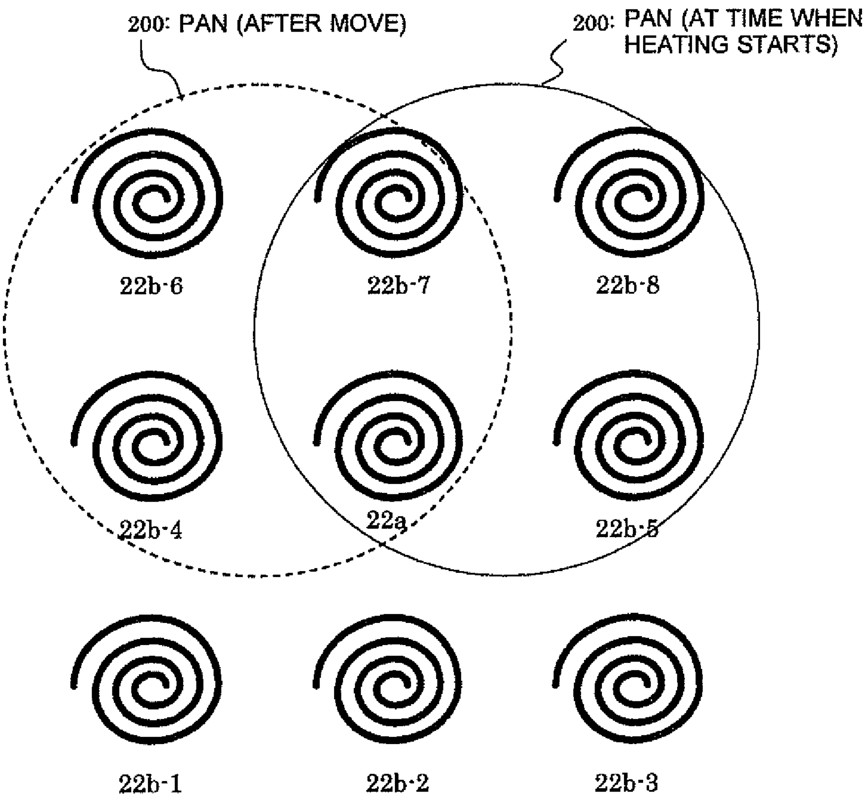

(A) HIGH OUTPUT STATE
PRECEDING ARM
UPPER SWITCH DRIVING SIGNAL
ON
OFF
LOWER SWITCH DRIVING SIGNAL
ON
OFF
PRECEDING ARM OUTPUT POTENTIAL
FOLLOWING ARM
UPPER SWITCH DRIVING SIGNAL
ON
OFF
LOWER SWITCH DRIVING SIGNAL
ON
OFF
FOLLOWING ARM OUTPUT POTENTIAL
OUTPUT VOLTAGE
OV
(B) MEDIUM OUTPUT STATE
PRECEDING ARM
UPPER SWITCH DRIVING SIGNAL
ON
OFF
LOWER SWITCH DRIVING SIGNAL
ON
OFF
PRECEDING ARM OUTPUT POTENTIAL
FOLLOWING ARM
UPPER SWITCH DRIVING SIGNAL
ON
OFF
LOWER SWITCH DRIVING SIGNAL
ON
OFF
FOLLOWING ARM OUTPUT POTENTIAL
OUTPUT VOLTAGE
OV

F I G. 4

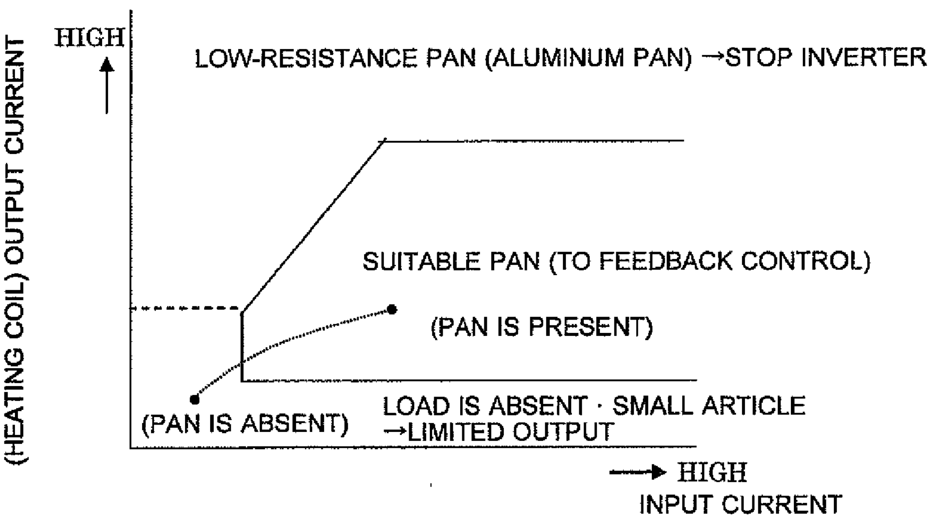
(C) LOW OUTPUT STATE



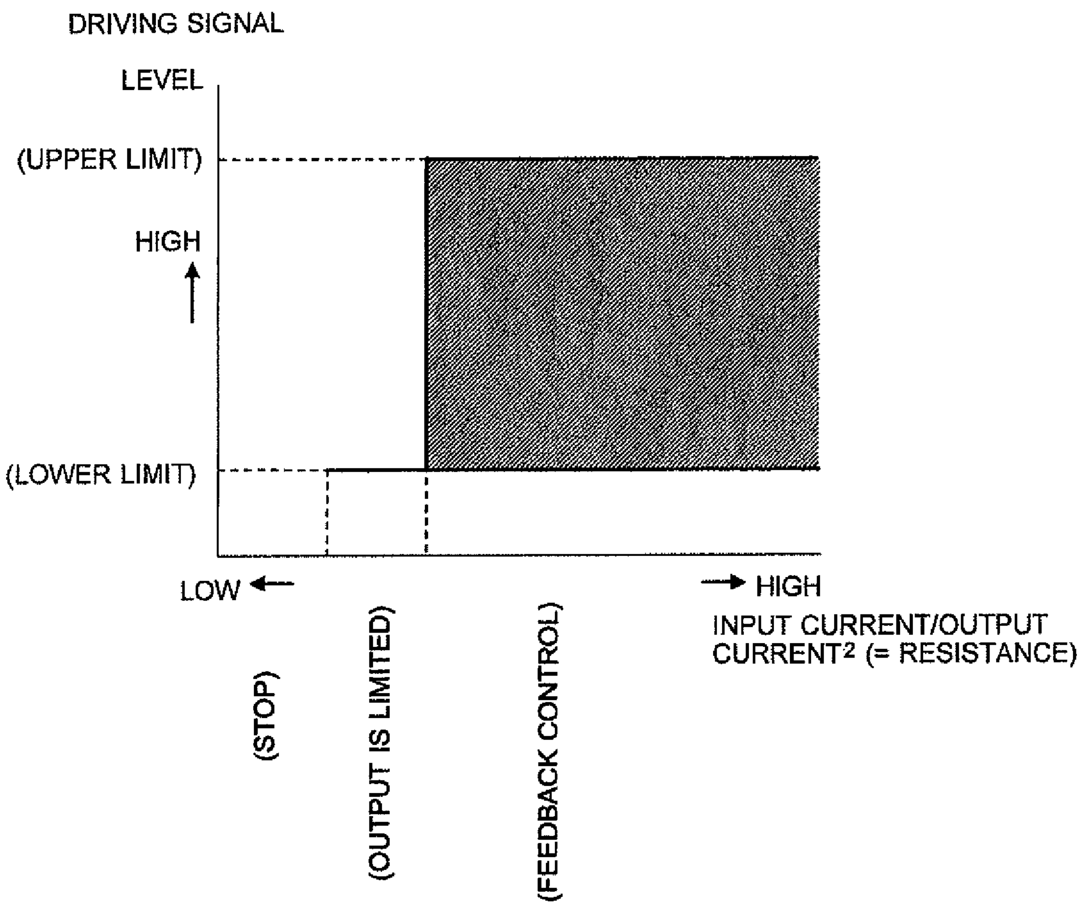
F I G. 5


200: PAN (AFTER MOVE)
200: PAN (AT TIME WHEN HEATING STARTS)
22b-6
22b-7
22b-8
22b-4
22a
22b-5
22b-1
22b-2
22b-3

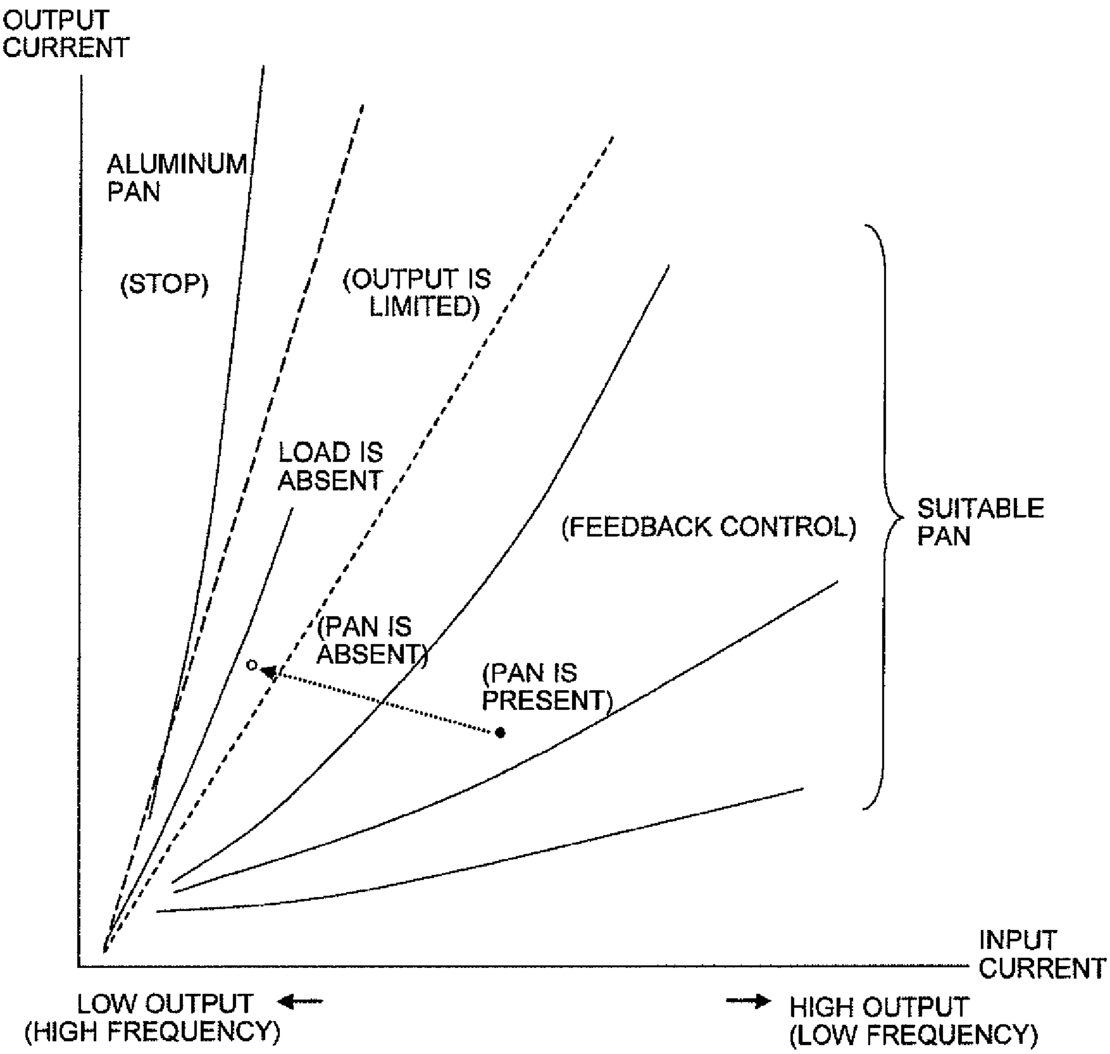
F I G. 6


(HEATING COIL) OUTPUT CURRENT
HIGH
LOW-RESISTANCE PAN (ALUMINUM PAN) →STOP INVERTER
SUITABLE PAN (TO FEEDBACK CONTROL)
(PAN IS PRESENT)
(PAN IS ABSENT)
LOAD IS ABSENT · SMALL ARTICLE
→LIMITED OUTPUT
HIGH
INPUT CURRENT

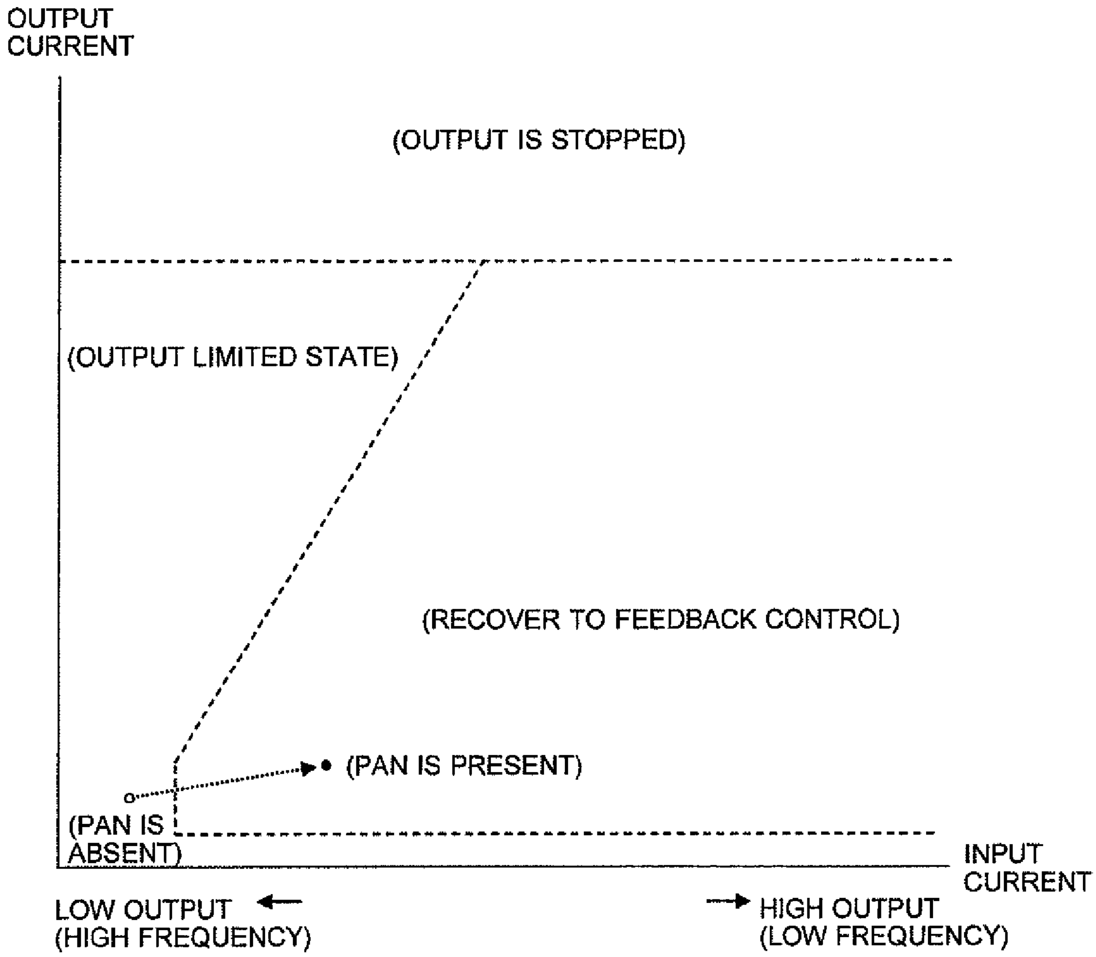
F I G. 7


DRIVING SIGNAL
LEVEL
(UPPER LIMIT)
HIGH
(LOWER LIMIT)
LOW
HIGH
INPUT CURRENT/OUTPUT CURRENT2 (= RESISTANCE)
(STOP)
(OUTPUT IS LIMITED)
(FEEDBACK CONTROL)

F I G. 8


OUTPUT
CURRENT
ALUMINUM
PAN
(STOP)
(OUTPUT IS
LIMITED)
LOAD IS
ABSENT
(FEEDBACK CONTROL)
SUITABLE
PAN
(PAN IS
ABSENT)
(PAN IS
PRESENT)
INPUT
CURRENT
LOW OUTPUT
(HIGH FREQUENCY)
HIGH OUTPUT
(LOW FREQUENCY)

F I G. 9


OUTPUT
CURRENT
(OUTPUT IS STOPPED)
(OUTPUT LIMITED STATE)
(RECOVER TO FEEDBACK CONTROL)
(PAN IS PRESENT)
(PAN IS
ABSENT)
INPUT
CURRENT
LOW OUTPUT
(HIGH FREQUENCY)
HIGH OUTPUT
(LOW FREQUENCY)

F I G. 1 0

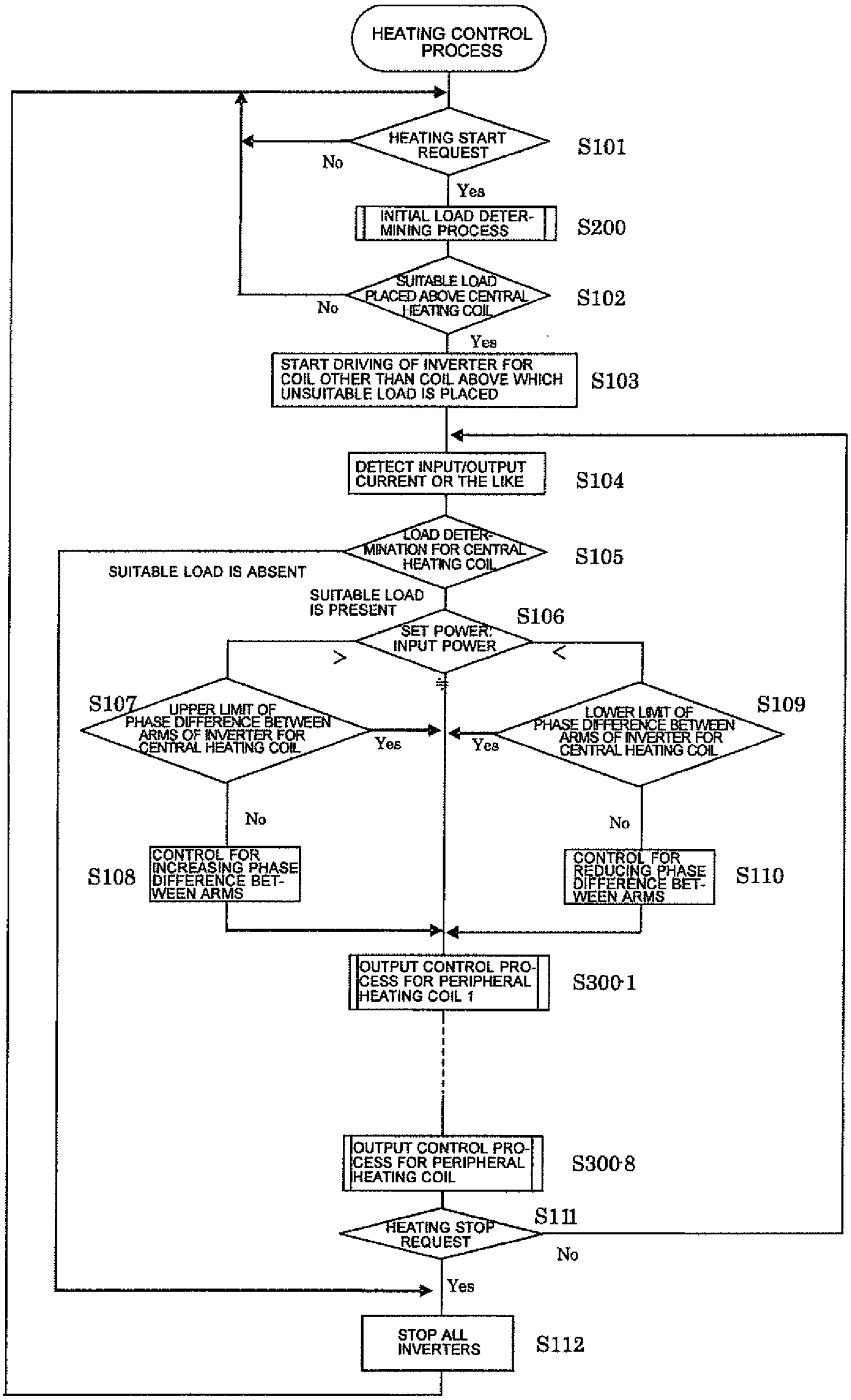

HEATING CONTROL PROCESS
HEATING START REQUEST
S101
No
Yes
INITIAL LOAD DETERMINING PROCESS
S200
SUITABLE LOAD PLACED ABOVE CENTRAL HEATING COIL
S102
No
Yes
START DRIVING OF INVERTER FOR COIL OTHER THAN COIL ABOVE WHICH UNSUITABLE LOAD IS PLACED
S103
DETECT INPUT/OUTPUT CURRENT OR THE LIKE
S104
LOAD DETERMINATION FOR CENTRAL HEATING COIL
S105
SUITABLE LOAD IS ABSENT
SUITABLE LOAD IS PRESENT
SET POWER: INPUT POWER
S106
>
<
≒
S107
UPPER LIMIT OF PHASE DIFFERENCE BETWEEN ARMS OF INVERTER FOR CENTRAL HEATING COIL
Yes
No
LOWER LIMIT OF PHASE DIFFERENCE BETWEEN ARMS OF INVERTER FOR CENTRAL HEATING COIL
S109
Yes
No
S108
CONTROL FOR INCREASING PHASE DIFFERENCE BETWEEN ARMS
CONTROL FOR REDUCING PHASE DIFFERENCE BETWEEN ARMS
S110
OUTPUT CONTROL PROCESS FOR PERIPHERAL HEATING COIL 1
S300-1
OUTPUT CONTROL PROCESS FOR PERIPHERAL HEATING COIL
S300-8
HEATING STOP REQUEST
S111
No
Yes
STOP ALL INVERTERS
S112

FIG. 11

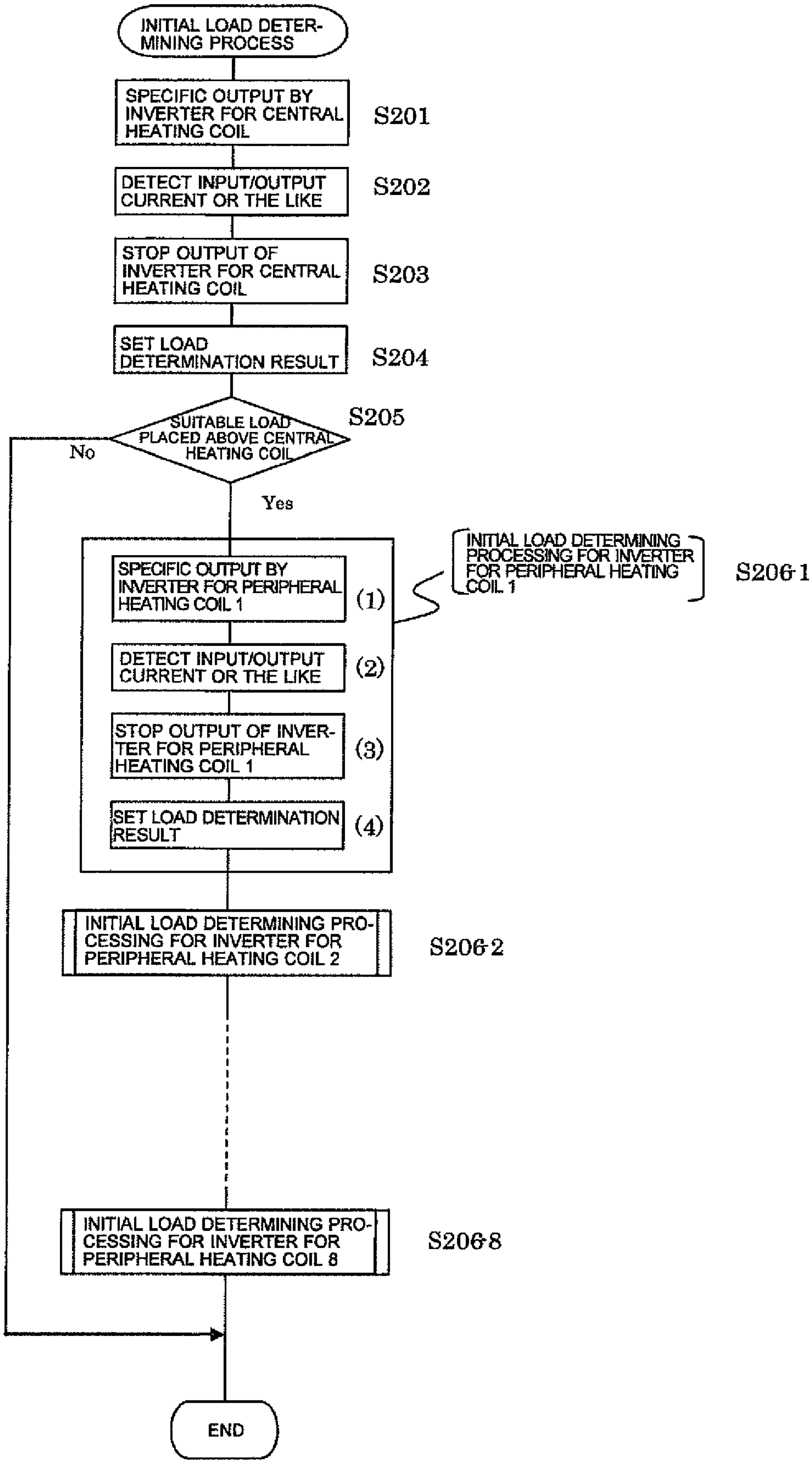
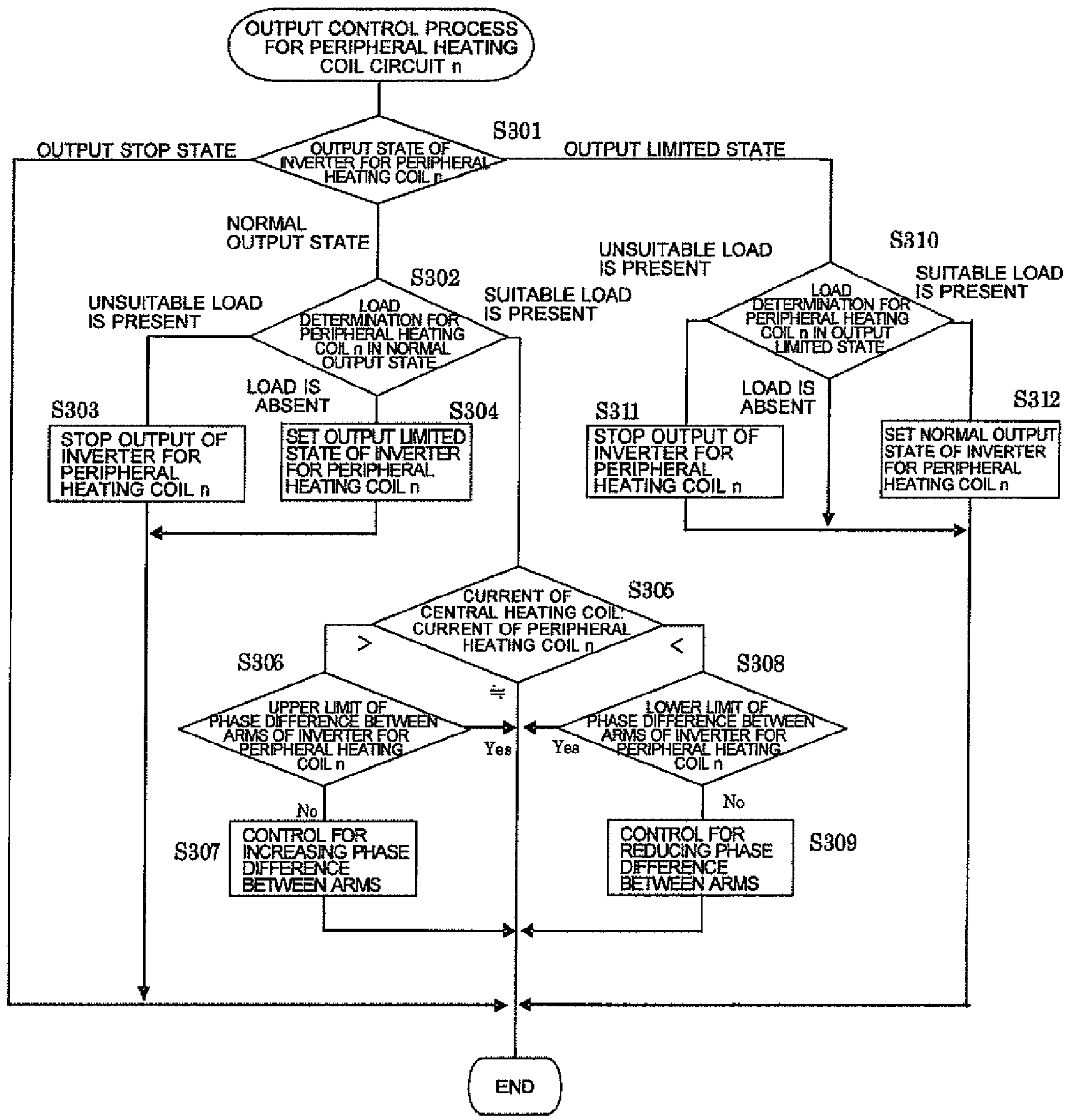

INITIAL LOAD DETERMINING PROCESS
SPECIFIC OUTPUT BY INVERTER FOR CENTRAL HEATING COIL
S201
DETECT INPUT/OUTPUT CURRENT OR THE LIKE
S202
STOP OUTPUT OF INVERTER FOR CENTRAL HEATING COIL
S203
SET LOAD DETERMINATION RESULT
S204
SUITABLE LOAD PLACED ABOVE CENTRAL HEATING COIL
S205
No
Yes
SPECIFIC OUTPUT BY INVERTER FOR PERIPHERAL HEATING COIL 1
(1)
DETECT INPUT/OUTPUT CURRENT OR THE LIKE
(2)
STOP OUTPUT OF INVERTER FOR PERIPHERAL HEATING COIL 1
(3)
SET LOAD DETERMINATION RESULT
(4)
INITIAL LOAD DETERMINING PROCESSING FOR INVERTER FOR PERIPHERAL HEATING COIL 1
S206-1
INITIAL LOAD DETERMINING PROCESSING FOR INVERTER FOR PERIPHERAL HEATING COIL 2
S206-2
INITIAL LOAD DETERMINING PROCESSING FOR INVERTER FOR PERIPHERAL HEATING COIL 8
S206-8
END

FIG. 12


OUTPUT CONTROL PROCESS FOR PERIPHERAL HEATING COIL CIRCUIT n
S301
OUTPUT STATE OF INVERTER FOR PERIPHERAL HEATING COIL n
OUTPUT STOP STATE
OUTPUT LIMITED STATE
NORMAL OUTPUT STATE
S302
LOAD DETERMINATION FOR PERIPHERAL HEATING COIL n IN NORMAL OUTPUT STATE
UNSUITABLE LOAD IS PRESENT
SUITABLE LOAD IS PRESENT
LOAD IS ABSENT
S303
STOP OUTPUT OF INVERTER FOR PERIPHERAL HEATING COIL n
S304
SET OUTPUT LIMITED STATE OF INVERTER FOR PERIPHERAL HEATING COIL n
S310
LOAD DETERMINATION FOR PERIPHERAL HEATING COIL n IN OUTPUT LIMITED STATE
UNSUITABLE LOAD IS PRESENT
SUITABLE LOAD IS PRESENT
LOAD IS ABSENT
S311
STOP OUTPUT OF INVERTER FOR PERIPHERAL HEATING COIL n
S312
SET NORMAL OUTPUT STATE OF INVERTER FOR PERIPHERAL HEATING COIL n
S305
CURRENT OF CENTRAL HEATING COIL: CURRENT OF PERIPHERAL HEATING COIL n
>
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≒
S306
UPPER LIMIT OF PHASE DIFFERENCE BETWEEN ARMS OF INVERTER FOR PERIPHERAL HEATING COIL n
Yes
No
S307
CONTROL FOR INCREASING PHASE DIFFERENCE BETWEEN ARMS
S308
LOWER LIMIT OF PHASE DIFFERENCE BETWEEN ARMS OF INVERTER FOR PERIPHERAL HEATING COIL n
Yes
No
S309
CONTROL FOR REDUCING PHASE DIFFERENCE BETWEEN ARMS
END

F I G. 1 3

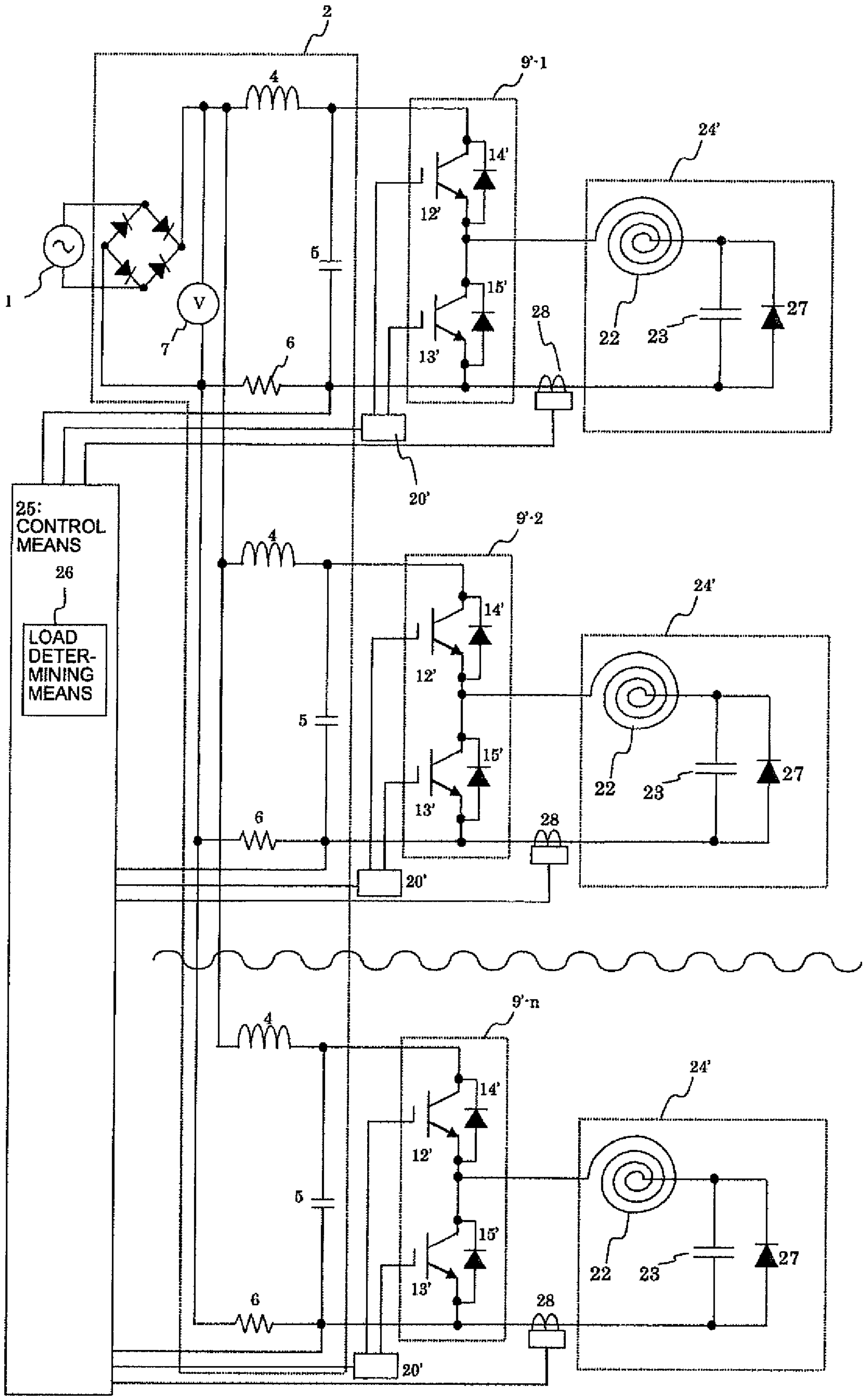

2
9'-1
4
14'
24'
12'
5
15'
1
V
28
27
7
6
13'
22
23
20'
25:
CONTROL
MEANS
9'-2
26
LOAD
DETER-
MINING
MEANS
9'-n

FIG. 14

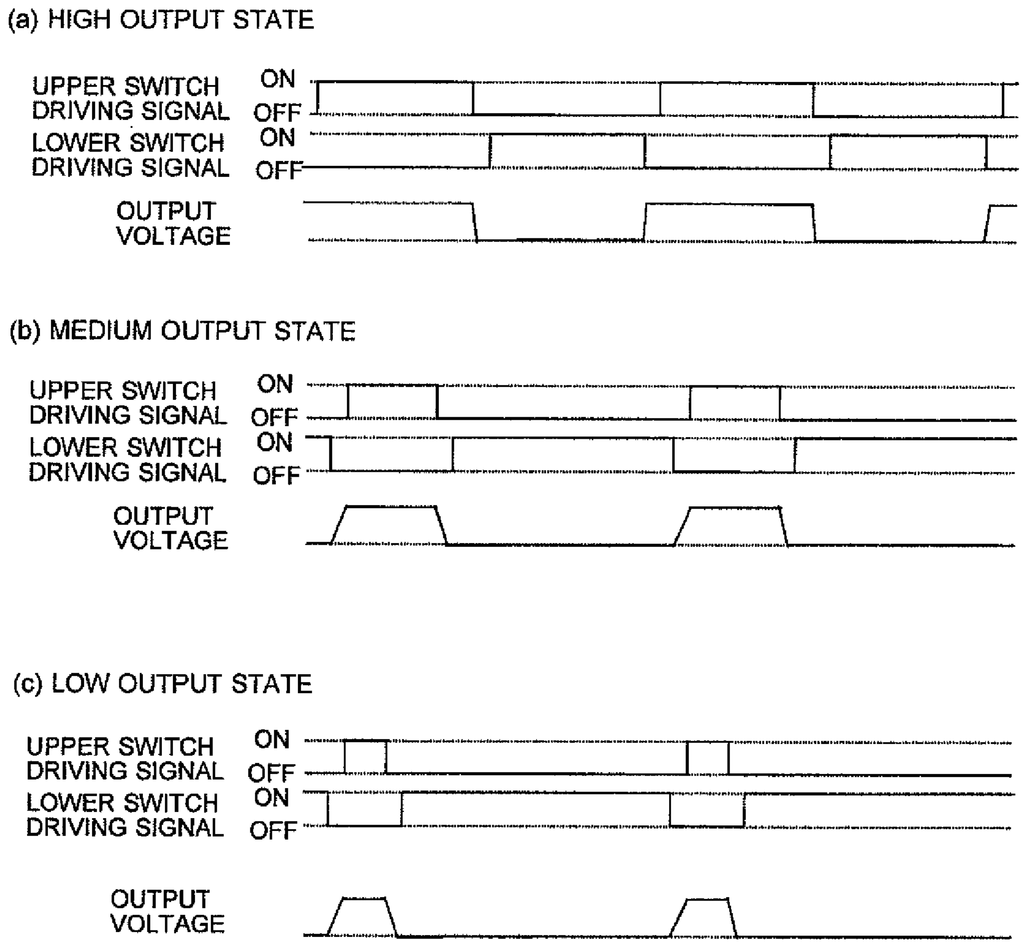

(a) HIGH OUTPUT STATE
UPPER SWITCH DRIVING SIGNAL
ON
OFF
LOWER SWITCH DRIVING SIGNAL
ON
OFF
OUTPUT VOLTAGE
(b) MEDIUM OUTPUT STATE
UPPER SWITCH DRIVING SIGNAL
ON
OFF
LOWER SWITCH DRIVING SIGNAL
ON
OFF
OUTPUT VOLTAGE
(c) LOW OUTPUT STATE
UPPER SWITCH DRIVING SIGNAL
ON
OFF
LOWER SWITCH DRIVING SIGNAL
ON
OFF
OUTPUT VOLTAGE

FIG. 15

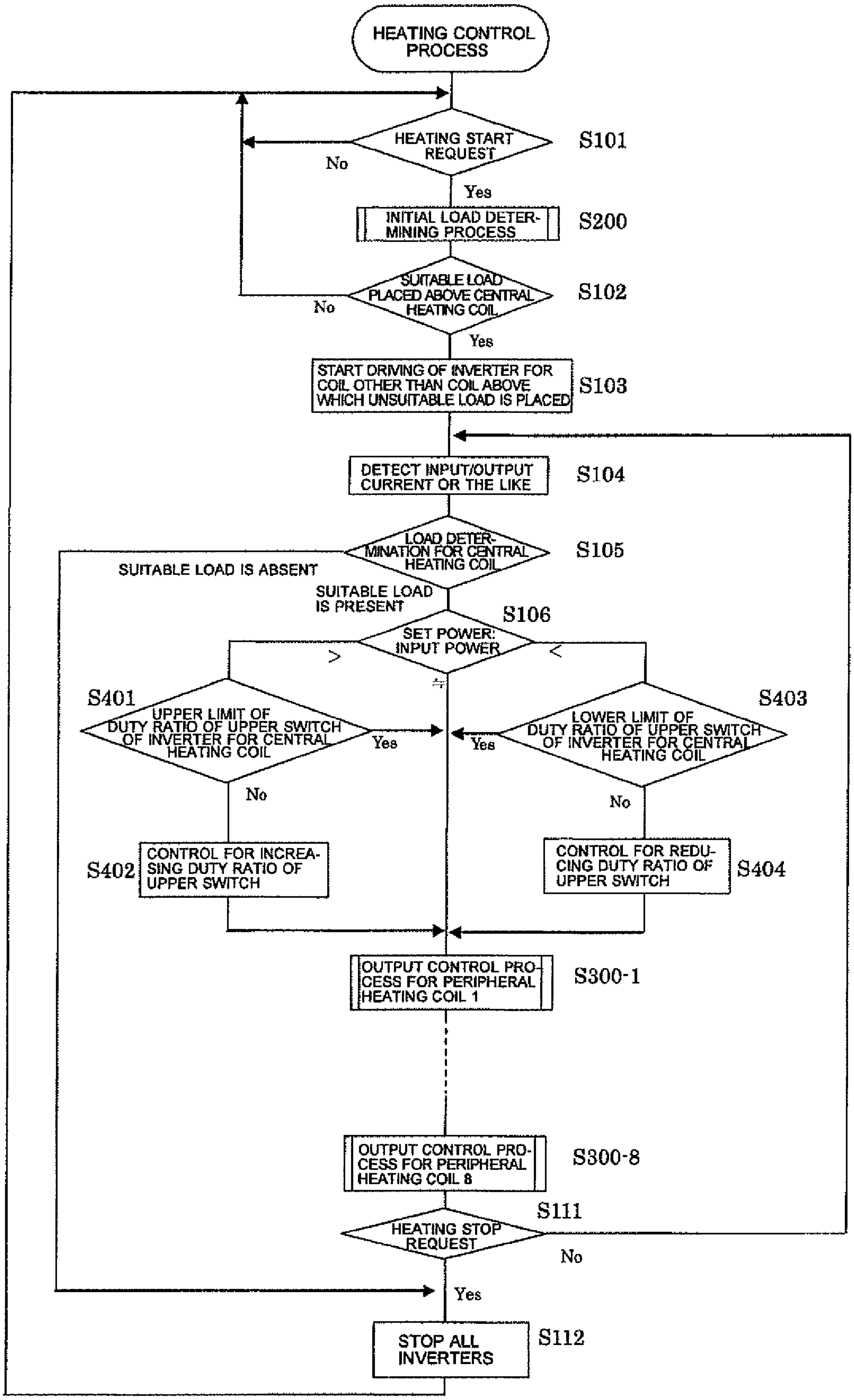
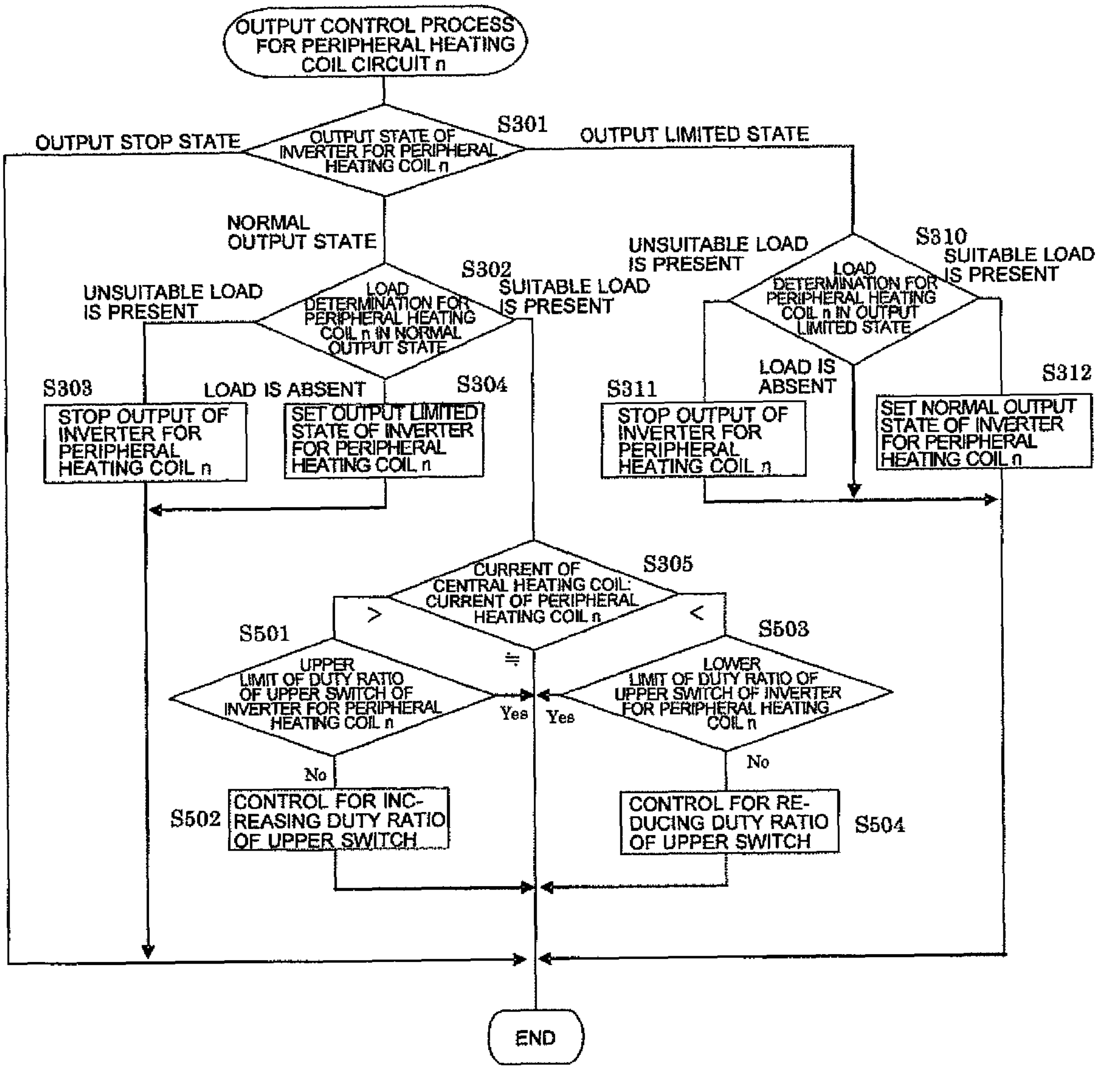
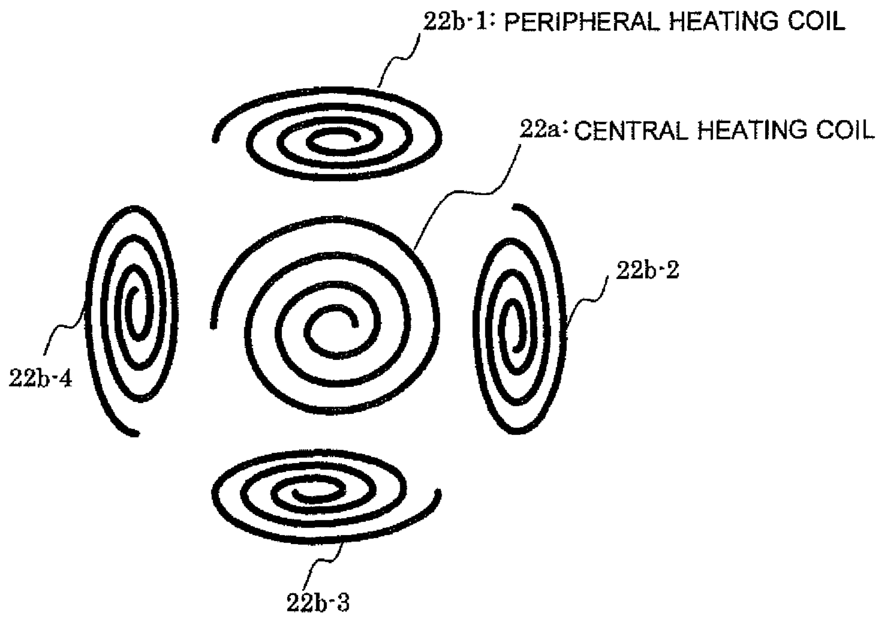

HEATING CONTROL PROCESS
HEATING START REQUEST
S101
No
Yes
INITIAL LOAD DETERMINING PROCESS
S200
SUITABLE LOAD PLACED ABOVE CENTRAL HEATING COIL
S102
No
Yes
START DRIVING OF INVERTER FOR COIL OTHER THAN COIL ABOVE WHICH UNSUITABLE LOAD IS PLACED
S103
DETECT INPUT/OUTPUT CURRENT OR THE LIKE
S104
LOAD DETERMINATION FOR CENTRAL HEATING COIL
S105
SUITABLE LOAD IS ABSENT
SUITABLE LOAD IS PRESENT
S106
SET POWER: INPUT POWER
>
<
≒
S401
UPPER LIMIT OF DUTY RATIO OF UPPER SWITCH OF INVERTER FOR CENTRAL HEATING COIL
Yes
No
S403
LOWER LIMIT OF DUTY RATIO OF UPPER SWITCH OF INVERTER FOR CENTRAL HEATING COIL
Yes
No
S402
CONTROL FOR INCREASING DUTY RATIO OF UPPER SWITCH
CONTROL FOR REDUCING DUTY RATIO OF UPPER SWITCH
S404
OUTPUT CONTROL PROCESS FOR PERIPHERAL HEATING COIL 1
S300-1
OUTPUT CONTROL PROCESS FOR PERIPHERAL HEATING COIL 8
S300-8
S111
HEATING STOP REQUEST
No
Yes
STOP ALL INVERTERS
S112

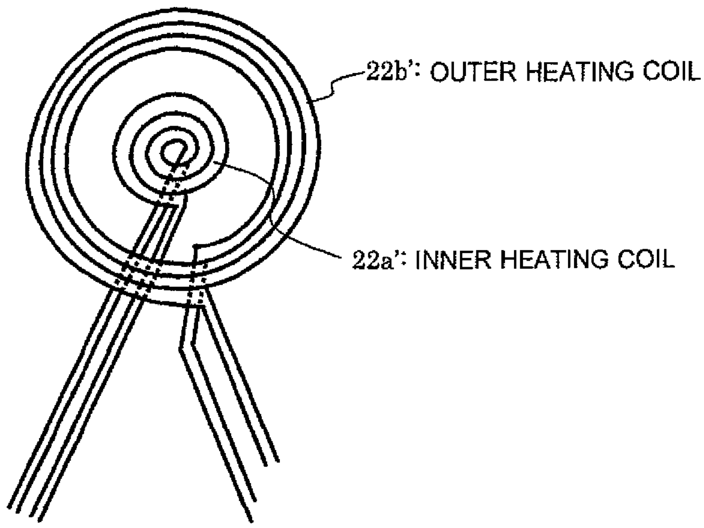
FIG. 16


OUTPUT CONTROL PROCESS FOR PERIPHERAL HEATING COIL CIRCUIT n
S301
OUTPUT STATE OF INVERTER FOR PERIPHERAL HEATING COIL n
OUTPUT STOP STATE
OUTPUT LIMITED STATE
NORMAL OUTPUT STATE
S302
LOAD DETERMINATION FOR PERIPHERAL HEATING COIL n IN NORMAL OUTPUT STATE
UNSUITABLE LOAD IS PRESENT
SUITABLE LOAD IS PRESENT
LOAD IS ABSENT
S303
STOP OUTPUT OF INVERTER FOR PERIPHERAL HEATING COIL n
S304
SET OUTPUT LIMITED STATE OF INVERTER FOR PERIPHERAL HEATING COIL n
S310
LOAD DETERMINATION FOR PERIPHERAL HEATING COIL n IN OUTPUT LIMITED STATE
UNSUITABLE LOAD IS PRESENT
SUITABLE LOAD IS PRESENT
LOAD IS ABSENT
S311
STOP OUTPUT OF INVERTER FOR PERIPHERAL HEATING COIL n
S312
SET NORMAL OUTPUT STATE OF INVERTER FOR PERIPHERAL HEATING COIL n
S305
CURRENT OF CENTRAL HEATING COIL: CURRENT OF PERIPHERAL HEATING COIL n
>
<
≒
S501
UPPER LIMIT OF DUTY RATIO OF UPPER SWITCH OF INVERTER FOR PERIPHERAL HEATING COIL n
Yes
No
S502
CONTROL FOR INCREASING DUTY RATIO OF UPPER SWITCH
S503
LOWER LIMIT OF DUTY RATIO OF UPPER SWITCH OF INVERTER FOR PERIPHERAL HEATING COIL n
Yes
No
S504
CONTROL FOR REDUCING DUTY RATIO OF UPPER SWITCH
END

F I G. 1 7


22b-1: PERIPHERAL HEATING COIL
22a: CENTRAL HEATING COIL
22b-2
22b-4
22b-3

F I G. 1 8


22b': OUTER HEATING COIL
22a': INNER HEATING COIL

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/000109

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 2009-165291 A (Mitsubishi Electric Corp.), 23 July 2009 (23.07.2009), paragraphs [0102] to [0113]; fig. 10 (Family: none)	1-10
Y	JP 2008-282609 A (Mitsubishi Electric Corp.), 20 November 2008 (20.11.2008), paragraphs [0008] to [0029]; fig. 1 to 7 (Family: none)	1-10
Y	JP 10-214679 A (Toshiba Corp.), 11 August 1998 (11.08.1998), paragraph [0052] (Family: none)	7-10

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

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search
06 March, 2012 (06.03.12)

Date of mailing of the international search report
13 March, 2012 (13.03.12)

Name and mailing address of the ISA/
Japanese Patent Office

Facsimile No.

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/000109

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. 3 to 5, 9, 10, 12, 14, 17, 19 (Family: none)	8-10
A	JP 2009-99299 A (Mitsubishi Electric Corp.), 07 May 2009 (07.05.2009), entire text; all drawings (Family: none)	1-10

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Patent documents cited in the description

- JP 2008293871 A **[0003]**