



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

(43) Date of publication:
01.07.2020 Bulletin 2020/27

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

(21) Application number: **18849140.1**

(86) International application number:
PCT/JP2018/027581

(22) Date of filing: **24.07.2018**

(87) International publication number:
WO 2019/039166 (28.02.2019 Gazette 2019/09)

(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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Panasonic Intellectual Property Management Co., Ltd.**
Osaka-shi, Osaka 540-6207 (JP)

(72) Inventor: **ASANO Masato**
Osaka-shi
Osaka 540-6207 (JP)

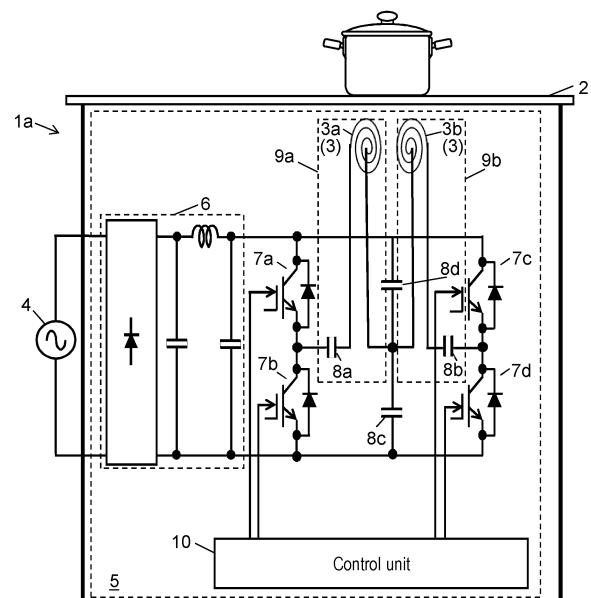
(30) Priority: **24.08.2017 JP 2017160711**

(74) Representative: **SSM Sandmair Patentanwälte Rechtsanwalt Partnerschaft mbB**
Joseph-Wild-Straße 20
81829 München (DE)

(54) **INDUCTION-HEATING COOKER**

(57) An induction-heating cooker includes: a direct-current power supply; first to fourth switching elements; a first resonant circuit including a first heating coil and a first resonant capacitor; a second resonant circuit including a second heating coil and a second resonant capacitor; a third resonant capacitor; and a controller. The first and second switching elements are connected in series between output terminals of the direct-current power supply. The third and fourth switching elements are connected in series between the output terminals of the direct-current power supply. One end of the first resonant circuit is connected to a connection point between the first and second switching elements. The second resonant circuit has one end connected to a connection point between the third and fourth switching elements and the other end connected to the other end of the first resonant circuit. The third resonant capacitor is connected between the positive or negative output terminal of the direct-current power supply and a connection point between the first and second resonant circuits. The controller controls the first to fourth switching elements.

FIG. 1



Description

TECHNICAL FIELD

5 [0001] The present disclosure relates to an induction-heating cooker including a function for switching the resonance frequency of an inverter circuit in order to heat objects made of various materials.

BACKGROUND ART

10 [0002] Conventionally, an induction-heating cooker of this type includes: a main body forming an outline; a top plate disposed on an upper surface of the main body; and at least one inverter unit. The inverter unit includes: four switching elements, one heating coil, and at least one changeover relay (for example, refer to Patent Literature (PTL) 1).

[0003] With the above related art, it is possible to switch the resonance frequency of the inverter circuit by operating the changeover relay. This enables heating pots made of various materials such as aluminum pots, multilayer pots
15 including aluminum and stainless steel, and iron pots.

Citation List

Patent Literature

20 [0004] PTL 1: Unexamined Japanese Patent Publication No. 2008-010165

SUMMARY OF THE INVENTION

25 [0005] In the above related art, however, in order to heat pots made of various materials, it is necessary to increase the breakdown voltage of a resonant capacitor, increase losses at the switching elements, and use the changeover relay in the inverter unit. Therefore, the problems of a rise in the cost of the inverter unit and an increase in the size of the inverter unit arise.

[0006] There is also a problem in that a user feels discomfort from the operating noise of the changeover relay until
30 the changeover relay is actuated.

[0007] The present disclosure is conceived to solve the above conventional problems and aims to provide an induction-heating cooker capable of switching the resonance frequency of an inverter circuit without using a changeover relay in order to heat pots made of various materials.

[0008] An induction-heating cooker according to one aspect of the present disclosure includes: a direct-current power supply; first to fourth switching elements; a first resonant circuit including a first heating coil and a first resonant capacitor;
35 a second resonant circuit including a second heating coil and a second resonant capacitor; a third resonant capacitor; and a controller.

[0009] The first and second switching elements are connected in series between output terminals of the direct-current power supply. The third and fourth switching elements are connected in series between the output terminals of the direct-current power supply.
40

[0010] One end of the first resonant circuit is connected to a connection point between the first and second switching elements. The second resonant circuit has one end connected to a connection point between the third and fourth switching elements and the other end connected to the other end of the first resonant circuit.

[0011] The third resonant capacitor is connected between one of a positive output terminal and a negative output terminal of the direct-current power supply and a connection point between the first and second resonant circuits. The controller controls the first to fourth switching elements.
45

[0012] According to the present embodiment, operations of the switching elements can cause a change in a path in which an electric current flows. This results in a change of a resonant capacitor in which the electric current flows, and thus the combined volume of the resonant capacitors in the inverter unit can be changed. In other words, it is possible
50 to switch the resonant frequency of the inverter unit without using a changeover relay.

[0013] Since no changeover relay is required, inverter unit 5 can be easily downsized. There is no longer time for switching the changeover relay or no switching noise of the changeover relay anymore; thus, it is possible to improve the level of comfort for users.

55 BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

FIG. 1 is a block diagram of an induction-heating cooker according to Embodiment 1 of the present disclosure.
 FIG. 2A is a diagram illustrating a control sequence performed in Embodiment 1.
 FIG. 2B is a diagram illustrating a control sequence performed in Embodiment 1.
 FIG. 3 is a block diagram of an induction-heating cooker according to Embodiment 2 of the present disclosure.
 FIG. 4A is a diagram illustrating a control sequence performed in Embodiment 2.
 FIG. 4B is a diagram illustrating a control sequence performed in Embodiment 2.
 FIG. 5 is a block diagram of an induction-heating cooker according to Embodiment 4 of the present disclosure.
 FIG. 6 is a flowchart illustrating operations of the induction-heating cooker according to Embodiment 4.
 FIG. 7 is a block diagram of an induction-heating cooker according to Embodiment 5 of the present disclosure.
 FIG. 8 is a block diagram of an induction-heating cooker according to Embodiment 6 of the present disclosure.
 FIG. 9 is a block diagram of an induction-heating cooker according to Embodiment 7 of the present disclosure.
 FIG. 10 is a block diagram of an induction-heating cooker according to Embodiment 8 of the present disclosure.
 FIG. 11 is a block diagram of an induction-heating cooker according to Embodiment 9 of the present disclosure.

DESCRIPTION OF EMBODIMENTS

[0015] An induction-heating cooker according to the first aspect of the present disclosure includes: a direct-current power supply; first to fourth switching elements; a first resonant circuit including a first heating coil and a first resonant capacitor; a second resonant circuit including a second heating coil and a second resonant capacitor; a third resonant capacitor; and a controller.

[0016] The first and second switching elements are connected in series between output terminals of the direct-current power supply. The third and fourth switching elements are connected in series between the output terminals of the direct-current power supply.

[0017] One end of the first resonant circuit is connected to a connection point between the first and second switching elements. The second resonant circuit has one end connected to a connection point between the third and fourth switching elements and the other end connected to the other end of the first resonant circuit.

[0018] The third resonant capacitor is connected between one of a positive output terminal and a negative output terminal of the direct-current power supply and a connection point between the first and second resonant circuits. The controller controls the first to fourth switching elements.

[0019] The induction-heating cooker according to the second aspect of the present disclosure further includes, in addition to those in the first aspect, a fourth resonant capacitor connected between the positive output terminal of the direct-current power supply and the connection point between the first and second resonant circuits. The third resonant capacitor is connected between the negative output terminal of the direct-current power supply and the connection point between the first and second resonant circuits.

[0020] The induction-heating cooker according to the third aspect of the present disclosure further includes a switch unit in addition to those in the first aspect. The controller outputs a first control signal to the first switching element and outputs a second control signal to the second switching element. The switch unit causes a transition between a state in which the first control signal is further output to the third switching element and the second control signal is further output to the fourth switching element and a state in which the first control signal is further output to the fourth switching element and the second control signal is further output to the third switching element.

[0021] The induction-heating cooker according to the fourth aspect of the present disclosure further includes, in addition to those in the first aspect: one of an electric current sensor and a voltage sensor that is connected in series to the first resonant circuit; and one of an electric current sensor and a voltage sensor that is connected in series to the second resonant circuit.

[0022] The induction-heating cooker according to the fifth aspect of the present disclosure further includes, in addition to those in the fourth aspect, one of an electric current sensor and a voltage sensor that is connected in series to the third resonant circuit.

[0023] In the induction-heating cooker according to the sixth aspect of the present disclosure, in addition to the first aspect, while setting dead time, the controller alternately turns on and off the first switching element and the second switching element and alternately turns on and off the third switching element and the fourth switching element.

[0024] When an object to be heated is made of a non-magnetic material, the controller implements a first heating mode in which the first switching element and the third switching element are simultaneously turned on and the second switching element and the fourth switching element are simultaneously turned on. When the object to be heated is made of a magnetic material, the controller implements a second heating mode in which the first switching element and the fourth switching element are simultaneously turned on and the second switching element and the third switching element are simultaneously turned on.

[0025] In the induction-heating cooker according to the seventh aspect of the present disclosure, in addition to the first aspect, while setting dead time, the controller alternately turns on and off the first switching element and the second

switching element and alternately turns on and off the third switching element and the fourth switching element.

[0026] The controller implements a first heating mode in which the first switching element and the third switching element are simultaneously turned on and the second switching element and the fourth switching element are simultaneously turned on. The controller implements a second heating mode in which the first switching element and the fourth switching element are simultaneously turned on and the second switching element and the third switching element are simultaneously turned on. The controller alternately implements the first heating mode and the second heating mode.

[0027] The induction-heating cooker according to the eighth aspect of the present disclosure further includes first and second coils in addition to those in the second aspect. The first coil is disposed between the negative output terminal of the direct-current power supply and the connection point between the first and second resonant circuits and is connected in series to the third resonant capacitor. The second coil is disposed between the positive output terminal of the direct-current power supply and the connection point between the first and second resonant circuits and is connected in series to the fourth resonant capacitor.

[0028] In the induction-heating cooker according to the ninth aspect of the present disclosure, in addition to the eighth aspect, the first coil is a third heating coil, and the second coil is a fourth heating coil.

[0029] Hereinafter, exemplary embodiments of the present disclosure will be described with reference to the drawings. In the subsequent description, the same reference marks are given to the same or equivalent portions and redundant description thereof will be omitted.

EMBODIMENT 1

[0030] FIG. 1 is a block diagram of induction-heating cooker 1a according to Embodiment 1 of the present disclosure. As illustrated in FIG. 1, induction-heating cooker 1a includes: top plate 2 disposed on an upper surface of a main body forming an outline; and inverter unit 5 disposed below top plate 2.

[0031] Top plate 2 is made from an electrical insulator such as glass. Inverter unit 5 includes heating coil unit 3, smoothing circuit 6, switching elements 7a, 7b, 7c, 7d, resonant capacitors 8a, 8b, 8c, 8d, and controller 10.

[0032] Heating coil unit 3 includes two adjacent heating coils (heating coils 3a, 3b). Heating coil 3a is disposed at the front, and heating coil 3b is disposed at the back. Heating coil 3a and heating coil 3b correspond to a first heating coil and a second heating coil, respectively.

[0033] Heating coils 3a, 3b each include: an inner terminal located in an inner area of the coil; and an outer terminal located in an outer area of the coil. The inner terminal is the start of winding of the coil, and the outer terminal is the end of the winding of the coil. Heating coil 3a is wound counter-clockwise, and heating coil 3b is wound clockwise.

[0034] Smoothing circuit 6 includes a diode bridge which serves as a full-wave rectifier circuit, a capacitor, and a coil. Smoothing circuit 6 rectifies an alternating-current voltage supplied by utility power supply 4 and smoothes a direct-current voltage resulting from the rectification. Smoothing circuit 6 corresponds to a direct-current power supply.

[0035] Switching elements 7a, 7b are connected in series between output terminals of the direct-current power supply. Switching element 7a is disposed on the high potential side, and switching element 7b is disposed on the low potential side. Switching elements 7c, 7d are connected in series between the output terminals of the direct-current power supply. Switching element 7c is disposed on the high potential side, and switching element 7d is disposed on the low potential side.

[0036] Switching elements 7a, 7b, 7c, 7d are formed of insulated-gate bipolar transistors (IGBTs) and incorporate diodes connected in opposite directions.

[0037] Resonant capacitors 8c, 8d are connected in series between the output terminals of the direct-current power supply. Resonant capacitor 8d is disposed on the high potential side, and resonant capacitor 8c is disposed on the low potential side.

[0038] An inner terminal of heating coil 3a is connected to the connection point between resonant capacitors 8c, 8d. An outer terminal of heating coil 3a is connected to one end of resonant capacitor 8a. The other end of resonant capacitor 8a is connected to the connection point between switching elements 7a, 7b. Heating coil 3a and resonant capacitor 8a constitute resonant circuit 9a.

[0039] An inner terminal of heating coil 3b is connected to the connection point between resonant capacitors 8c, 8d. An outer terminal of heating coil 3b is connected to one end of resonant capacitor 8b. The other end of resonant capacitor 8b is connected to the connection point between switching elements 7c, 7d. Heating coil 3b and resonant capacitor 8b constitute resonant circuit 9b. Resonant circuit 9a and resonant circuit 9b correspond to a first resonant circuit and a second resonant circuit, respectively.

[0040] In the present embodiment, the inner terminals of heating coils 3a, 3b are connected to each other, and the outer terminal of heating coil 3a and the outer terminal of heating coil 3b are connected to resonant capacitor 8a and resonant capacitor 8b, respectively.

[0041] Controller 10 outputs control signals SGa, SGb, SGc, SGd to switching elements 7a, 7b, 7c, 7d, respectively, to control switching elements 7a, 7b, 7c, 7d. Controller 10 controls the frequency and the duty ratio of each of control signals SGa, SGb, SGc, SGd to control heating output. Control signals SGa, SGb, SGc, SGd correspond to first, second,

third, and fourth control signals, respectively.

[0042] Inverter unit 5 generates a high-frequency current from the alternating-current voltage supplied by utility power supply 4, and outputs the generated high-frequency current to heating coil unit 3, thereby driving heating coil unit 3. Using the high-frequency current, heating coil unit 3 inductively heats a pot that is an object to be heated placed on top plate 2.

[0043] Switching elements 7a, 7b, 7c, 7d correspond to first, second, third, and fourth switching elements, respectively. Resonant capacitors 8a, 8b, 8c, 8d correspond to first, second, third, and fourth resonant capacitors, respectively.

[0044] Although not illustrated in the drawings, if smoothing circuit 6 includes a booster circuit including a switching element and a diode, the direct-current voltage resulting from the rectification is increased, and thus the smoothed direct-current voltage is higher. This allows an increase in the heating output.

[0045] FIG. 2A and FIG. 2B illustrate control sequence SQa and control sequence SQb, respectively. In the case where the pot placed on top plate 2 is a pot made of a non-magnetic material such as an aluminum pot, the operating mode of inverter unit 5 is set to a first heating mode. In the first heating mode, control sequence SQa is performed.

[0046] In the case where the pot placed on top plate 2 is a pot made of a magnetic material such as a multilayer pot or an iron pot, the operating mode of inverter unit 5 is set to a second heating mode. In the second heating mode, control sequence SQa is performed.

[0047] As illustrated in FIG. 2A, in control sequence SQa, control signal SGb is 180 degrees different in phase from control signal SGa. Control signal SGc is the same signal as control signal SGa, and control signal SGd is the same signal as control signal SGb.

[0048] Using these signals, controller 10 alternately turns on and off switching element 7a and switching element 7b, and alternately turns on and off switching element 7c and switching element 7d while setting dead time for preventing short-circuiting between the output terminals of the direct-current power supply. Controller 10 simultaneously turns on switching element 7a and switching element 7c, and simultaneously turns on switching element 7b and switching element 7d.

[0049] In the first heating mode, an electric current flows through each of heating coils 3a, 3b, sometimes from the inner terminal to the outer terminal, and at other times, from the outer terminal to the inner terminal. In other words, at a portion where heating coils 3a, 3b face each other, electric currents flow in the same direction (refer to FIG. 1). This results in an increase in magnetic flux in the region between heating coils 3a, 3b.

[0050] As illustrated in FIG. 2B, in control sequence SQb, control signal SGb is a half-wavelength different in phase from control signal SGa. Control signal SGd is the same signal as control signal SGa, and control signal SGc is the same signal as control signal SGd.

[0051] Using these signals, while setting the dead time, controller 10 alternately turns on and off switching element 7a and switching element 7b, and alternately turns on and off switching element 7c and switching element 7d. Controller 10 simultaneously turns on switching element 7a and switching element 7d, and simultaneously turns on switching element 7b and switching element 7c.

[0052] In the second heating mode, sometimes, an electric current flows through heating coil 3a from the outer terminal to the inner terminal, and an electric current flows through heating coil 3b from the inner terminal to the outer terminal. At other times, an electric current flows through heating coil 3a from the inner terminal to the outer terminal, and an electric current flows through heating coil 3b from the outer terminal to the inner terminal.

[0053] In other words, at the portion where heating coils 3a, 3b face each other, electric currents flow in opposite directions (refer to FIG. 1). This results in a decrease in the magnetic flux in the region between heating coils 3a, 3b.

[0054] According to the present embodiment, a path in which the electric current flows can be changed by switching between control sequences SQa, SQb. This results in a change of a resonant capacitor in which the electric current flows, and thus the combined volume of the resonant capacitors in inverter unit 5 can be changed. In other words, it is possible to switch the resonant frequency of inverter unit 5 without using a changeover relay.

[0055] Since no changeover relay is required, inverter unit 5 can be easily downsized. There is no longer time for switching the changeover relay or no switching noise of the changeover relay anymore; thus, it is possible to improve the level of comfort for users.

[0056] According to the present embodiment, voltages that are applied to heating coils 3a, 3b can be changed by switching between control sequence SQa and control sequence SQb. Therefore, in the case of an aluminum pot, a copper pot, or the like, when switching elements 7a to 7d are operated according to control sequence SQa, the maximum resonance voltage, the maximum resonance current, and the maximum power output can be reduced.

[0057] As a result, it is possible to improve withstand voltage performance and withstand current performance of inverter unit 5. Inverter unit 5 can be easily downsized. A pot can be heated with high output power regardless of the material of the pot.

[0058] According to the present embodiment, in the case of an iron pot, a stainless steel pot, or the like, when switching element 7a to 7d are operated according to control sequence SQb, a highly loaded pot can be heated with high output power.

[0059] According to the present embodiment, in the case where switching elements 7a to 7d have large losses, switching elements 7a to 7d are operated according to control sequence SQa. This allows a reduction in electric currents flowing through switching elements 7a to 7d. As a result, losses at switching elements 7a to 7d can be reduced.

[0060] According to the present embodiments, resonant capacitors 8c, 8d are connected in series between the output terminals of the direct-current power supply. This allows a reduction in ripple currents in inverter unit 5. As a result, noise at inverter unit 5 can be reduced, losses in inverter unit 5 can be smoothed, and the volume of smoothing circuit 6 can be reduced.

[0061] In the present embodiment, when heating coils 3a, 3b have the same constant and resonant capacitors 8a, 8b have the same constant, resonant circuits 9a, 9b have the same resonant frequency, Q value, and attenuation. With this, the resonance current, the resonance voltage, and the loss in inverter unit 5 can be smoothed. As a result, improvements can be made to variations in heating. Furthermore, resonant capacitors 8c, 8d may have the same constant.

[0062] According to the present embodiment, the electric current flowing through heating coils 3a, 3b can be controlled to bias the buoyancy of a pot. Thus, the likelihood of fall or slippage of the pot can be reduced.

[0063] According to the present embodiment, the direction of the electric current flowing through each of heating coils 3a, 3b can be controlled. Thus, it is possible to control the strength of the magnetic flux between heating coils 3a, 3b. Therefore, in the case of a pot that requires a large resonance current for heating, the electric current flowing through each of heating coils 3a, 3b is controlled to increase the magnetic flux between heating coils 3a, 3b. As a result, the resonance current can be reduced.

[0064] In the case of a high-impedance pot that is hard to heat with high power, the electric current flowing through each of heating coils 3a, 3b is controlled to decrease the magnetic flux between heating coils 3a, 3b. This allows the pot to be heated with high power.

[0065] As described above, in the present embodiment, the inner terminals of heating coils 3a, 3b are connected to each other, and the outer terminal of heating coil 3a and the outer terminal of heating coil 3b are connected to resonant capacitor 8a and resonant capacitor 8b, respectively.

[0066] However, the outer terminals of heating coils 3a, 3b may be connected to each other, and the inner terminal of heating coil 3a and the inner terminal of heating coil 3b may be connected to resonant capacitor 8a and resonant capacitor 8b, respectively. The inner terminal of one of the heating coils may be connected to the outer terminal of the other of the heating coils.

[0067] The position of heating coil 3a and the position of resonant capacitor 8a may be reversed. The position of heating coil 3b and the position of resonant capacitor 8b may be reversed.

[0068] Heating coils 3a, 3b may be arranged widthwise instead of lengthwise. Heating coils 3a, 3b may have the same number of turns or may have different numbers of turns. Heating coils 3a, 3b may be of the same shape or may be of different shapes.

EMBODIMENT 2

[0069] Hereinafter, Embodiment 2 of the present disclosure will be described. FIG. 3 is a block diagram of induction-heating cooker 1b according to the present embodiment. As illustrated in FIG. 3, the present embodiment is different from Embodiment 1 in that induction-heating cooker 1b includes switch unit 11. The other elements in induction-heating cooker 1b are the same as those in induction-heating cooker 1a according to Embodiment 1.

[0070] Controller 10 outputs control signals SGa, SGb. Switching element 7a and switching element 7b receive control signal SGa and control signal SGb, respectively. Switch unit 11 receives control signals SGa, SGb.

[0071] Controller 10 controls switch unit 11 so that in control sequence SQa, switching element 7c and switching element 7d receive control signal SGa and control signal SGb, respectively. Controller 10 controls switch unit 11 so that in control sequence SQb, switching element 7c and switching element 7d receive control signal SGb and control signal SGa, respectively.

[0072] In other words, sometimes, by way of switch unit 11, switching element 7c receives control signal SGa, and switching element 7d receives control signal SGb. At other times, by way of switch unit 11, switching element 7d receives control signal SGa, and switching element 7c receives control signal SGb.

[0073] FIG. 4A is a diagram illustrating control sequence SQa performed in the case where a pot placed on top plate 2 is an aluminum pot. FIG. 4B is a diagram illustrating control sequence SQb performed in the case where a pot placed on top plate 2 is a multilayer pot or an iron pot.

[0074] As illustrated in FIG. 4A, in control sequence SQa, control signal SGa is output to switching elements 7a, 7c, and control signal SGb is output to switching elements 7b, 7d. As illustrated in FIG. 4B, in control sequence SQb, control signal SGa is output to switching elements 7a, 7d, and control signal SGb is output to switching elements 7b, 7c.

[0075] In the present embodiment, controller 10 outputs control signals SGa, SGb to control switch unit 11, thereby controlling switching elements 7a, 7b, 7c, 7d.

[0076] In the present embodiment, control signal SGc in Embodiment 1 is control signal SGa or control signal SGb,

and control signal SGd in Embodiment 1 is control signal SGb or control signal SGa.

[0077] According to the present embodiment, providing switch unit 11 eliminates the need for controller 10 to output four signals; thus, controller 10 can be simplified.

EMBODIMENT 3

[0078] Hereinafter, Embodiment 3 of the present disclosure will be described. The elements in the present embodiment are the same as those in Embodiment 1 or 2. In the present embodiment, controller 10 implements a third heating mode in which the first heating mode and the second heating mode are alternately implemented regardless of the material of a pot. In other words, in the third heating mode, control sequences SQa, SQb are alternately performed.

[0079] According to the present embodiment, a pot can be more evenly heated by changing a bias in heat distribution. As a result, improvements can be made to variations in heating.

EMBODIMENT 4

[0080] Hereinafter, Embodiment 4 of the present disclosure will be described. FIG. 5 is a block diagram of induction-heating cooker 1c according to the present embodiment. As illustrated in FIG. 5, the present embodiment is different from Embodiment 2 in that induction-heating cooker 1c includes electric current sensors 12a, 12b. The other elements in induction-heating cooker 1c are the same as those in induction-heating cooker 1b according to Embodiment 2.

[0081] Electric current sensor 12a is disposed between heating coil 3a and resonant capacitor 8a and is connected in series to resonant circuit 9a. Electric current sensor 12a detects an electric current flowing through resonant circuit 9a and transmits the value of the detected electric current to controller 10.

[0082] Electric current sensor 12b is disposed between heating coil 3b and resonant capacitor 8b and is connected in series to resonant circuit 9b. Electric current sensor 12b detects an electric current flowing through resonant circuit 9b and transmits the value of the detected electric current to controller 10.

[0083] Operations of induction-heating cooker 1c configured as described above will be described below.

[0084] FIG. 6 is a flowchart illustrating the operations of induction-heating cooker 1c. As illustrated in FIG. 6, in a power-off mode (Step S1) in which inverter unit 5 is supplied with no electric power, when the power supply is turned on, the operating mode of inverter unit 5 transitions to a default mode (Step S2) in which the heating operation is not started.

[0085] When an instruction to start heating is provided, the operating mode of inverter unit 5 transitions to a load determination mode (Step S3) in which the material of a pot is determined. According to the result of the load determination mode (Step S3), the operating mode of inverter unit 5 transitions to the first heating mode (Step S4) or the second heating mode (Step S5).

[0086] In the load determination mode (Step S3), when a pot placed on top plate 2 is determined as a pot made of a non-magnetic material such as an aluminum pot, the operating mode of inverter unit 5 transitions to the first heating mode (Step S4).

[0087] In the first heating mode (Step S4), controller 10 controls switching elements 7a to 7d so that switching elements 7a to 7d operate according to control sequence SQa illustrated in FIG. 4A.

[0088] In the load determination mode (Step S3), when a pot placed on top plate 2 is determined as a pot made of a magnetic material such as a multilayer pot or an iron pot, the operating mode of inverter unit 5 transitions to the second heating mode (Step S5).

[0089] In the second heating mode (Step S5), controller 10 controls switching elements 7a to 7d so that switching elements 7a to 7d operate according to control sequence SQb illustrated in FIG. 4B.

[0090] According to the present embodiment, sensing the electric current flowing through each of resonant circuits 9a, 9b enables controller 10 to determine the material of the pot placed on top plate 2. Controller 10 can automatically select and implement one of the first and second heating modes according to the material of the pot.

[0091] Voltage sensors may be disposed instead of electric current sensors 12a, 12b. It is sufficient that a change in at least one of the properties of resonant circuits 9a, 9b can be detected.

EMBODIMENT 5

[0092] Hereinafter, Embodiment 5 of the present disclosure will be described. FIG. 7 is a block diagram of induction-heating cooker 1d according to the present embodiment. As illustrated in FIG. 7, the present embodiment is different from Embodiment 4 in that induction-heating cooker 1d includes electric current sensor 12c. The other elements in induction-heating cooker 1d are the same as those in induction-heating cooker 1c according to Embodiment 4.

[0093] Electric current sensor 12c is disposed between resonant capacitor 8c and the negative output terminal of the direct-current power supply and is connected in series to resonant capacitor 8c. Electric current sensor 12c detects an electric current flowing through resonant capacitor 8c and transmits the value of the detected electric current to controller

10.

[0094] According to the present embodiment, sensing the electric current flowing through each of resonant circuits 9a, 9b, for example, enables controller 10 to determine the material of the pot placed on top plate 2. Controller 10 can automatically select and implement one of the first and second heating modes according to the material of the pot.

[0095] Electric current sensor 12c may be disposed between resonant capacitor 8d and the positive output terminal of the direct-current power supply or between resonant capacitors 8c, 8d. Voltage sensors may be disposed instead of electric current sensors 12a, 12b, 12c.

EMBODIMENT 6

[0096] Hereinafter, Embodiment 6 of the present disclosure will be described. FIG. 8 is a block diagram of induction-heating cooker 1e according to the present embodiment. As illustrated in FIG. 8, the present embodiment is different from Embodiment 1 in that induction-heating cooker 1e does not include resonant capacitor 8d. The other elements in induction-heating cooker 1e are the same as those in induction-heating cooker 1a according to Embodiment 1.

[0097] In the present embodiment, resonant capacitor 8c connected between the negative output terminal of the direct-current power supply and the connection point between heating coils 3a, 3b corresponds to a third capacitor.

[0098] According to the present embodiment, substantially the same advantageous effects as those obtained in Embodiment 1 can be obtained with a simpler configuration.

EMBODIMENT 7

[0099] Hereinafter, Embodiment 7 of the present disclosure will be described. FIG. 9 is a block diagram of induction-heating cooker 1f according to the present embodiment. As illustrated in FIG. 9, the present embodiment is different from Embodiment 6 in that resonant capacitor 8c is connected between the positive output terminal of the direct-current power supply and the connection point between heating coils 3a, 3b. The other elements in induction-heating cooker 1f are the same as those in induction-heating cooker 1a according to Embodiment 1.

[0100] In the present embodiment, resonant capacitor 8c connected between the positive output terminal of the direct-current power supply and the connection point between heating coils 3a, 3b corresponds to the third capacitor.

[0101] According to the present embodiment, substantially the same advantageous effects as those obtained in Embodiment 1 can be obtained with a simpler configuration.

EMBODIMENT 8

[0102] Hereinafter, Embodiment 8 of the present disclosure will be described. FIG. 10 is a block diagram of induction-heating cooker 1g according to the present embodiment. As illustrated in FIG. 10, the present embodiment is different from Embodiment 1 in that induction-heating cooker 1g includes coils 13a, 13b. The other elements in induction-heating cooker 1g are the same as those in induction-heating cooker 1a according to Embodiment 1.

[0103] Coil 13a is disposed between the negative output terminal of the direct-current power supply and the connection point between heating coils 3a, 3b and is connected in series to resonant capacitor 8c. Coil 13b is disposed between the positive output terminal of the direct-current power supply and the connection point between heating coils 3a, 3b and is connected in series to resonant capacitor 8d. Coil 13a and coil 13b correspond to a first coil and a second coil, respectively.

[0104] According to the present embodiment, the impedance of inverter unit 5 can be changed, and thus losses at semiconductor elements can be reduced. Pots with various loads can be heated with high power.

EMBODIMENT 9

[0105] Hereinafter, Embodiment 9 of the present disclosure will be described. FIG. 11 is a block diagram of induction-heating cooker 1h according to the present embodiment. As illustrated in FIG. 11, the present embodiment is different from Embodiment 1 in that heating coil unit 3 further includes heating coils 3c, 3d. The other elements in induction-heating cooker 1h are the same as those in induction-heating cooker 1a according to Embodiment 1.

[0106] Heating coil 3c is disposed between the negative output terminal of the direct-current power supply and the connection point between heating coils 3a, 3b and is connected in series to resonant capacitor 8c. Heating coil 3d is disposed between the positive output terminal of the direct-current power supply and the connection point between heating coils 3a, 3b and is connected in series to resonant capacitor 8d.

[0107] Heating coils 3c, 3d are disposed between heating coils 3a, 3b, in proximity to heating coils 3a, 3b. Heating coil 3c and heating coil 3d correspond to a third heating coil and a fourth heating coil, respectively.

[0108] According to the present embodiment, coil 13a and coil 13b in Embodiment 8 are replaced by heating coil 3c

and heating coil 3d, respectively, and thus losses at coils 13a, 13b can be used for heating, enabling an increase in heating efficiency.

[0109] An increase in the number of heating coils enables more even heating of pots of various shapes. When heating coils 3c, 3d are provided, a load can be detected using heating coils 3c, 3d. This makes it possible to more easily detect displacement of a pot. As a result of providing heating coils 3c, 3d, losses can be dispersed.

INDUSTRIAL APPLICABILITY

[0110] The present disclosure is applicable to induction-heating cookers for household use and commercial use.

REFERENCE MARKS IN THE DRAWINGS

[0111]

1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h	induction-heating cooker
2	top plate
3	heating coil unit
3a, 3b, 3c, 3d	heating coil
4	utility power supply
5	inverter unit
6	smoothing circuit
7a, 7b, 7c, 7d	switching element
8a, 8b, 8c, 8d	resonant capacitor
9a, 9b	resonant circuit
10	controller
11	switch unit
12a, 12b, 12c	electric current sensor
13a, 13b	coil

Claims

1. An induction-heating cooker, comprising:

a direct-current power supply;
 a first switching element and a second switching element connected in series between output terminals of the direct-current power supply;
 a third switching element and a fourth switching element connected in series between the output terminals of the direct-current power supply;
 a first resonant circuit including a first heating coil and a first resonant capacitor connected in series, the first resonant circuit having one end connected to a connection point between the first switching element and the second switching element;
 a second resonant circuit including a second heating coil and a second resonant capacitor connected in series, the second resonant circuit having one end connected to a connection point between the third switching element and the fourth switching element and the other end connected to the other end of the first resonant circuit;
 a third resonant capacitor connected between one of a positive output terminal and a negative output terminal of the direct-current power supply and a connection point between the first resonant circuit and the second resonant circuit; and
 a controller configured to control the first switching element, the second switching element, the third switching element, and the fourth switching element.

2. The induction-heating cooker according to claim 1, further comprising:

a fourth resonant capacitor connected between the positive output terminal of the direct-current power supply and the connection point between the first resonant circuit and the second resonant circuit, wherein the third resonant capacitor is connected between the negative output terminal of the direct-current power supply and the connection point between the first resonant circuit and the second resonant circuit.

3. The induction-heating cooker according to claim 1, further comprising:

a switch unit, wherein

the controller outputs a first control signal to the first switching element and outputs a second control signal to the second switching element, and

the switch unit is configured to cause a transition between a state in which the first control signal is further output to the third switching element and the second control signal is further output to the fourth switching element and a state in which the first control signal is further output to the fourth switching element and the second control signal is further output to the third switching element.

4. The induction-heating cooker according to claim 1, further comprising:

one of an electric current sensor and a voltage sensor that is connected in series to the first resonant circuit; and one of an electric current sensor and a voltage sensor that is connected in series to the second resonant circuit.

5. The induction-heating cooker according to claim 4, further comprising:

one of an electric current sensor and a voltage sensor that is connected in series to the third resonant circuit.

6. The induction-heating cooker according to claim 1, wherein

the controller is configured to, while setting dead time, alternately turn on and off the first switching element and the second switching element and alternately turn on and off the third switching element and the fourth switching element, the controller is configured to, when an object to be heated is made of a non-magnetic material, implement a first heating mode in which the first switching element and the third switching element are simultaneously turned on and the second switching element and the fourth switching element are simultaneously turned on, and

the controller is configured to, when the object to be heated is made of a magnetic material, implement a second heating mode in which the first switching element and the fourth switching element are simultaneously turned on and the second switching element and the third switching element are simultaneously turned on.

7. The induction-heating cooker according to claim 1, wherein

the controller is configured to, while setting dead time, alternately turn on and off the first switching element and the second switching element and alternately turn on and off the third switching element and the fourth switching element, the controller is configured to implement a first heating mode in which the first switching element and the third switching element are simultaneously turned on and the second switching element and the fourth switching element are simultaneously turned on,

the controller is configured to implement a second heating mode in which the first switching element and the fourth switching element are simultaneously turned on and the second switching element and the third switching element are simultaneously turned on, and

the controller is configured to alternately implement the first heating mode and the second heating mode.

8. The induction-heating cooker according to claim 2, further comprising:

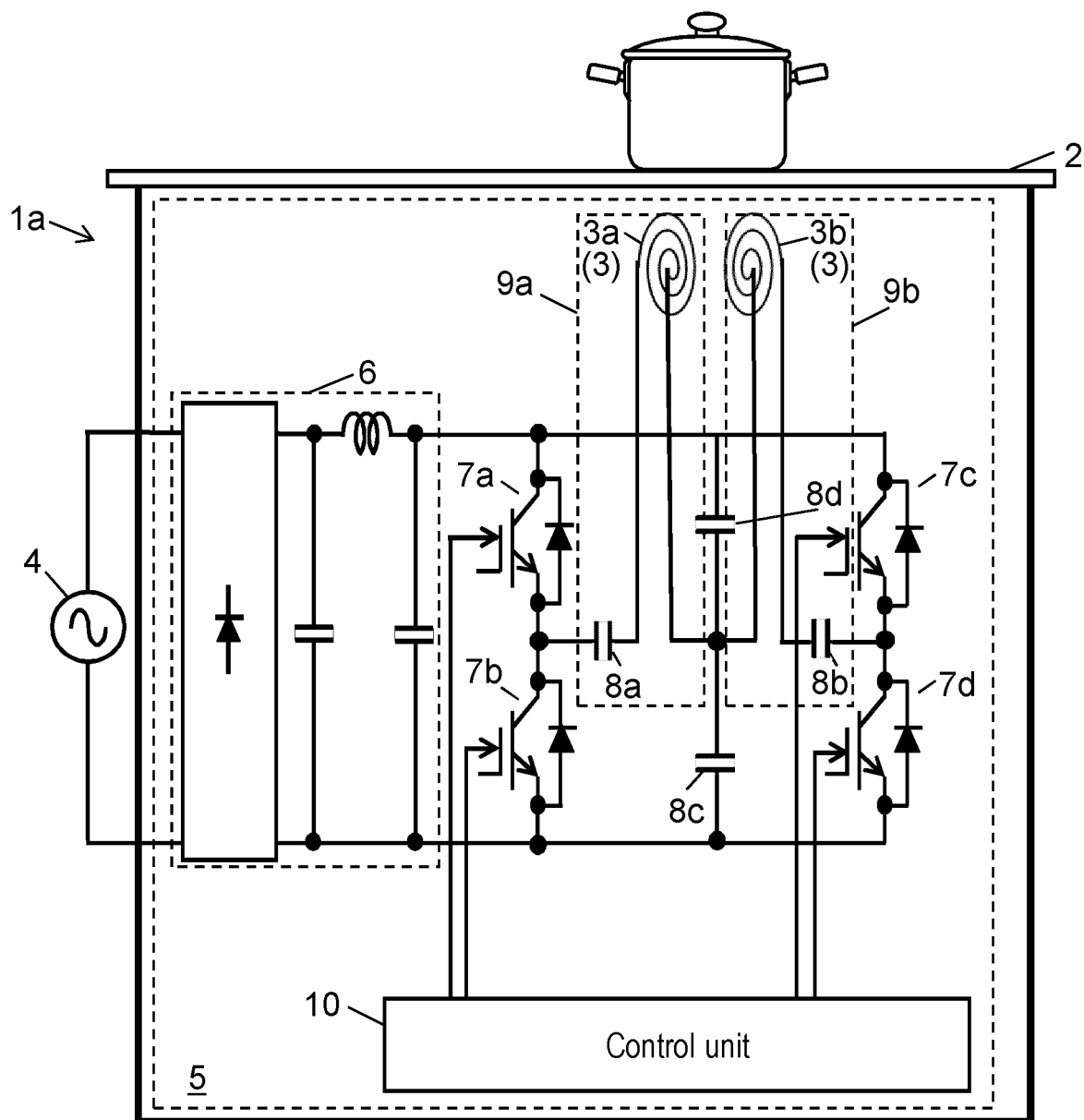
a first coil disposed between the negative output terminal of the direct-current power supply and the connection point between the first resonant circuit and the second resonant circuit, the first coil being connected in series to the third resonant capacitor; and

a second coil disposed between the positive output terminal of the direct-current power supply and the connection point between the first resonant circuit and the second resonant circuit, the second coil being connected in series to the fourth resonant capacitor.

9. The induction-heating cooker according to claim 8, wherein

the first coil is a third heating coil, and the second coil is a fourth heating coil.

FIG. 1



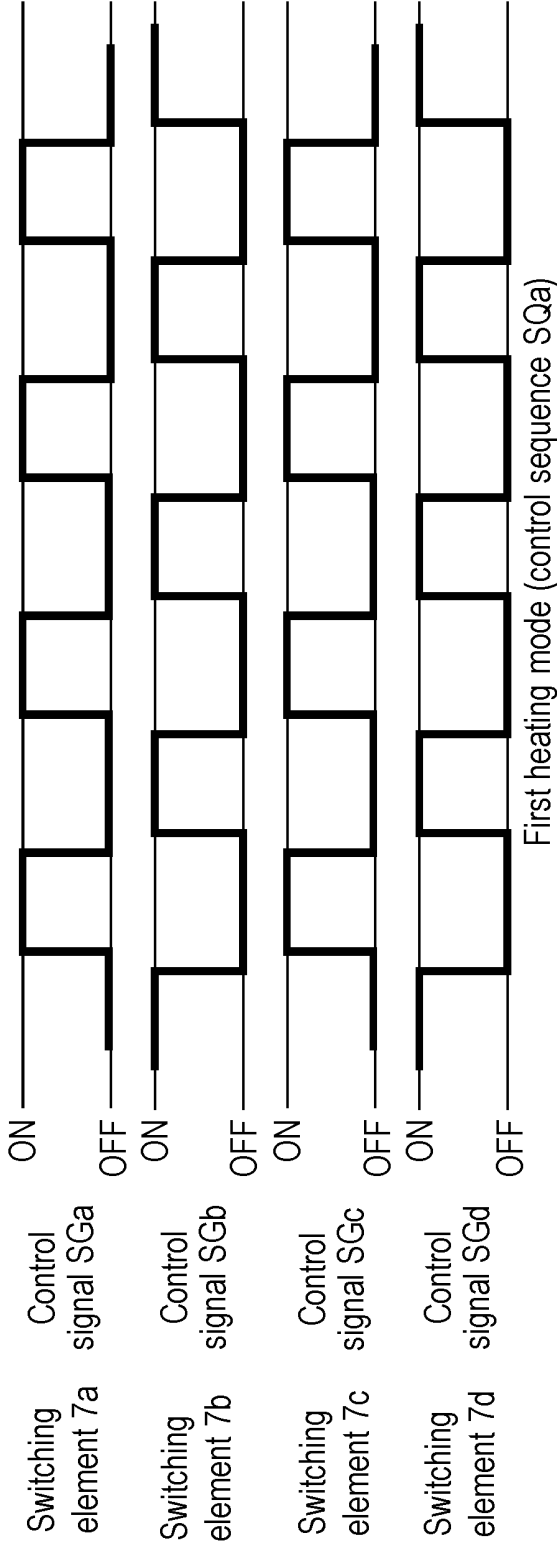


FIG. 2A

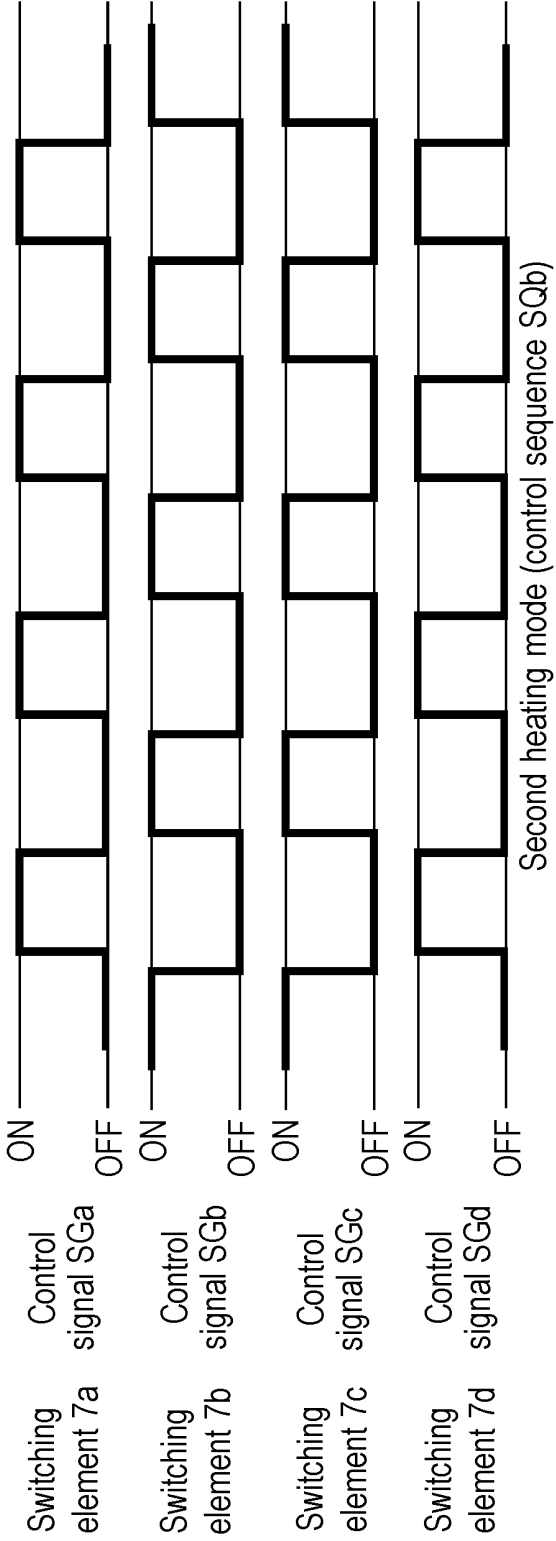
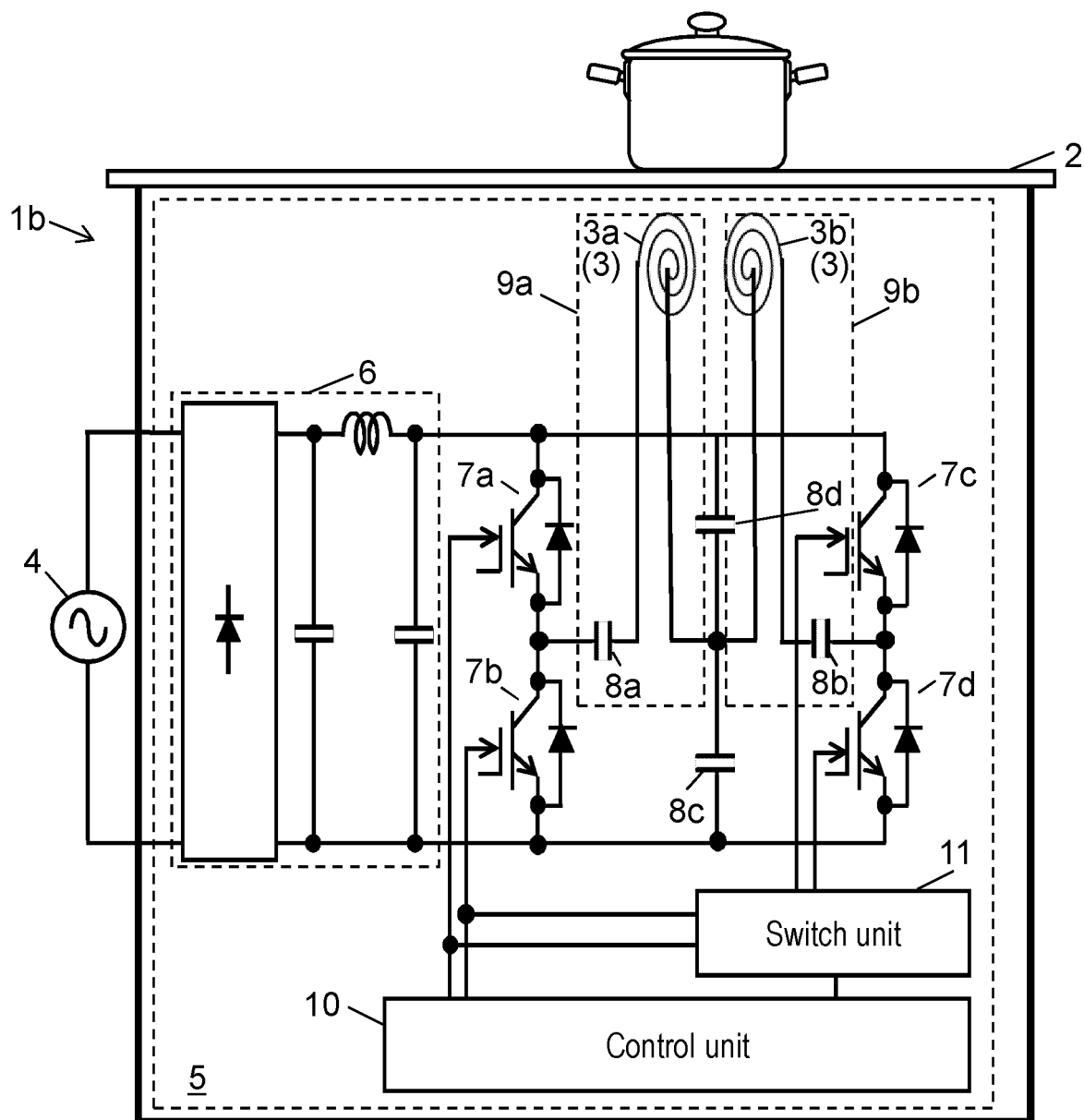


FIG. 2B

FIG. 3



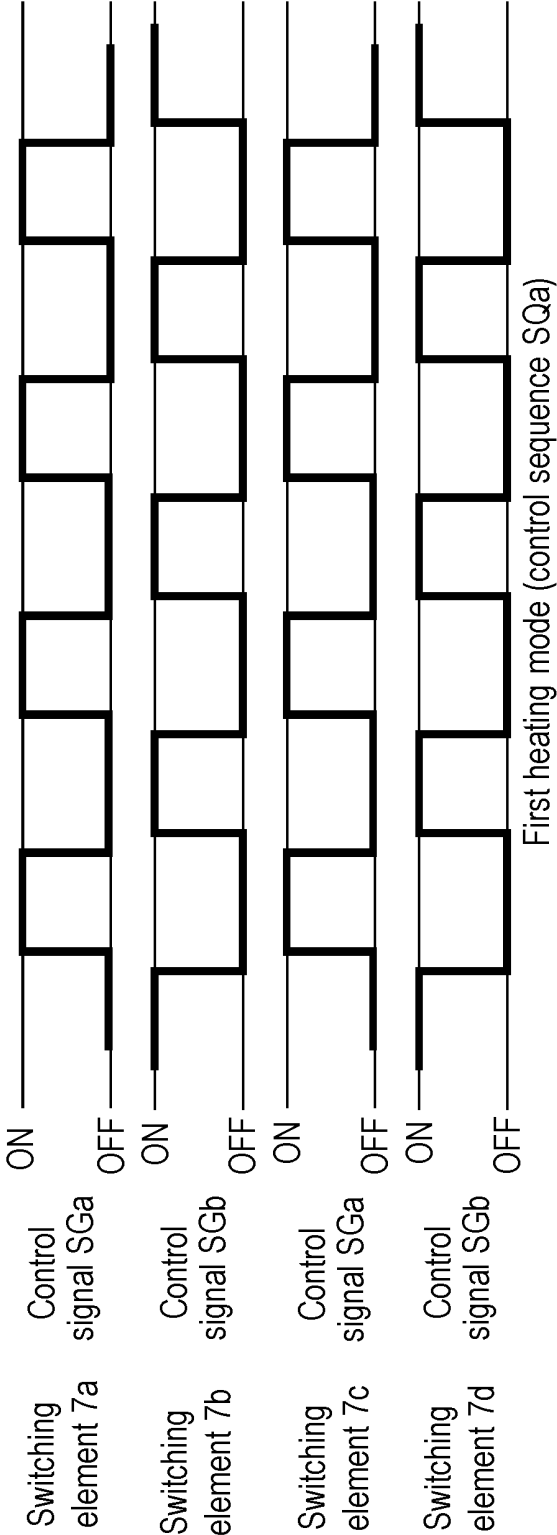


FIG. 4A

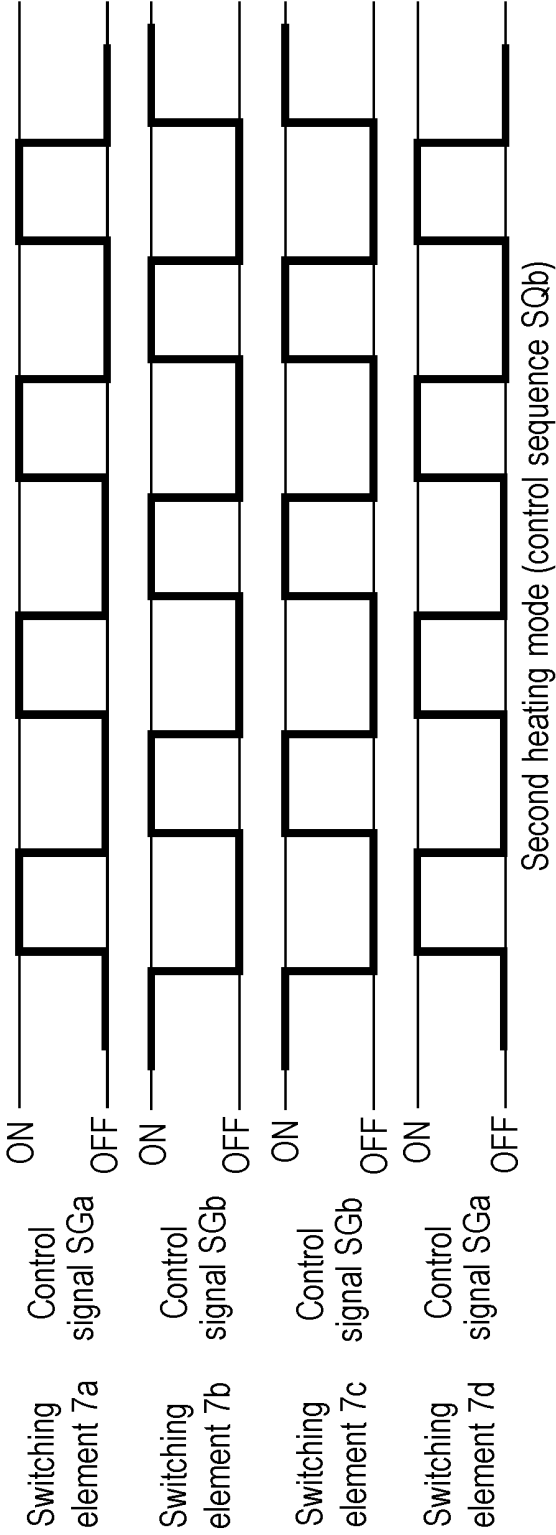


FIG. 4B

FIG. 5

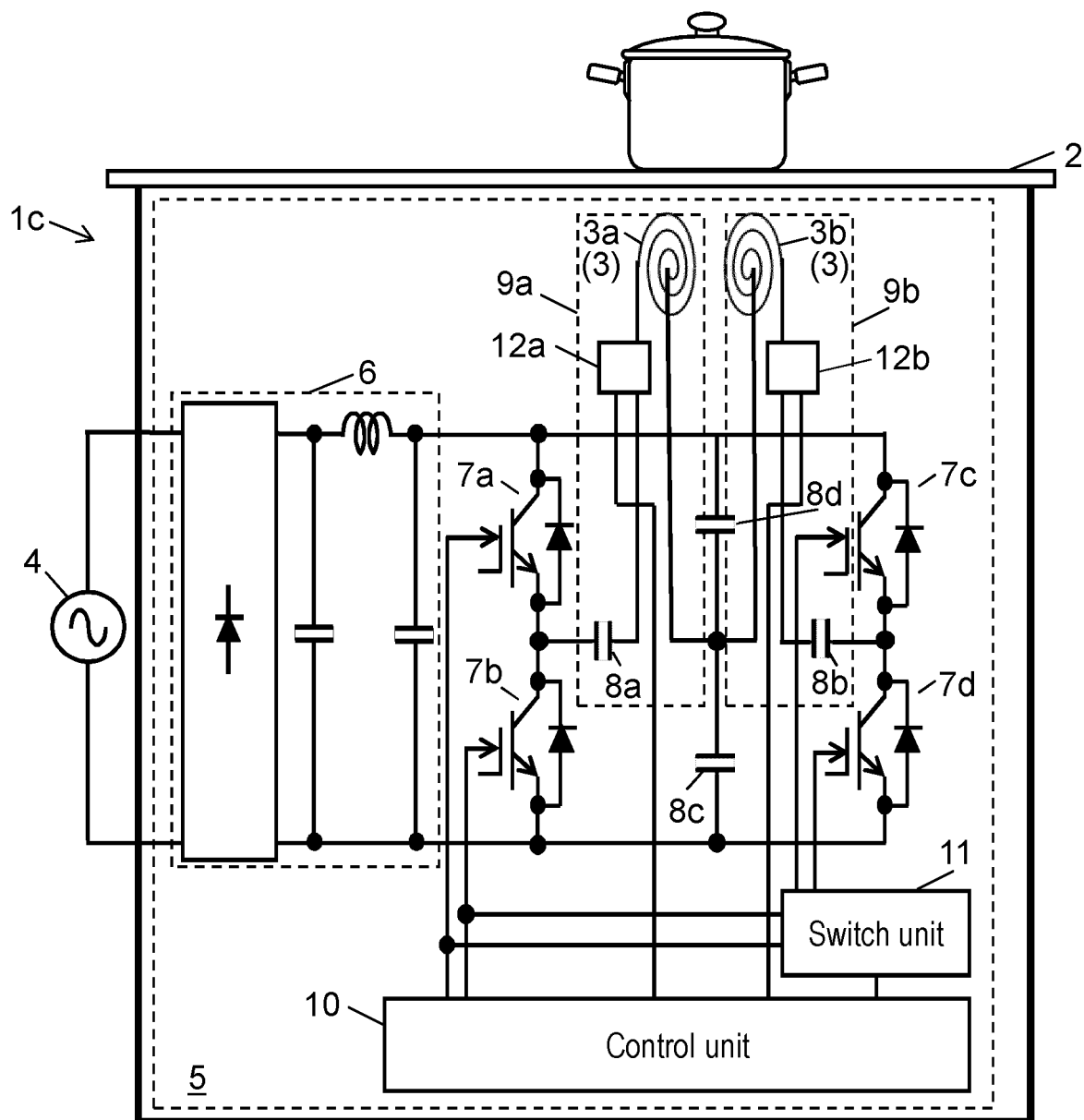


FIG. 6

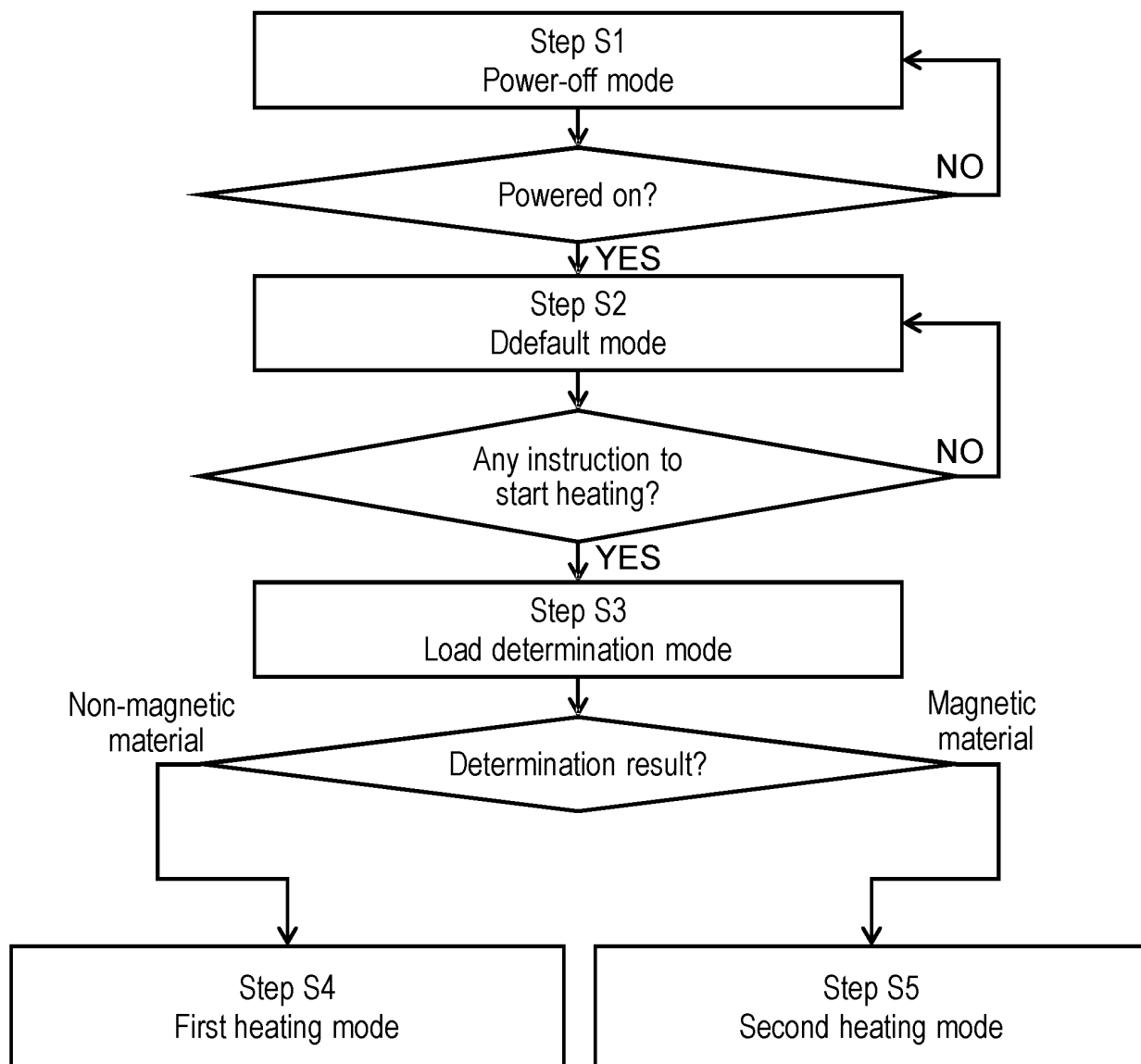


FIG. 7

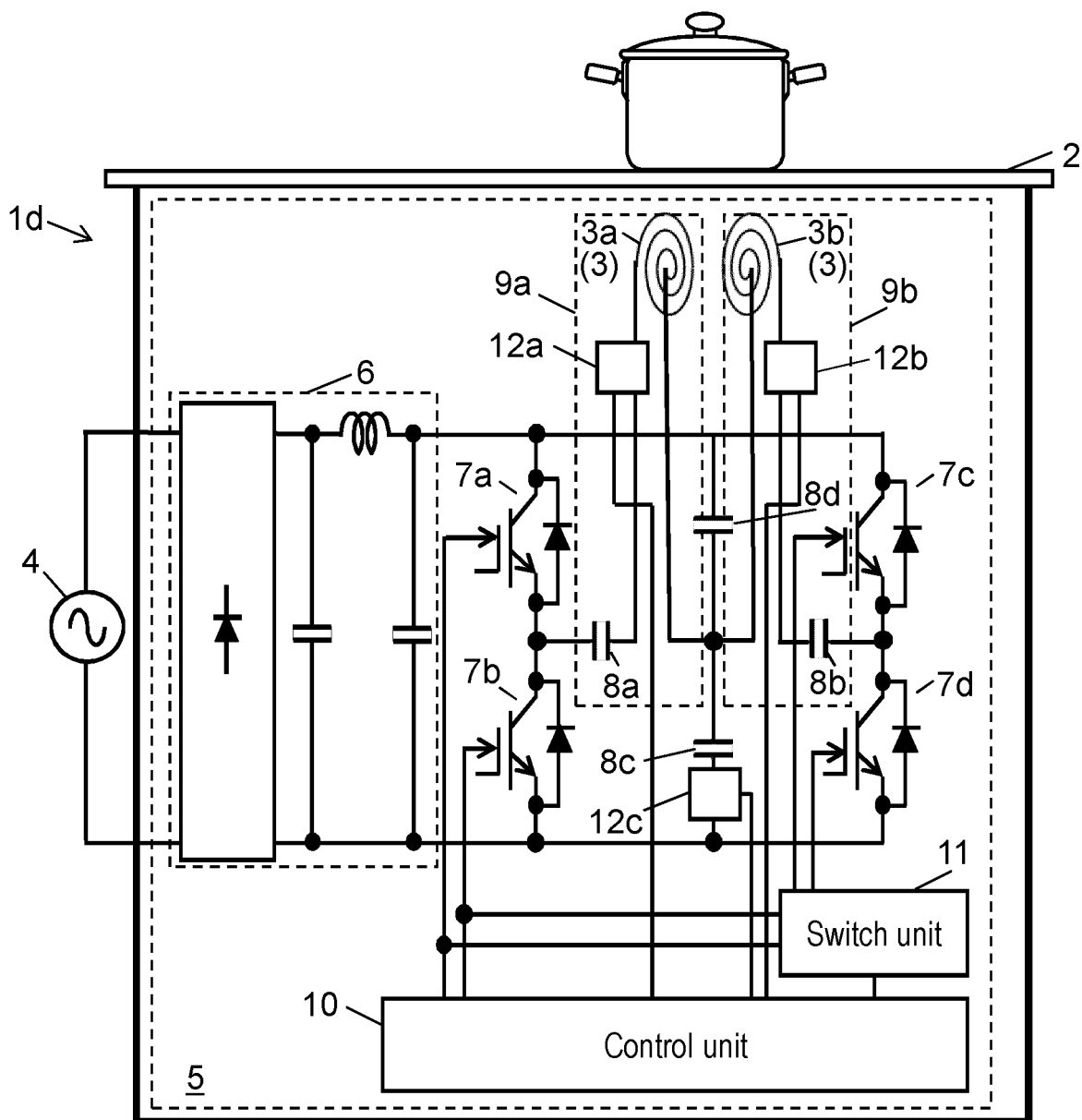


FIG. 8

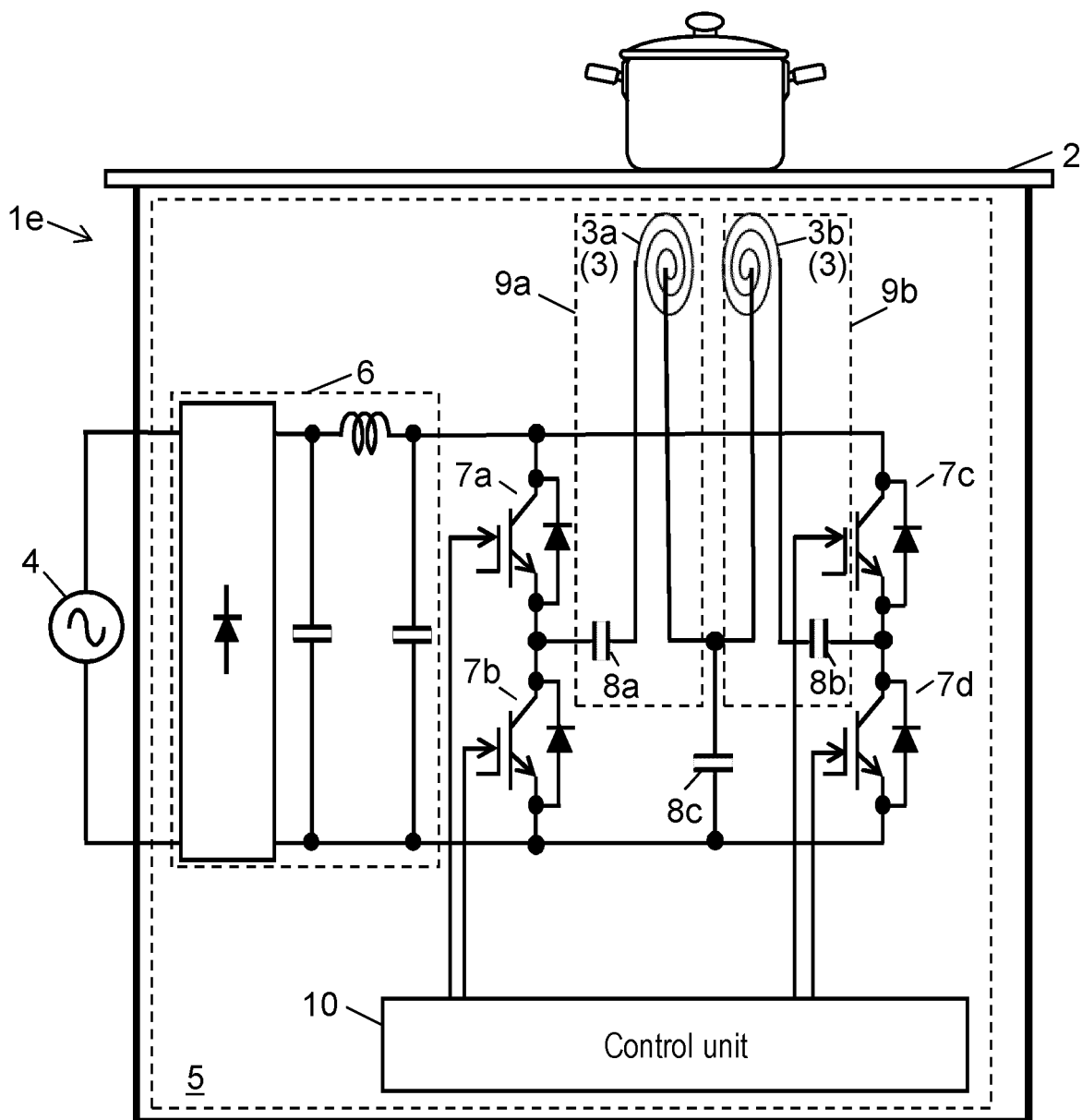


FIG. 9

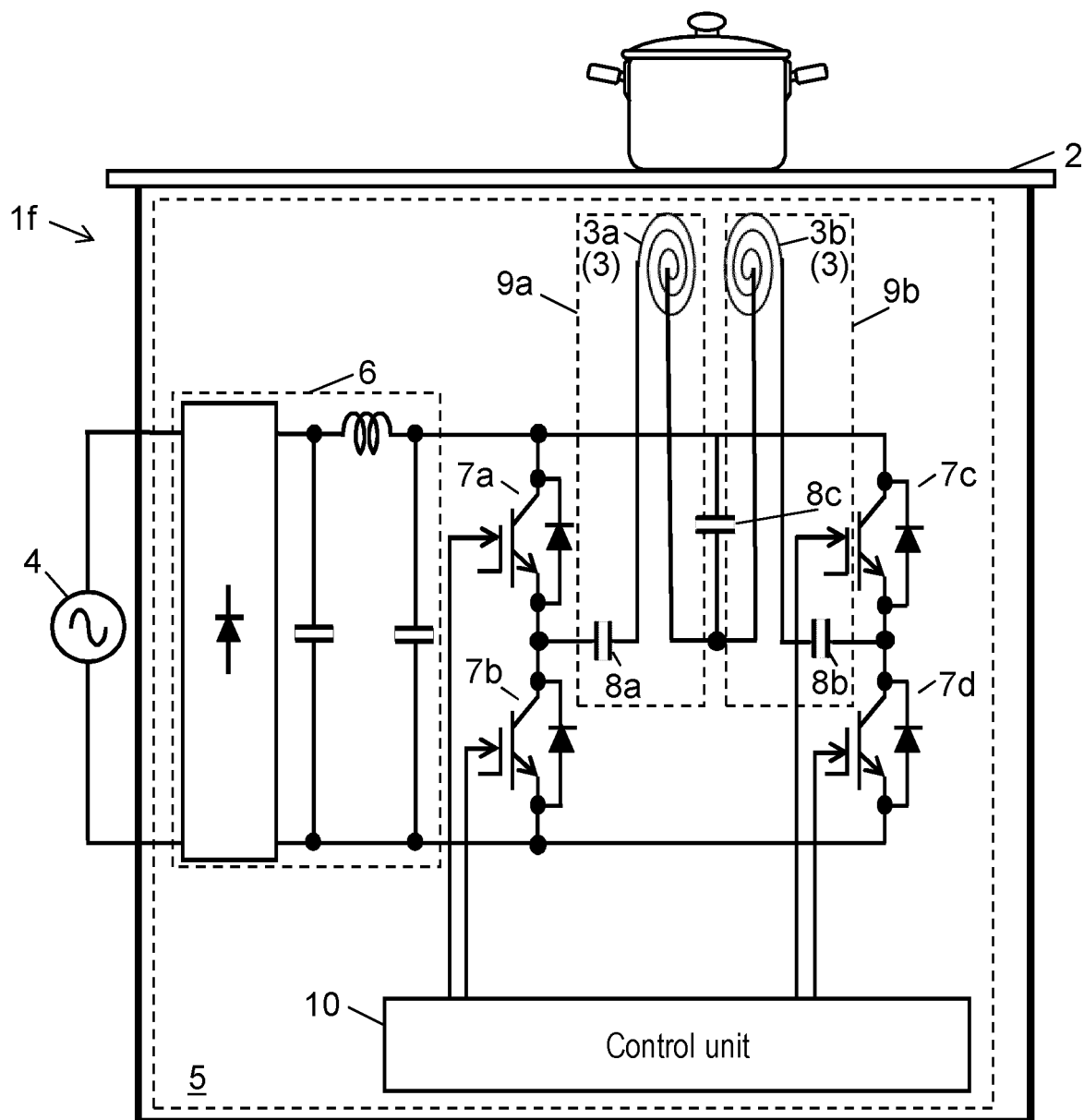


FIG. 10

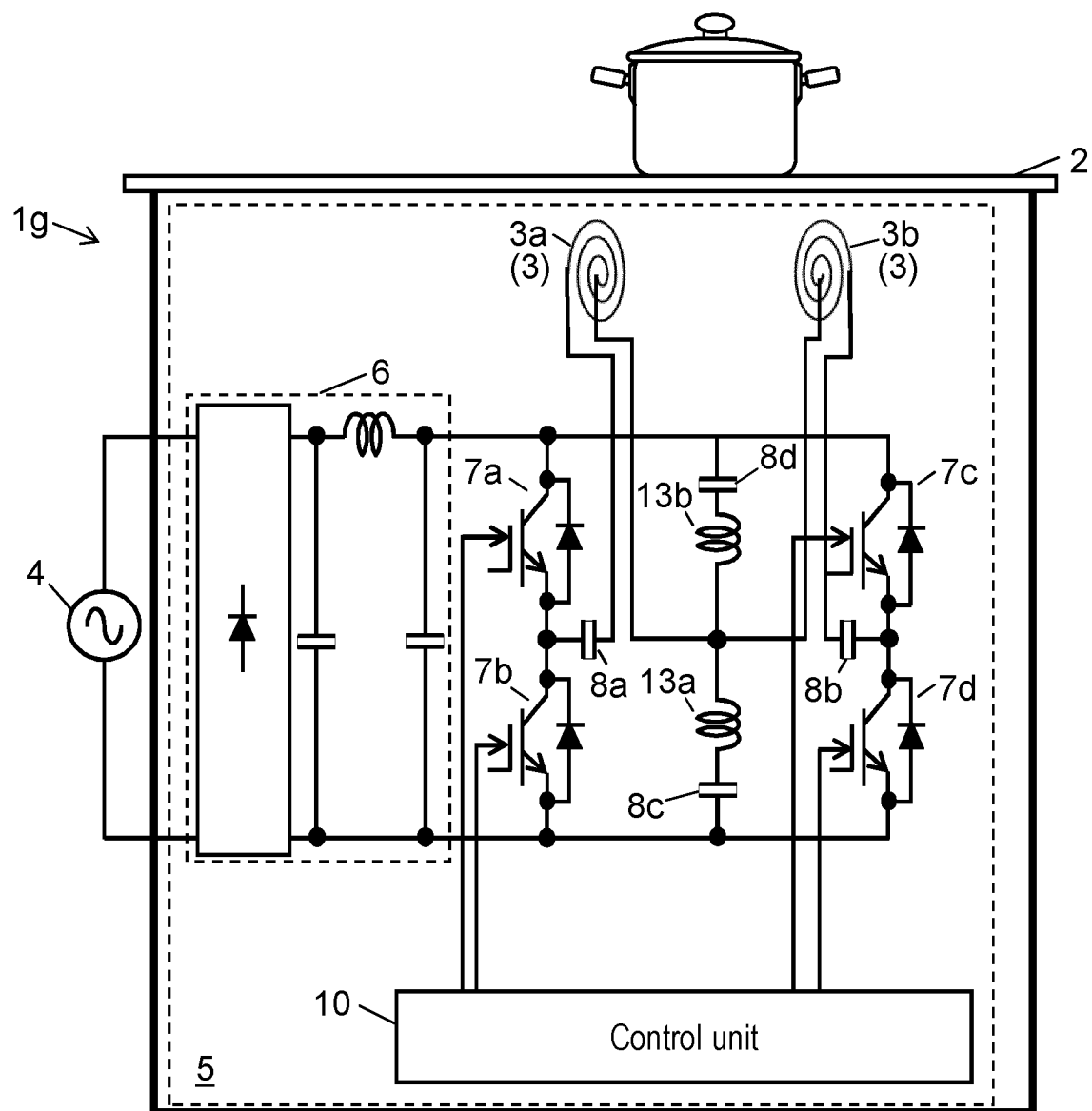
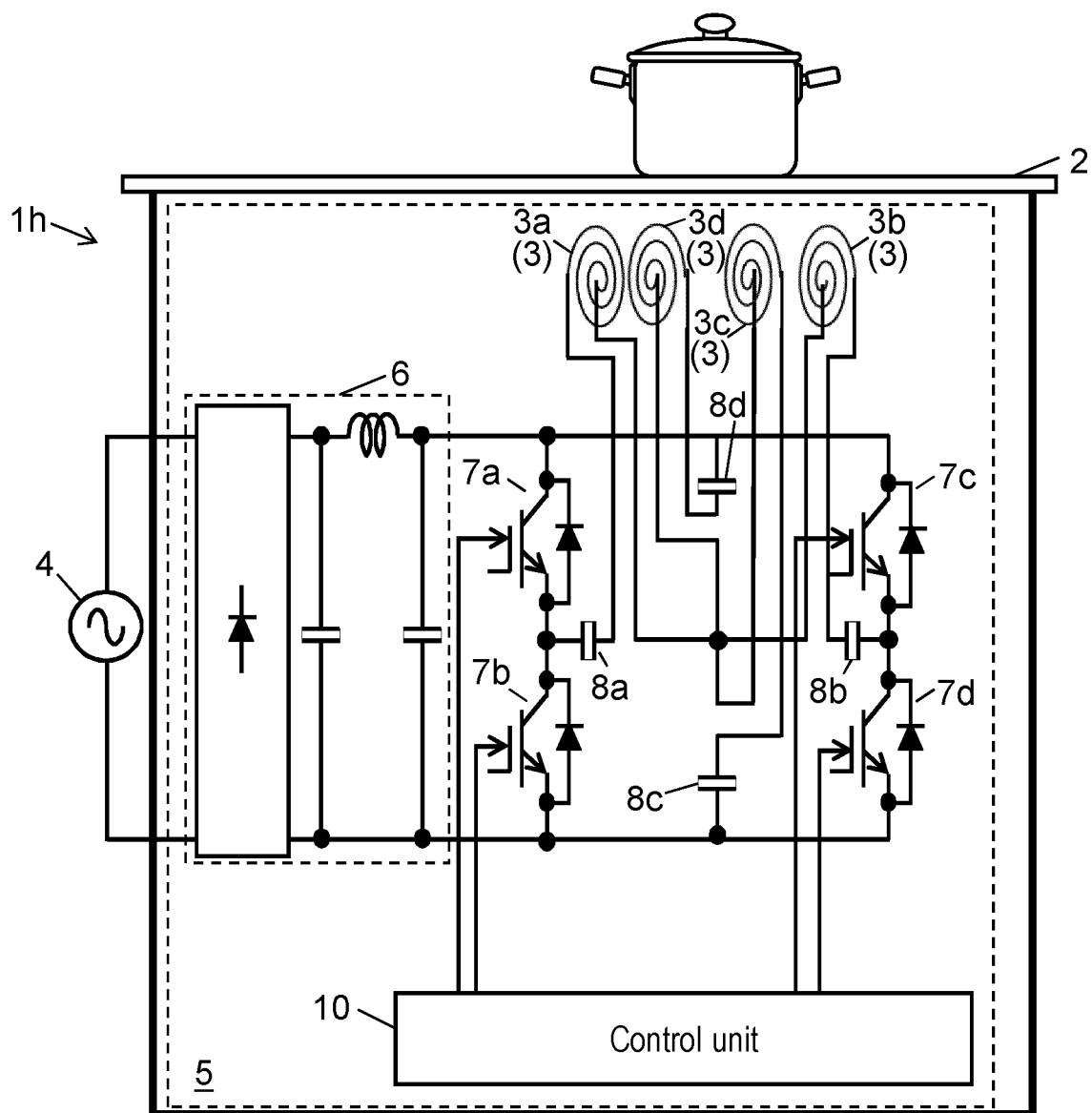


FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/027581

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. 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)

Int.Cl. H05B6/12

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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.
A	JP 2007-12482 A (MITSUBISHI ELECTRIC CORP.) 18 January 2007, paragraphs [0049]-[0063], fig. 23, 26, 31 (Family: none)	1-9
A	JP 2013-149470 A (PANASONIC CORP.) 01 August 2013, paragraph [0073] (Family: none)	1-9
A	JP 2013-229346 A (PANASONIC CORP.) 07 November 2013, paragraphs [0067]-[0074], fig. 13 (Family: none)	1-9

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search
04 October 2018 (04.10.2018)Date of mailing of the international search report
23 October 2018 (23.10.2018)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2008010165 A [0004]