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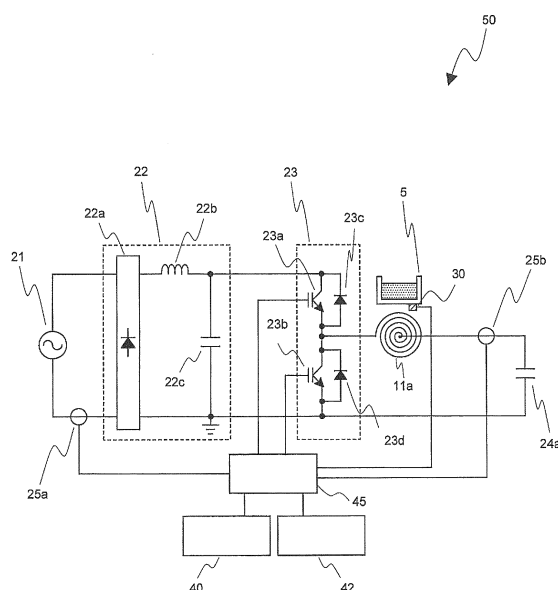
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(54) **INDUCTION HEAT COOKER**

(57) An inverter circuit 23 is driven in accordance with a result of determination by load determining means. While a driving frequency for the inverter circuit 23 is fixed, a variation in input current or coil current per predetermined time period is obtained. A change in temperature of a target 5 is detected based on the variation per predetermined time period.

FIG. 2



Description

Technical Field

[0001] The present invention relates to an induction heating cooker.

Background Art

[0002] Some of conventional-art induction heating cookers determine the temperature of a target which is being heated on the basis of an input current to an inverter or a control amount.

[0003] For example, a recently developed induction heating cooker of this type includes control means for controlling an inverter so that an input current to the inverter becomes constant, determines there is a large change in temperature of a target when a control amount has changed by a predetermined amount or more during a predetermined time period, and reduces output power of the inverter (see, for example, Patent Literature 1).

[0004] For example, another recently developed induction heating cooker of this type includes a temperature detecting device that includes input current variation detecting means for detecting only a variation in input current and temperature determining means for determining a temperature corresponding to the detected variation in input current (see, for example, Patent Literature 2).

Citation List

Patent Literature

[0005]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2008-181892 (pp. 3-5, Fig. 1)

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 5-62773 (pp. 2-3, Fig. 1)

Summary of Invention

Technical Problem

[0006] The induction heating cooker disclosed in Patent Literature 1 controls a driving frequency for the inverter so that input power becomes constant, and determines a change in temperature of the target on the basis of a variation (Δf) in this control amount. The variation (Δf) in this control amount, the driving frequency, may be too small depending on material of a target. Disadvantageously, a change in temperature of the target may fail to be detected.

[0007] In the temperature detecting device of the induction heating cooker disclosed in Patent Literature 2, when a target which is being heated is changed to an-

other target of a material different from that of the target, an excessive input current may be provided depending on driving frequency for the inverter. Unfortunately, the inverter may excessively rise in temperature and be damaged.

[0008] The present invention has been made to overcome the above-described disadvantages and provides an induction heating cooker capable of sensing a change in temperature of a target regardless of the material of the target. The induction heating cooker according to the present invention suppresses an increase in input current and exhibits high reliability.

Solution to Problem

[0009] The induction heating cooker according to the present invention includes a heating coil that induction-heats a target, a drive circuit that supplies high frequency power to the heating coil, load determining means for performing a process of determining a load on the heating coil, and a control unit that controls driving of the drive circuit to control the high frequency power supplied to the heating coil. The control unit is configured to drive the drive circuit in accordance with a result of determination by the load determining means. The control unit is configured to obtain a variation per predetermined time period in at least one of input current to the drive circuit and coil current flowing through the heating coil while fixing a driving frequency for the drive circuit. The control unit is configured to sense a change in temperature of the target based on the variation per predetermined time period. Advantageous Effects of Invention

[0010] According to the present invention, a change in temperature of a target can be sensed regardless of the material of the target. Furthermore, an increase in input current can be suppressed, thus enhancing reliability.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is an exploded perspective view of an induction heating cooker according to Embodiment 1.

[Fig. 2] Fig. 2 is a diagram illustrating a drive circuit of the induction heating cooker according to Embodiment 1.

[Fig. 3] Fig. 3 is a characteristic diagram to determine a load on the target based on the relationship between heating coil current and input current in the induction heating cooker according to Embodiment 1.

[Fig. 4] Fig. 4 is a diagram illustrating the correlation between input current and driving frequency in the induction heating cooker according to Embodiment 1 during change of the temperature of the target.

[Fig. 5] Fig. 5 is an enlarged view of part indicated by a dotted line in Fig. 4.

[Fig. 6] Fig. 6 includes diagrams illustrating the relationship between driving frequency and time, the relationship between temperature and time, and the relationship between input current and time in the induction heating cooker according to Embodiment 1.

[Fig. 7] Fig. 7 is an enlarged view of the part indicated by the dotted line in Fig. 4.

[Fig. 8] Fig. 8 includes diagrams illustrating the relationship between the driving frequency and the time, the relationship between the temperature and the time, and the relationship between the input current and the time in the induction heating cooker according to Embodiment 1.

[Fig. 9] Fig. 9 is a diagram illustrating another drive circuit of the induction heating cooker according to Embodiment 1.

[Fig. 10] Fig. 10 includes diagrams illustrating the relationship between driving frequency and time, the relationship between temperature and time, and the relationship between input current and time in an induction heating cooker according to Embodiment 2.

[Fig. 11] Fig. 11 is a diagram illustrating part of a drive circuit of an induction heating cooker according to Embodiment 3.

[Fig. 12] Fig. 12 includes diagrams illustrating examples of driving signals for a half-bridge circuit in Embodiment 3.

[Fig. 13] Fig. 13 is a diagram illustrating part of a drive circuit of an induction heating cooker according to Embodiment 4.

[Fig. 14] Fig. 14 includes diagrams illustrating examples of driving signals for full-bridge circuits in Embodiment 4.

Description of Embodiments

Embodiment 1

(Configuration)

[0012] Fig. 1 is an exploded perspective view of an induction heating cooker according to Embodiment 1.

[0013] As illustrated in Fig. 1, an induction heating cooker 100 includes a top panel 4 on which a target 5, such as a pan, is placed. The top panel 4 is disposed in upper part of the induction heating cooker 100. The top panel 4 has a first heating zone 1, a second heating zone 2, and a third heating zone 3 for induction-heating the target 5 and includes first heating means 11, second heating means 12, and third heating means 13 corresponding to the respective heating zones such that the target 5 can be placed on each heating zone and be induction heated.

[0014] In Embodiment 1, the first heating means 11 and the second heating means 12 are laterally arranged adjacent to a front surface of a body and the third heating means 13 is disposed in substantially the middle of the

body adjacent to a rear surface of the body.

[0015] The heating zones may be arranged in other patterns. For example, the three heating zones may be arranged laterally and substantially linearly. The center of the first heating means 11 may be provided in a position different in a direction along the depth from the center of the second heating means 12 in a direction along the depth.

[0016] The top panel 4 is made entirely of a material that permits infrared rays to pass therethrough, for example, heat-resistant tempered glass or crystallized glass. The top panel 4 is fixed to an opened upper surface of the body of the induction heating cooker 100 in a watertight manner such that a rubber gasket or a seal is disposed between the top panel 4 and an outer edge of the opened upper surface. Disk-shaped pan position indicators each indicating a general placement position for a pan are painted or printed on the top panel 4 such that the indicators correspond to heating ranges (heating zones) of the first heating means 11, the second heating means 12, and the third heating means 13.

[0017] An operation unit 40a, an operation unit 40b, and an operation unit 40c (which may also be collectively referred to as "operation units 40" hereinafter) are arranged adjacent to a front end of the top panel 4 so as to correspond to the first heating means 11, the second heating means 12, and the third heating means 13, respectively. The operation units 40a, 40b, and 40c each function as an input unit to set heating power for heating the target 5 through the heating means or a cooking menu (e.g., boiling mode or fry mode). A display unit 41 a, a display unit 41 b, and a display unit 41 c to display an operating condition of the induction heating cooker 100 or information about an input operation from the operation unit 40 are arranged, as notifying means 42, near the operation units 40. The operation units 40a to 40c and the display units 41 a to 41 c may be arranged in other patterns. For example, the operation unit 40 and the display unit 41 may be arranged for each or all of the heating zones.

[0018] The first heating means 11, the second heating means 12, and the third heating means 13 are arranged under the top panel 4 within the body. Each heating means includes a heating coil (not illustrated).

[0019] The body of the induction heating cooker 100 accommodates drive circuits 50 to supply high frequency power to the heating coils in the first heating means 11, the second heating means 12, and the third heating means 13, and a control unit 45 to control the operation of the entire induction heating cooker including the drive circuits 50.

[0020] The control unit 45 in Embodiment 1 corresponds to a "control unit" and "load determining means" in the present invention.

[0021] Each heating coil is flat and substantially circular in shape and is formed of a circumferentially wound conductive wire of any metal (e.g., copper or aluminum) coated with an insulator. Each drive circuit 50 supplies

high frequency power to the corresponding heating coil, thus achieving an induction heating operation.

[0022] Fig. 2 is a diagram illustrating the drive circuit of the induction heating cooker according to Embodiment 1. The drive circuits 50 are provided for the respective heating means and have the same configuration. Fig. 2 illustrates only one drive circuit 50.

[0023] As illustrated in Fig. 2, the drive circuit 50 includes a DC power supply circuit 22, an inverter circuit 23, and a resonant capacitor 24a.

[0024] Input current detecting means 25a detects current input from an AC power supply (commercial power supply) 21 to the DC power supply circuit 22 and outputs a voltage signal corresponding to an input current to the control unit 45.

[0025] The DC power supply circuit 22 includes a diode bridge 22a, a reactor 22b, and a smoothing capacitor 22c. The DC power supply circuit 22 converts an AC voltage supplied from the AC power supply 21 to a DC voltage and outputs the DC voltage to the inverter circuit 23.

[0026] The inverter circuit 23 is what is called a half-bridge inverter that includes IGBTs 23a and 23b, serving as switching elements, connected in series with an output of the DC power supply circuit 22, and further includes diodes 23c and 23d, serving as flywheel diodes, connected in parallel with the IGBTs 23a and 23b. The inverter circuit 23 converts DC power output from the DC power supply circuit 22 to AC power having a high frequency ranging from approximately 20 kHz to approximately 50 kHz, and supplies the AC power to a resonant circuit including a heating coil 11 a and the resonant capacitor 24a.

[0027] Such a configuration allows a high frequency current on the order of several tens of amperes to flow through the heating coil 11 a. The target 5 placed on the top panel 4 just above the heating coil 11 a is induction heated by a high frequency magnetic flux generated by the flowing high frequency current. The IGBTs 23a and 23b, serving as switching elements, include a semiconductor containing silicon, for example. The IGBTs 23a and 23b may include a wide bandgap semiconductor, such as silicon carbide or gallium nitride.

[0028] Coil current detecting means 25b is connected between the heating coil 11 a and the resonant capacitor 24a. The coil current detecting means 25b detects, for example, the peak of the current flowing through the heating coil 11 a and outputs a voltage signal corresponding to a peak value of the current flowing through the coil to the control unit 45.

[0029] Temperature sensing means 30 is a thermistor, for example. The temperature sensing means 30 senses a temperature based on heat transferred from the target 5 to the top panel 4. The temperature sensing means 30 is not limited to a thermistor. Any sensor, such as an infrared sensor, may be used.

(Operations)

[0030] Operations of the induction heating cooker 100 according to Embodiment 1 will be described below.

[0031] An operation to induction heat the target 5 placed on any heating zone of the top panel 4 with heating power set through the operation unit 40 will now be described.

[0032] When a user places the target 5 on the heating zone and gives a heating start (power-on) instruction to the operation unit 40, the control unit 45 (load determining means) performs a load determining process.

[0033] Fig. 3 is a characteristic diagram to determine a load on the target on the basis of the relationship between the heating coil current and the input current in the induction heating cooker according to Embodiment 1.

[0034] The materials, serving as loads, of targets 5 (pans) are classified broadly into a magnetic material, such as iron or SUS 430, a high-resistance nonmagnetic material, such as SUS 304, and a low-resistance nonmagnetic material, such as aluminum or copper.

[0035] As illustrated in Fig. 3, the relationship between the coil current and the input current varies depending on the material, serving as a load, of a pan placed on the top panel 4. The control unit 45 previously stores therein a load determination table illustrating the relationship between the coil current and the input current illustrated in Fig. 3. Since the control unit 45 stores the load determination table therein, the load determining means can be configured with low cost.

[0036] In the load determining process, the control unit 45 drives the inverter circuit 23 in accordance with a specific driving signal for load determination, and detects an input current from an output signal of the input current detecting means 25a. The control unit 45, at the same time, detects a coil current from an output signal of the coil current detecting means 25b. The control unit 45 determines the material of the placed target (pan) 5 on the basis of the detected input current, the detected coil current, and the load determination table illustrating the relationship of Fig. 3. The control unit 45 (load determining means) determines the material of the target 5 placed above the heating coil 11 a on the basis of the correlation between the input current and the coil current in the above-described manner.

[0037] After performing the above-described load determining process, the control unit 45 performs a control operation based on the result of load determination.

[0038] If the result of load determination indicates a low-resistance nonmagnetic material, the induction heating cooker 100 according to Embodiment 1 cannot heat the target 5. Accordingly, the notifying means 42 is allowed to notify information indicating that heating cannot be done, thus prompting the user to change the pan for another pan.

[0039] If the result of load determination indicates no load, the notifying means 42 is allowed to notify of information indicating that heating cannot be done, thus

prompting the user to place a pan.

[0040] If the result of load determination indicates a magnetic material or a high-resistance nonmagnetic material, a pan of such a material can be heated by the induction heating cooker 100 according to Embodiment 1. Accordingly, the control unit 45 determines a driving frequency suitable for the determined material of the pan. The driving frequency is higher than a resonant frequency so that an excessive input current is not caused. The driving frequency can be determined with reference to a table of frequencies depending on, for example, the material of the target 5 and set heating power.

[0041] The control unit 45 fixes the determined driving frequency and drives the inverter circuit 23 to start the induction heating operation. While the driving frequency is fixed, the ON duty (ON-OFF ratio) of the switching elements of the inverter circuit 23 is also fixed.

[0042] Fig. 4 is a diagram illustrating the correlation between the driving frequency and the input current during change of the temperature of the target heated by the induction heating cooker according to Embodiment 1. In Fig. 4, a thin line indicates the characteristic of the target 5 (pan) in a low temperature state and a thick line indicates the characteristic of the target 5 in a high temperature state.

[0043] A change in characteristic depending on the temperature of the target 5, as illustrated in Fig. 4, is due to an increase in resistivity of the target 5 caused by an increase in temperature and a change in magnetic coupling of the heating coil 11 a and the target 5 caused by a reduction in permeability.

[0044] The control unit 45 of the induction heating cooker 100 according to Embodiment 1 determines a driving frequency higher than a frequency at which a maximum input current illustrated in Fig. 4 is provided, fixes the determined driving frequency, and controls the inverter circuit 23 with the driving frequency being fixed.

[0045] Fig. 5 is an enlarged view of part indicated by a dotted line in Fig. 4.

[0046] In the control of the inverter circuit 23 with the driving frequency being fixed depending on the material of the pan determined by the above-described load determining process, an input current (operation point) at the driving frequency shifts from point A to point B as the temperature of the target 5 increases from a low temperature to a high temperature, so that the input current gradually decreases with increasing temperature of the target 5.

[0047] At that time, the control unit 45 obtains a variation (time variation) in input current per predetermined time period while the driving frequency for the inverter circuit 23 is fixed, and senses a change in temperature of the target 5 on the basis of the variation per predetermined time period.

[0048] Consequently, a change in temperature of the target 5 can be sensed regardless of the material of the target 5. Furthermore, since a change in temperature of the target 5 can be sensed on the basis of a variation in

input current, the change in temperature can be sensed more quickly than sensed using a temperature sensor or the like.

[0049] The material of the target 5 placed above the heating coil 11 a is determined, the driving frequency for the inverter circuit 23 is determined depending on the material of the target 5, and the inverter circuit 23 is driven with the determined driving frequency. Accordingly, the inverter circuit 23 can be fixedly driven with the driving frequency depending on the material of the target 5, so that an increase in input current can be suppressed. Thus, the likelihood of the inverter circuit 23 reaching a high temperature can be reduced, thus increasing reliability.

(Boiling Mode 1)

[0050] An operation performed when the boiling mode for boiling water in the target 5 is selected as a cooking menu (operation mode) through the operation unit 40 will now be described.

[0051] The control unit 45 performs the load determining process in the same way as in the above-described operation, determines a driving frequency depending on the determined material of the pan, fixes the determined driving frequency, and drives the inverter circuit 23 to perform the induction heating operation. The control unit 45 determines on the basis of a time variation in input current whether boiling has been completed. Elapsed time to boil water and a change in each of characteristics will now be described with reference to Fig. 6.

[0052] Fig. 6 includes diagrams illustrating the relationship between the driving frequency and the time, the relationship between the temperature and the time, and the relationship between the input current and the time in the induction heating cooker according to Embodiment 1. Fig. 6 illustrates a change in each of the characteristics plotted against the elapsed time to boil water in the target 5. Fig. 6(a) illustrates the driving frequency, Fig. 6(b) illustrates the temperature (water temperature), and Fig. 6(c) illustrates the input current.

[0053] The inverter circuit 23 is controlled with the driving frequency being fixed as illustrated in Fig. 6(a). Referring to Fig. 6(b), the temperature (water temperature) of the target 5 gradually rises until the water is boiling. After the water has been boiling, the temperature is constant. Referring to Fig. 6(c), the input current gradually decreases with increasing temperature of the target 5. When water is boiling and the temperature becomes constant, the input current also becomes constant. In other words, having been constant of input current means that the water has been boiling, namely, boiling has been completed.

[0054] As described above, the control unit 45 in Embodiment 1 obtains a variation (time variation) in input current per predetermined time period while the driving frequency for the inverter circuit 23 is fixed, and determines that boiling has been completed when the variation

per predetermined time period is less than or equal to a predetermined value.

[0055] Information about the predetermined value may be previously set in the control unit 45 or may be input through the operation unit 40 or the like.

[0056] The control unit 45 allows the notifying means 42 to notify the completion of boiling. The notifying means 42 may be of any type. For example, the notifying means 42 may allow the display unit 41 to display information indicating the completion of boiling or may allow a loud-speaker (not illustrated) to notify the user of the completion of boiling by sound or voice.

[0057] As described above, in the boiling mode for setting a water boiling operation, a variation in input current per predetermined time period is obtained while the driving frequency for the inverter circuit 23 is fixed, and when the variation per predetermined time period is less than or equal to the predetermined value, the notifying means 42 is allowed to notify of the completion of boiling.

[0058] Consequently, a notification indicating the completion of water boiling can be immediately provided, thus providing an induction heating cooker exhibiting ease of use.

(Boiling Mode 2)

[0059] Another control operation performed when the boiling mode is selected through the operation unit 40 will now be described.

[0060] The control unit 45 performs the load determining process in the same way as in the above-described operation, determines a driving frequency depending on the determined material of the pan, fixes the determined driving frequency, and drives the inverter circuit 23 to perform the induction heating operation. The control unit 45 determines on the basis of a time variation in input current whether boiling has been completed.

[0061] Furthermore, when the variation per predetermined time period obtained with the driving frequency being fixed for the inverter circuit 23 is less than or equal to the predetermined value, the control unit 45 cancels fixing the driving frequency and changes the driving frequency for the inverter circuit 23 to change the high frequency power supplied to the heating coil 11 a. This operation will be described in detail with reference to Figs. 7 and 8.

[0062] Fig. 7 is an enlarged view of the part indicated by the dotted line in Fig. 4.

[0063] Fig. 8 includes diagrams illustrating the relationship between the driving frequency and the time, the relationship between the temperature and the time, and the relationship between the input current and the time in the induction heating cooker according to Embodiment 1. Fig. 8 illustrates a change in each of the characteristics plotted against the elapsed time to boil water in the target 5. Fig. 8(a) illustrates the driving frequency, Fig. 8(b) illustrates the temperature (water temperature), and Fig. 8(c) illustrates the input current.

[0064] When the driving frequency is fixed and heating is started (Fig. 8(a)), the temperature (water temperature) of the target 5 gradually increases (Fig. 8(b)) until water is boiling in the same way as in the above-described boiling mode 1. In the control with the driving frequency being fixed, as illustrated in Fig. 7, an input current (operation point) at the driving frequency shifts from point E to point B. The input current gradually decreases with increasing temperature of the target 5.

[0065] When the water is boiling and the temperature becomes constant, the input current also becomes constant (Fig. 8(c)). Thus, the control unit 45 determines at time t1 that the variation in input current per predetermined time period has reached less than or equal to the predetermined value, thus determining that boiling has been completed.

[0066] Then, the control unit 45 cancels fixing the driving frequency and increases the driving frequency for the inverter circuit 23 to reduce the input current, thus reducing the high frequency power (heating power) supplied to the heating coil 11 a. At that time, when the heating power is reduced by increasing the driving frequency, the temperature falls little. Therefore, the operation point accordingly shifts (changes) from point B to point C as illustrated in Fig. 7.

[0067] The control unit 45 again fixes the driving frequency for the inverter circuit 23 and continues heating with the reduced heating power.

[0068] In boiling (water boiling), if the heating power is increased to be higher than necessary, the temperature of water will not exceed 100 degrees C. If the heating power is reduced by increasing the driving frequency, therefore, the water temperature can be maintained.

[0069] As described above, when a variation in input current per predetermined time period is less than or equal to the predetermined value, driving of the inverter circuit 23 is controlled to reduce the high frequency power supplied to the heating coil 11 a. Thus, input power is reduced, thus achieving energy saving.

[0070] At time t1, the control unit 45 increases the driving frequency for the inverter circuit 23 and allows the notifying means 42 to notify the user of the completion of boiling. A notification to the user may be provided before or after the driving frequency is increased.

[0071] The user may put a food ingredient into the target (pan) 5 in response to the notification indicating the completion of boiling. A case where a food ingredient is put into the target 5 at time t2 will be described below.

[0072] When a food ingredient is put into the target 5 at time t2, the temperature of the target 5 decreases as illustrated in Fig. 8(b). If the put food ingredient has a low temperature like, for example, a frozen food, the temperature decreases more significantly. Furthermore, the input current rapidly increases with decreasing temperature as illustrated in Fig. 8(c).

[0073] At that time, the operation point shifts (changes) from point C to point D as illustrated in Fig. 7.

[0074] When a variation per predetermined time period

obtained with the driving frequency being fixed for the inverter circuit 23 reaches a second predetermined value or more, the control unit 45 determines that the temperature has decreased due to an operation for putting a food ingredient or an operation for additionally putting water (time t3).

[0075] Information about the second predetermined value may be previously set in the control unit 45 or may be input through the operation unit 40 or the like.

[0076] At time t3, the control unit 45 cancels fixing the driving frequency, reduces the driving frequency for the inverter circuit 23 to increase the input current, thus increasing the high frequency power (heating power) supplied to the heating coil 11 a. Consequently, the operation point shifts (changes) from point D to point E as illustrated in Fig. 7.

[0077] The control unit 45 again fixes the driving frequency for the inverter circuit 23 and continues heating with the increased heating power.

[0078] Since the driving frequency is reduced in a low temperature state at time t3, the input current further increases and then gradually decreases with increasing temperature (Fig. 8(b) and (c)). At that time, the operation point shifts (changes) from point E to point B as illustrated in Fig. 7.

[0079] Consequently, the control unit 45 determines at time t4 that a variation in input current per predetermined time period has reached less than or equal to the predetermined value and again determines that boiling has been completed.

[0080] The control unit 45 then cancels fixing the driving frequency and again increases the driving frequency for the inverter circuit 23 to reduce the input current, thus reducing the high frequency power (heating power) supplied to the heating coil 11 a. This operation is repeated until an operation for stopping heating (terminating the boiling mode) is performed through the operation unit 40.

[0081] The above-described operation allows the operation point to shift (change) to another point in this order of E, B, and C.

[0082] As described above, when a variation per predetermined time period with the driving frequency being fixed for the inverter circuit 23 reaches the second predetermined value or more, fixing driving frequency is canceled and driving of the inverter circuit 23 is controlled to increase the high frequency power supplied to the heating coil 11 a, so that a reduction in temperature of the target 5 can be immediately sensed and the heating power can be increased, thus achieving short-time cooking. Furthermore, the achievement of short-time cooking enhances the ease of use, thus achieving energy saving.

[0083] For example, if control is performed with the driving frequency being fixed upon putting a food ingredient or additionally putting water into the pan after boiling, heating power enough to heat the food ingredient (or water) would fail to be provided. This would result in extended cooking time, leading to lower ease of use and increased overall power consumption.

[0084] Although the method of controlling the heating power by changing the driving frequency has been described, a method of controlling the heating power by changing the ON duty (ON-OFF ratio) of the switching elements in the inverter circuit 23 may be used.

(Fry Mode)

[0085] A fry cooking operation for heating oil in the target 5 to a predetermined temperature will now be described.

[0086] If oil heating is continuously controlled with a fixed driving frequency, a change in input current would not be constant, unlike in the case of water boiling. The temperature of oil would continue to rise. The oil may fire at worst.

[0087] Embodiment 1 uses the temperature sensing means 30, such as a thermistor or an infrared sensor, for sensing the temperature of the target 5, as illustrated in Fig. 2, and combines sensing of a variation in input current and temperature sensing through the temperature sensing means 30, thus allowing the induction heating cooker to reduce the likelihood of oil being excessively heated and exhibit high reliability.

[0088] When the fry mode is selected as a cooking menu (operation mode) through the operation unit 40, the control unit 45 performs the load determining process in the same way as that described above, determines a driving frequency suitable for the material of the target 5, fixes the determined driving frequency, and performs the induction heating operation.

[0089] Furthermore, an input current and a temperature sensed by the temperature sensing means 30 during heating are output to the control unit 45, so that the control unit 45 can store the relationship between the temperature and the input current.

[0090] When the temperature sensed by the temperature sensing means 30 reaches a temperature (predetermined temperature) suitable for fry cooking, the control unit 45 cancels fixing the driving frequency and gradually increases the driving frequency so that the temperature is maintained, thus reducing heating power. At that time, namely, when the driving frequency is gradually increased, the control unit 45 is allowed to store a changed driving frequency, an input current detected by the input current detecting means 25a, and a temperature sensed by the temperature sensing means 30.

[0091] The control unit 45 allows the notifying means 42 to notify the user of completion of preheating for fry cooking and again fixes the driving frequency for the inverter circuit 23, and continues heating with the reduced heating power. A notification to the user may be provided before or after the driving frequency is increased.

[0092] When the user puts a food ingredient into the target 5 after being notified of the completion of preheating, the temperature of oil decreases. If the put food ingredient is frozen, the difference in temperature between the food ingredient and the oil is large. If a large amount

of food ingredient is put, the oil temperature would rapidly drop.

[0093] When a variation in input current or coil current per predetermined time period obtained with the driving frequency being fixed for the inverter circuit 23 reaches a third predetermined value or more, the control unit 45 controls driving of the inverter circuit 23 to increase the high frequency power supplied to the heating coil 11 a.

[0094] Information about the third predetermined value may be previously set in the control unit 45 or may be input through the operation unit 40 or the like.

[0095] As described above, when a temperature detected by the temperature sensing means 30 exceeds the predetermined temperature, the high frequency power supplied to the heating coil 11 a is reduced. When a variation in input current per predetermined time period obtained with the driving frequency being fixed for the inverter circuit 23 reaches the third predetermined value or more, driving of the inverter circuit 23 is controlled to increase the high frequency power supplied to the heating coil 11 a. Consequently, a reduction in oil temperature can be suppressed such that a temperature suitable for fry cooking can be maintained. This allows the induction heating cooker to achieve short-time fry cooking and accordingly exhibit the ease of use.

[0096] Temperature sensing only by the temperature sensing means 30, such as a thermistor or an infrared sensor, would cause time lag in sensing of a change in oil temperature upon putting a food ingredient. According to Embodiment 1, since the input current rapidly changes during control with the driving frequency being fixed, a reduction in oil temperature can be sensed by sensing a change in input current.

(Exemplary Configuration of Another Drive circuit)

[0097] An example using another drive circuit will now be described.

[0098] Fig. 9 is a diagram illustrating another drive circuit of the induction heating cooker according to Embodiment 1.

[0099] The drive circuit 50 illustrated in Fig. 9 includes a resonant capacitor 24b in addition to the components illustrated in Fig. 2. The other components are the same as those in Fig. 2. The same components as those in Fig. 2 are designated by the same reference numerals.

[0100] Since the resonant circuit includes the heating coil 11 a and the resonant capacitors as described above, the capacitance of each resonant capacitor is determined depending on maximum heating power (maximum input power) necessary for the induction heating cooker. In the drive circuit 50 illustrated in Fig. 9, the resonant capacitors 24a and 24b are connected in parallel with each other, so that the capacitance of each resonant capacitor can be reduced by half. An inexpensive control circuit can be provided in the use of two resonant capacitors.

[0101] Furthermore, the coil current detecting means 25b is disposed adjacent to the resonant capacitor 24a

of the resonant capacitors connected in parallel, so that a current flowing through the coil current detecting means 25b is half that flowing through the heating coil 11 a. Consequently, compact coil current detecting means 25b having a small capacitance can be used. Thus, a compact and inexpensive control circuit can be provided, thus achieving a reduction in cost of the induction heating cooker.

10 Embodiment 2

[0102] Fig. 10 includes diagrams illustrating the relationship between driving frequency and time, the relationship between temperature and time, and the relationship between input current and time in an induction heating cooker according to Embodiment 2. Fig. 10 illustrates a change in each of the characteristics plotted against elapsed time to boil water in the target 5. Fig. 10(a) illustrates the driving frequency, Fig. 10(b) illustrates the temperature (temperature of the bottom of the target 5), and Fig. 10(c) illustrates the input current.

(Boiling Mode 3)

25 **[0103]** Another control operation performed when the boiling mode is selected through the operation unit 40 will be described.

[0104] The control unit 45 performs the load determining process, determines a driving frequency depending on the determined material of the pan, fixes the determined driving frequency, and drives the inverter circuit 23 to perform the induction heating operation in the same way as the operation described in Embodiment 1. The control unit 45 determines on the basis of a time variation in input current whether boiling has been completed.

[0105] Furthermore, when a variation per predetermined time period obtained with the driving frequency being fixed for the inverter circuit 23 is less than or equal to the predetermined value, the control unit 45 cancels fixing the driving frequency and changes the driving frequency for the inverter circuit 23 to change high frequency power supplied to the heating coil 11 a. Such an operation will be described in detail with reference to Fig. 10.

[0106] When the driving frequency is fixed and heating is started (Fig. 10(a)) in the same way as in the above-described boiling modes 1 and 2, the temperature of the bottom of the target 5 gradually increases (Fig. 10(b)) until water in the target 5 is boiling. In the control with the driving frequency being fixed, the input current gradually decreases with increasing temperature of the target 5.

[0107] When the water is boiling and the temperature becomes constant, the input current also becomes constant (Fig. 10(c)). Thus, the control unit 45 determines at time t1 that the variation in input current per predetermined time period has reached less than or equal to the predetermined value, thus determining that boiling has been completed.

[0108] Then, the control unit 45 cancels fixing the driv-

ing frequency and increases the driving frequency for the inverter circuit 23 to reduce the input current, thus reducing the high frequency power (heating power) supplied to the heating coil 11 a. At that time, when the heating power is reduced by increasing the driving frequency, the temperature hardly falls. The control unit 45 again fixes the driving frequency for the inverter circuit 23 and continues heating with the reduced heating power.

[0109] In boiling (water boiling), if the heating power is increased to be higher than necessary, the temperature of water will not exceed 100 degrees C. If the heating power is reduced by increasing the driving frequency, therefore, the water temperature can be maintained.

[0110] As described above, when a variation in input current per predetermined time period is less than or equal to the predetermined value, driving of the inverter circuit 23 is controlled to reduce the high frequency power supplied to the heating coil 11 a. Thus, input power is reduced, thus achieving energy saving.

[0111] At time t1, the control unit 45 increases the driving frequency for the inverter circuit 23 and allows the notifying means 42 to notify the user of the completion of boiling. A notification to the user may be provided before or after the driving frequency is increased.

[0112] If the user is notified of the completion of boiling, the user may leave the target 5 such that water continues boiling. A case where water in the target 5 evaporates at time t2 will be described below.

[0113] If there is water in the target 5, the temperature of the target 5 (the temperature of the bottom of the pan) will be substantially equal to the temperature of water or undergo transition at a temperature slightly higher than the water temperature. In other words, the temperature of the target 5 is constant at approximately 100 degrees C while water is boiling.

[0114] When the water in the target 5 evaporates at time t2, the temperature of the target 5 rapidly increases. Thus, the input current sharply decreases with increasing temperature of the target 5 as illustrated in Fig. 10(c).

[0115] When a variation (decrease) per predetermined time period obtained with the driving frequency being fixed for the inverter circuit 23 reaches a fourth predetermined value or more (a decrease of the fourth predetermined value or more), the control unit 45 determines the evaporation of water (time t3).

[0116] Information about the fourth predetermined value may be previously set in the control unit 45 or can be input through the operation unit 40 or the like.

[0117] The control unit 45 then stops supplying the high frequency power (heating power) to the heating coil 11 a at time t3. At this time, the control unit 45 allows the notifying means 42 to notify the user of the evaporation of water.

[0118] As described above, when a decrease (variation) per predetermined time period obtained with the driving frequency being fixed for the inverter circuit 23 reaches the fourth predetermined value or more (a decrease of the fourth predetermined value or more), fixing

driving frequency is canceled, control is performed such that driving of the inverter circuit 23 is stopped, and supply of the high frequency power to the heating coil 11 a is stopped, so that a rapid increase in temperature of the target 5 can be suppressed. This allows the induction heating cooker to exhibit high safety. In addition, since the user is notified of the evaporation of water, the safety can be further enhanced. This allows the induction heating cooker to enhance the ease of use.

[0119] Although the evaporation of water can be sensed using, for example, a contact thermistor or a non-contact infrared sensor as the temperature sensing means 30, it is difficult to instantaneously sense a rapid change in temperature of the target 5 accompanied by the evaporation of water. There is a danger (or disadvantage in) that the temperature of the target 5 may rise rapidly.

[0120] Although the method of controlling heating power by changing the driving frequency has been described above, a method of controlling heating power by changing the ON duty (ON-OFF ratio) of the switching elements in the inverter circuit 23 may be used.

[0121] Furthermore, the operation modes described in Embodiments 1 and 2 can be combined. For example, the operation in the boiling mode 2 and the operation in the boiling mode 3 can be combined into an operation mode.

[0122] Although the case where a variation in input current detected by the input current detecting means 25a is sensed has been described in Embodiments 1 and 2, a variation in coil current detected by the coil current detecting means 25b may be sensed instead of the input current. Alternatively, both a variation in input current and a variation in coil current may be sensed.

[0123] Although the inverter circuit 23 of the half bridge type has been described in Embodiments 1 and 2, a full-bridge inverter or a single-transistor voltage-resonance inverter may be included.

[0124] Although the determination about the load, namely, the material of the pan, based on the relationship between coil current and primary current has been described, the load determination may be made by detecting a resonant voltage across the resonant capacitor may be used. The load determination may be made using any method.

Embodiment 3

[0125] The drive circuit 50 in Embodiments 1 and 2 will be described in detail in Embodiment 3.

[0126] Fig. 11 is a diagram illustrating part of a drive circuit included in an induction heating cooker according to Embodiment 3. Fig. 11 illustrates only some of components of the drive circuit 50 in Embodiments 1 and 2.

[0127] As illustrated in Fig. 11, the inverter circuit 23 includes a pair of arms including two switching elements (the IGBTs 23a and 23b) connected in series between a positive bus and a negative bus and the diodes 23c and

23d connected in antiparallel with the respective switching elements.

[0128] The IGBT 23a and the IGBT 23b are on-off driven in accordance with driving signals output from the control unit 45.

[0129] The control unit 45 outputs the driving signals to alternately turn on and off the IGBTs 23a and 23b such that while the IGBT 23a is turned on, the IGBT 23b is turned off, and while the IGBT 23a is turned off, the IGBT 23b is turned on.

[0130] Consequently, the IGBTs 23a and 23b are included in a half-bridge inverter that drives the heating coil 11 a.

[0131] The IGBTs 23a and 23b are included in a "half-bridge inverter circuit" in the present invention.

[0132] The control unit 45 inputs a high frequency driving signal to each of the IGBTs 23a and 23b depending on input power (heating power), thus controlling heating output. The driving signal output to each of the IGBTs 23a and 23b varies in a range of higher driving frequencies than a resonant frequency of a load circuit including the heating coil 11 a and the resonant capacitor 24a and is used to control a current flowing through the load circuit such that the current is delayed in phase from a voltage applied to the load circuit.

[0133] An operation for controlling input power (heating power) depending on the driving frequency for the inverter circuit 23 and the ON duty ratio will now be described.

[0134] Fig. 12 includes diagrams illustrating examples of the driving signals for the half-bridge circuit in Embodiment 3. Fig. 12(a) illustrates the driving signals for the switches in a high-power heating state. Fig. 12(b) illustrates the driving signals for the switches in a low-power heating state.

[0135] The control unit 45 outputs the driving signal having a higher high frequency frequency than the resonant frequency of the load circuit to each of the IGBTs 23a and 23b of the inverter circuit 23.

[0136] Varying the frequency of this driving signal increases or reduces output power of the inverter circuit 23.

[0137] For example, as illustrated in Fig. 12(a), when the driving frequency is reduced, the frequency of high frequency current supplied to the heating coil 11 a approaches the resonant frequency of the load circuit, thus increasing input power to the heating coil 11 a.

[0138] On the other hand, as illustrated in Fig. 12(b), when the driving frequency is increased, the frequency of high frequency current supplied to the heating coil 11 a shifts away from the resonant frequency of the load circuit, thus reducing the input power to the heating coil 11 a.

[0139] In addition to controlling the input power by changing the driving frequency as described above, the control unit 45 changes the ON duty ratio of the IGBTs 23a and 23b of the inverter circuit 23 to control time (or voltage application duration) during which a voltage is applied to the inverter circuit 23, so that the input power

to the heating coil 11 a can be controlled.

[0140] To increase heating power, the ratio (ON duty ratio) of the ON time of the IGBT 23a (or the OFF time of the IGBT 23b) to one period of the driving signal is increased to increase the voltage application duration in one period.

[0141] On the other hand, to reduce the heating power, the ratio (ON duty ratio) of the ON time of the IGBT 23a (or the OFF time of the IGBT 23b) to one period of the driving signal is reduced to reduce the voltage application duration in one period.

[0142] Fig. 12(a) illustrates a case where the ratio of ON time T11 a of the IGBT 23a (or OFF time of the IGBT 23b) to one period T11 of the driving signal is equal to the ratio of OFF time T11b of the IGBT 23a (or ON time of the IGBT 23b) (the ON duty ratio is 50%).

[0143] Fig. 12(b) illustrates a case where the ratio of ON time T12a of the IGBT 23a (or OFF time of the IGBT 23b) to one period T12 of the driving signal is equal to the ratio of OFF time T12b of the IGBT 23a (or ON time of the IGBT 23b) (the ON duty ratio is 50%).

[0144] When obtaining a variation in input current (or coil current) per predetermined time period as described in Embodiments 1 and 2, the control unit 45 fixes the ON duty ratio of the IGBTs 23a and 23b of the inverter circuit 23 while the driving frequency for the inverter circuit 23 is fixed.

[0145] Thus, a variation in input current (or coil current) per predetermined time period can be obtained while the input power to the heating coil 11 a is maintained constant.

Embodiment 4

[0146] An inverter circuit 23 including a full-bridge circuit will be described in Embodiment 4.

[0147] Fig. 13 is a diagram illustrating part of a drive circuit included in an induction heating cooker according to Embodiment 4. Fig. 13 illustrates only the difference between this drive circuit and the drive circuit 50 in Embodiments 1 and 2.

[0148] In Embodiment 4, two heating coils are arranged for each heating zone. The two heating coils have, for example, different diameters and are arranged concentrically. The heating coil having a small diameter will be referred to as an "inner coil 11 b" and the heating coil having a large diameter will be referred to as an "outer coil 11c" hereinafter.

[0149] Any number of heating coils may be arranged and the heating coils may be arranged in any pattern. For example, a plurality of heating coils may be arranged around a heating coil disposed at the center of a heating zone.

[0150] The inverter circuit 23 includes three arms each including two switching elements (IGBTs) connected in series between a positive bus and a negative bus and diodes connected in antiparallel with the switching elements. One of the three arms will be referred to as a

"common arm" and the other two arms will be referred to as an "inner coil arm" and an "outer coil arm" hereinafter.

[0151] The common arm is connected to the inner coil 11 b and the outer coil 11 c and includes an IGBT 232a, an IGBT 232b, a diode 232c, and a diode 232d.

[0152] The inner coil arm is connected to the inner coil 11 b and includes an IGBT 231 a, an IGBT 231 b, a diode 231 c, and a diode 231 d.

[0153] The outer coil arm is connected to the outer coil 11 c and includes an IGBT 233a, an IGBT 233b, a diode 233c, and a diode 233d.

[0154] The IGBTs 232a and 232b of the common arm, the IGBTs 231 a and 231 b of the inner coil arm, and the IGBTs 233a and 233b of the outer coil arm are on-off driven in accordance with driving signals output from the control unit 45.

[0155] The control unit 45 outputs driving signals to alternately turn on and off the IGBTs 232a and 232b such that while the IGBT 232a of the common arm is turned on, the IGBT 232b is turned off, and while the IGBT 232a is turned off, the IGBT 232b is turned on.

[0156] Similarly, the control unit 45 outputs driving signals to alternately turn on and off the IGBTs 231 a and 231 b of the inner coil arm and outputs driving signals to alternately turn on and off the IGBTs 233a and 233b of the outer coil arm.

[0157] Consequently, the common arm and the inner coil arm form a full-bridge inverter to drive the inner coil 11 b. The common arm and the outer coil arm form a full-bridge inverter to drive the outer coil 11 c.

[0158] The common arm and the inner coil arm form a "full-bridge inverter circuit" in the present invention. The common arm and the outer coil arm form the "full-bridge inverter circuit" in the present invention.

[0159] A load circuit including the inner coil 11 b and a resonant capacitor 24c is connected between an output point of the common arm (or point of connection between the IGBTs 232a and 232b) and an output point of the inner coil arm (or point of connection between the IGBTs 231 a and 231 b).

[0160] A load circuit including the outer coil 11 c and a resonant capacitor 24d is connected between the output point of the common arm and an output point of the outer coil arm (or point of connection between the IGBTs 233a and 233b).

[0161] The inner coil 11 b is a substantially circularly wound heating coil having a small outer dimension. The outer coil 11 c is disposed around the inner coil 11 b.

[0162] A coil current flowing through the inner coil 11 b is detected by coil current detecting means 25c. The coil current detecting means 25c detects, for example, the peak of the current flowing through the inner coil 11 b and outputs a voltage signal corresponding to a peak value of the heating coil current to the control unit 45.

[0163] A coil current flowing through the outer coil 11 c is detected by coil current detecting means 25d. The coil current detecting means 25d detects, for example, the peak of the current flowing through the outer coil 11 c and

outputs a voltage signal corresponding to a peak value of the heating coil current to the control unit 45.

[0164] The control unit 45 inputs a high frequency driving signal to each of the switching elements (IGBTs) of the arms depending on input power (heating power) to control heating output.

[0165] The driving signal output to each of the switching elements of each of the common arm and the inner coil arm varies in a range of higher driving frequencies than a resonant frequency of the load circuit including the inner coil 11 b and the resonant capacitor 24c and is used to control a current flowing through the load circuit such that the current is delayed in phase from a voltage applied to the load circuit.

[0166] The driving signal output to each of the switching elements of each of the common arm and the outer coil arm varies in a range of higher driving frequencies than a resonant frequency of the load circuit including the outer coil 11 c and the resonant capacitor 24d and is used to control a current flowing through the load circuit such that the current is delayed in phase from a voltage applied to the load circuit.

[0167] An operation for controlling input power (heating power) depending on a phase difference between the arms (hereinafter, "inter-arm phase difference") in the inverter circuit 23 will now be described.

[0168] Fig. 14 includes diagrams illustrating examples of the driving signals for the full-bridge circuits in Embodiment 4.

[0169] Fig. 14(a) illustrates the driving signals for the switches and energization timing of the heating coils in a high-power heating state.

[0170] Fig. 14(b) illustrates the driving signals for the switches and energization timing of the heating coils in a low-power heating state.

[0171] The energization timing illustrated in each of Fig. 14(a) and (b) is associated with the difference in potential between the output points (or the points of connection between the IGBTs) of the arms. A state in which the potential at the output point of the common arm is lower than that at the output point of the inner coil arm and that of the outer coil arm is indicated by "ON". A state in which the potential at the output point of the common arm is higher than or equal to that at the output point of the inner coil arm and that of the outer coil arm is indicated by "OFF".

[0172] Referring to Fig. 14, the control unit 45 outputs a driving signal having a higher high frequency than the resonant frequencies of the load circuits to each of the IGBTs 232a and 232b of the common arm.

[0173] Furthermore, the control unit 45 outputs a driving signal advanced in phase relative to the driving signal for the common arm to each of the IGBTs 231 a and 232b of the inner coil arm and the IGBTs 233a and 233b of the outer coil arm. The driving signals for the respective arms have the same frequency and the same ON duty ratio.

[0174] An output of the DC power supply circuit switching between a positive bus potential and a negative bus

potential at a high frequency depending on the ON and OFF states of the IGBTs is supplied to the output point of each arm (or the point of connection between the IGBTs). Thus, a potential difference between the output point of the common arm and the output point of the inner coil arm is applied across the inner coil 11 b and a potential difference between the output point of the common arm and the output point of the outer coil arm is applied across the outer coil 11c.

[0175] Accordingly, a high frequency voltage applied across each of the inner coil 11 b and the outer coil 11c can be controlled by increasing or reducing the phase difference between the driving signal for the common arm and that for each of the inner coil arm and the outer coil arm. Consequently, high frequency output current flowing through the inner coil 11 b and the outer coil 11c and input current can be controlled.

[0176] To increase heating power, an inter-arm phase α is increased to increase the voltage application duration in one period. An upper limit of the inter-arm phase α is provided in opposite phase (180 degrees out of phase). In this case, an output voltage has a substantially rectangular waveform.

[0177] Fig. 14(a) illustrates a case where the inter-arm phase α is 180 degrees and also illustrates a case where the ON duty ratio of the driving signal for each arm is 50%, namely, the proportion of ON time T13a to one period T13 is the same as that of OFF time T13b to the one period T13.

[0178] In this case, the proportion of an energization duration T14a of the inner coil 11 b and the outer coil 11 c to the one period T14 of the driving signal is the same as that of a de-energization duration T14b thereof to the one period T14.

[0179] To reduce heating power, the inter-arm phase α is made smaller than that in the high-power heating state to reduce the voltage application duration in one period. A lower limit of the inter-arm phase α is set to a level at which the switching elements are protected from breaking due to an excessive current flowing through the switching elements depending on, for example, the phase of current flowing through the load circuit upon turn-on.

[0180] Fig. 14(b) illustrates a case where the inter-arm phase α is smaller than that in Fig. 14(a). The frequency and the ON duty ratio of the driving signal for each arm are the same as those in Fig. 14(a).

[0181] In this case, the energization duration T14a of the inner coil 11 b and the outer coil 11 c in the one period T14 of the driving signal depends on the inter-arm phase α .

[0182] As described above, the input power (heating power) to the inner coil 11 b and the outer coil 11c can be controlled depending on the inter-arm phase difference.

[0183] Although the case where the inner coil 11 b and the outer coil 11 c are allowed to perform the heating operation has been described, driving of the inner coil

arm or the outer coil arm may be stopped so that either the inner coil 11 b or the outer coil 11 c performs the heating operation.

[0184] To obtain a variation in input current (or coil current) per predetermined time period as described in Embodiments 1 and 2, the control unit 45 fixes the inter-arm phase α and the ON duty ratio of the switching elements of each arm while the driving frequency for the inverter circuit 23 is fixed. The other operating steps are the same as those in Embodiments 1 and 2.

[0185] Thus, a variation in input current (or coil current) per predetermined time period can be obtained while the input power to the inner coil 11 b and the outer coil 11 c is maintained constant.

[0186] In Embodiment 4, coil current flowing through the inner coil 11 b and coil current flowing through the outer coil 11c are detected by the coil current detecting means 25c and the coil current detecting means 25d, respectively.

[0187] If either the coil current detecting means 25c or the coil current detecting means 25d is, for example, broken during the heating operation of the inner coil 11 b and the outer coil 11c and the broken detecting means fails to detect a coil current, a variation in coil current per predetermined time period can be detected on the basis of the other detected value.

[0188] Furthermore, the control unit 45 may obtain a variation in coil current detected by the coil current detecting means 25c per predetermined time period and a variation in coil current detected by the coil current detecting means 25d per predetermined time period and may perform each of the determining processes described in Embodiments 1 and 2 on the basis of a larger one of the variations. Alternatively, each of the determining processes described in Embodiments 1 and 2 may be performed on the basis of the average value of the variations.

[0189] The above-described control enables a variation in coil current per predetermined time period to be accurately obtained if either the coil current detecting means 25c or the coil current detecting means 25d has low detection accuracy.

[0190] Although an IH cooking heater has been described as an example of the induction heating cooker of the present invention in Embodiments 1 to 4, the present invention is not limited to this example. The present invention can be applied to any induction heating cooker using induction heating technology, for example, a rice cooker that performs cooking by induction heating.

Reference Signs List

[0191] 1 first heating zone 2 second heating zone 3 third heating zone 4 top panel 5 target 11 first heating means 11 a heating coil 12 second heating means 13 third heating means 21 AC power supply 22 DC power supply circuit 22a diode bridge 22b reactor 22c smoothing capacitor 23 inverter circuit 23a, 23b IGBT 23c, 23d

diode 24a, 24b resonant capacitor 25a input current detecting means 25b coil current detecting means 30 temperature sensing means 40a to 40c operation unit 41 a to 41 c display unit 42 notifying means 45 control unit 50 drive circuit 100 induction heating cooker 11 b inner coil 11c outer coil 24c, 24d resonant capacitor 25c, 25d coil current detecting means 231 a, 231 b, 232a, 232b, 233a, 233b IGBT 231 c, 231 d, 232c, 232d, 233c, 233d diode

Claims

1. An induction heating cooker comprising:

a heating coil that induction-heats a target;
a drive circuit that supplies high frequency power to the heating coil;
load determining means for performing a process of determining a load on the heating coil; and
a control unit that controls driving of the drive circuit to control the high frequency power supplied to the heating coil,
wherein the control unit is configured to drive the drive circuit in accordance with a result of determination by the load determining means,
wherein the control unit is configured to obtain a variation per predetermined time period in at least one of input current to the drive circuit and coil current flowing through the heating coil while fixing a driving frequency for the drive circuit, and
wherein the control unit is configured to sense a change in temperature of the target based on the variation per predetermined time period.

2. The induction heating cooker of claim 1, wherein when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is less than or equal to a predetermined value, the control unit is configured to control driving of the drive circuit to change the high frequency power supplied to the heating coil.

3. The induction heating cooker of claim 1 or 2, wherein when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is less than or equal to a predetermined value, the control unit is configured to cancel fixing the driving frequency and to increase the driving frequency for the drive circuit to reduce the high frequency power supplied to the heating coil.

4. The induction heating cooker of any one of claims 1 to 3, wherein when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is an increase of a second predetermined value or more, the control unit is configured to control driving of the drive circuit to increase the high frequency power supplied to the

heating coil.

5. The induction heating cooker of any one of claims 1 to 4, wherein when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is a decrease of a fourth predetermined value or more, the control unit is configured to stop driving the drive circuit to stop supplying the high frequency power to the heating coil.

6. The induction heating cooker of claim 3 or 4, wherein the control unit is configured to change the driving frequency for the drive circuit or an ON duty ratio of a switching element of the switching elements to change the high frequency power supplied to the heating coil.

7. The induction heating cooker of any one of claims 1 to 6,
wherein when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is less than or equal to a predetermined value, the control unit cancels fixing the driving frequency, increases the driving frequency for the drive circuit to reduce the high frequency power supplied to the heating coil, and then fixes the driving frequency for the drive circuit, and thereafter, when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is an increase of a second predetermined value or more, the control unit cancels fixing the driving frequency, reduces the driving frequency for the drive circuit to increase the high frequency power supplied to the heating coil, and then fixes the driving frequency for the drive circuit, and thereafter, when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is less than or equal to the predetermined value, the control unit cancels fixing the driving frequency, increases the driving frequency for the drive circuit to reduce the high frequency power supplied to the heating coil, and fixes the driving frequency for the drive circuit.

8. The induction heating cooker of any one of claims 1 to 6,
wherein when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is less than or equal to a predetermined value, the control unit cancels fixing the driving frequency, increases the driving frequency for the drive circuit to reduce the high frequency power supplied to the heating coil, and then fixes the driving frequency for the drive circuit, and thereafter, when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is an increase of a second predetermined value or more, the control unit cancels fixing

the driving frequency, reduces the driving frequency for the drive circuit to increase the high frequency power supplied to the heating coil, and fixes the driving frequency for the drive circuit,

when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is less than or equal to the predetermined value, the control unit cancels fixing the driving frequency, increases the driving frequency for the drive circuit to reduce the high frequency power supplied to the heating coil, and fixes the driving frequency for the drive circuit, and,
when a variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is a decrease of a fourth predetermined value or more, the control unit stops driving the drive circuit to stop supplying the high frequency power to the heating coil.

9. The induction heating cooker of any one of claims 1 to 8, further comprising:
an operation unit through which an operation for selecting an operation mode is performed; and notifying means,
wherein when a boiling mode for setting a water boiling operation is selected as the operation mode, the control unit is configured to drive the drive circuit, to obtain a variation per predetermined time period in the input current or the coil current while fixing the driving frequency for the drive circuit, and
wherein when the variation per predetermined time period obtained with the driving frequency being fixed for the drive circuit is less than or equal to a predetermined value, the control unit is configured to allow the notifying means to provide a notification indicating that boiling has been completed.
10. The induction heating cooker of any one of claims 1 to 8, further comprising:
an operation unit through which an operation for selecting an operation mode is performed; and temperature sensing means for sensing a temperature of the target,
wherein when a fry mode for heating oil to a predetermined temperature is selected as the operation mode, the control unit is configured to drive the drive circuit,
wherein when the temperature sensed by the temperature sensing means exceeds the predetermined temperature, the control unit controls driving of the drive circuit to reduce the high frequency power supplied to the heating coil and then fixes the driving frequency for the drive circuit, and
wherein when a variation per predetermined time period in the input current or the coil current obtained with the driving frequency being fixed

for the drive circuit is an increase of a third predetermined value or more, the control unit controls driving of the drive circuit to increase the high frequency power supplied to the heating coil.

11. The induction heating cooker of any one of claims 1 to 10, wherein the load determination means is configured to perform the process of determining a load on the target based on a correlation between the input current and the coil current.
12. The induction heating cooker of any one of claims 1 to 11, wherein the control unit is configured to fix an ON duty ratio of a switching element of the drive circuit while fixing the driving frequency for the drive circuit.
13. The induction heating cooker of any one of claims 1 to 11,
wherein the drive circuit includes a full-bridge inverter circuit that includes at least two arms each including two switching elements connected in series of the switching elements, and
wherein the control unit is configured to fix a difference in phase for driving the switching elements between the two arms and an ON duty ratio of the switching elements while fixing a driving frequency for the switching elements of the full-bridge inverter circuit.
14. The induction heating cooker of any one of claims 1 to 11,
wherein the drive circuit includes a half-bridge inverter circuit that includes an arm including two switching elements connected in series of the switching elements, and
wherein the control unit is configured to fix an ON duty ratio of the switching elements while fixing a driving frequency for the switching elements of the half-bridge inverter circuit.

FIG. 1

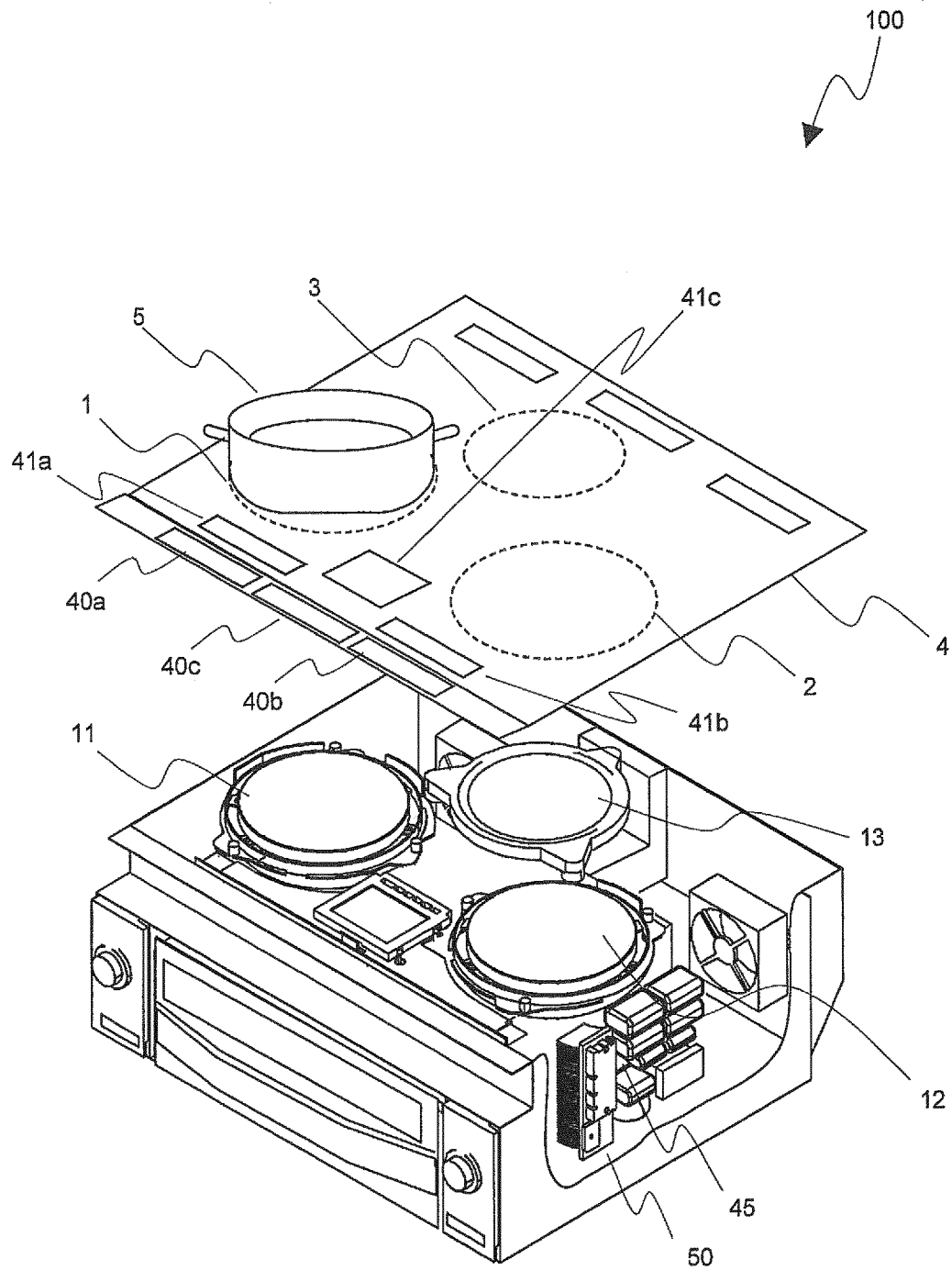


FIG. 2

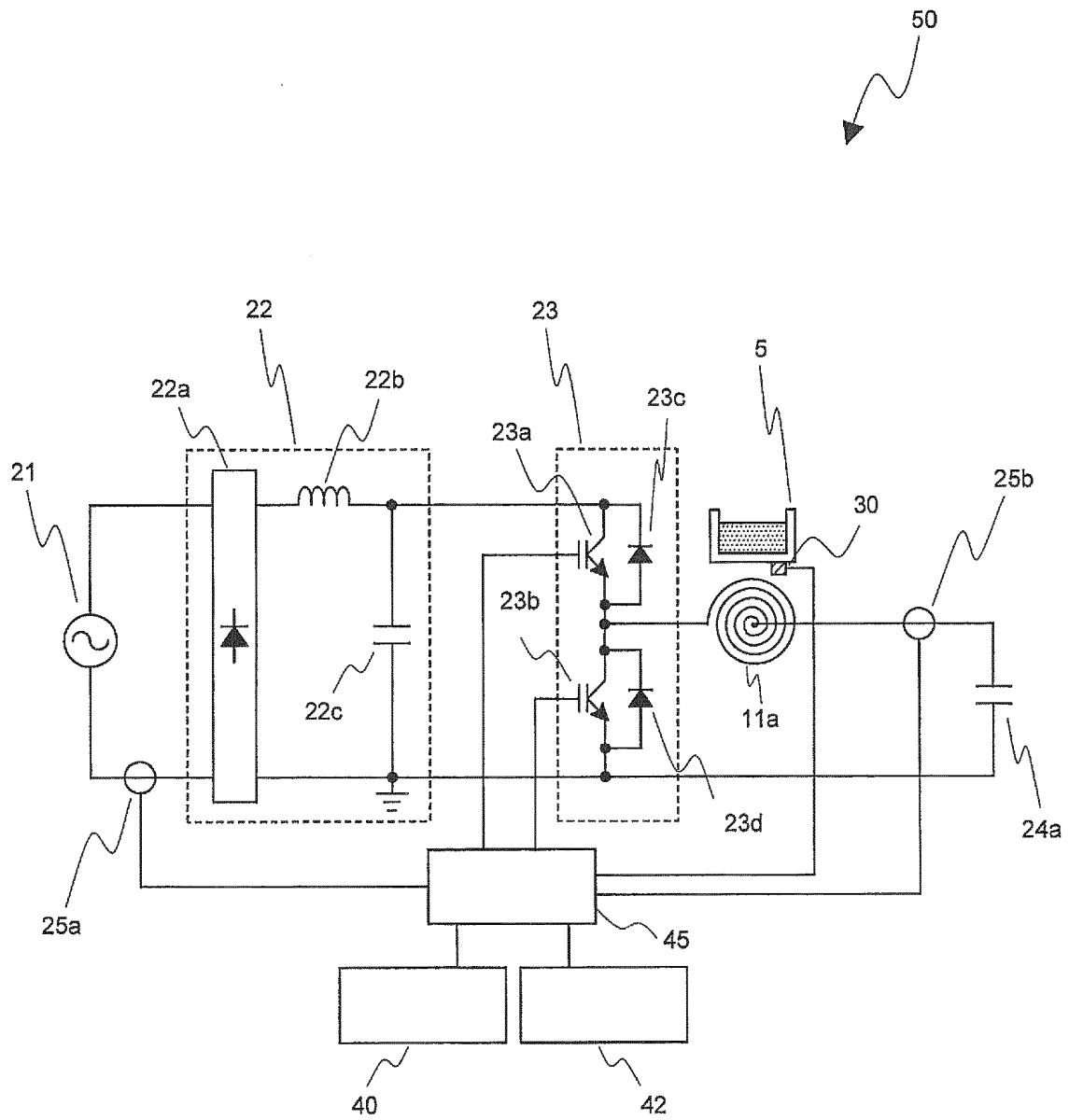


FIG. 3

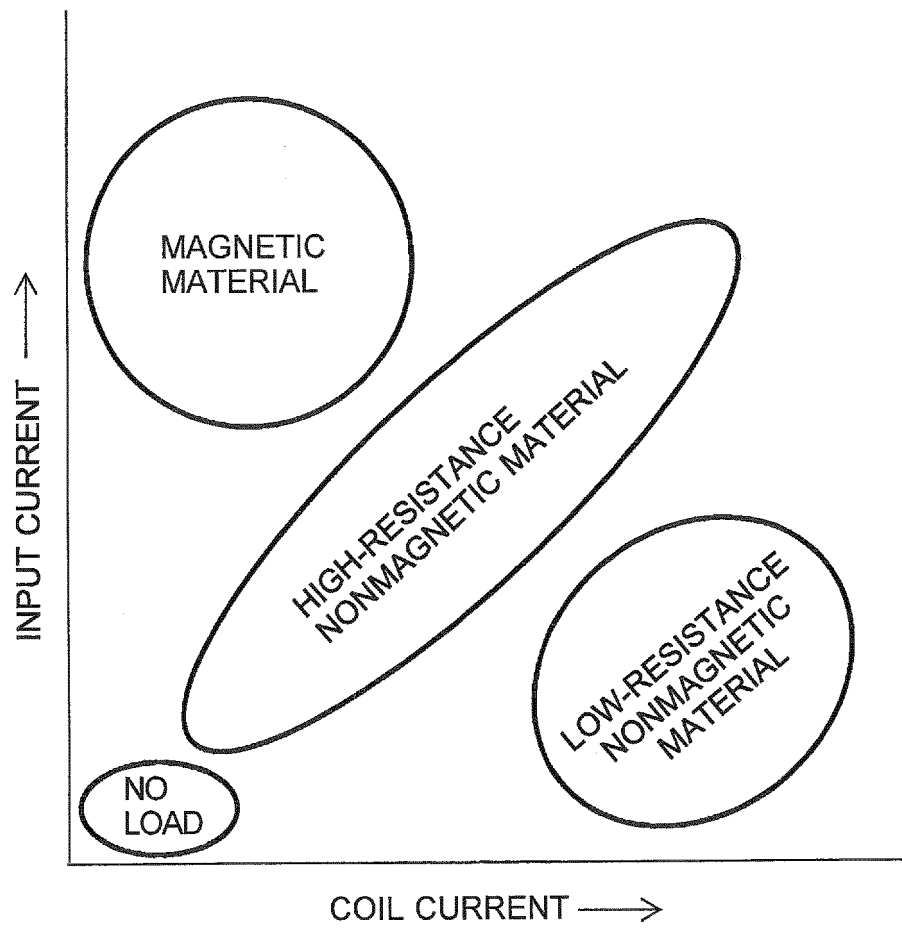


FIG. 4

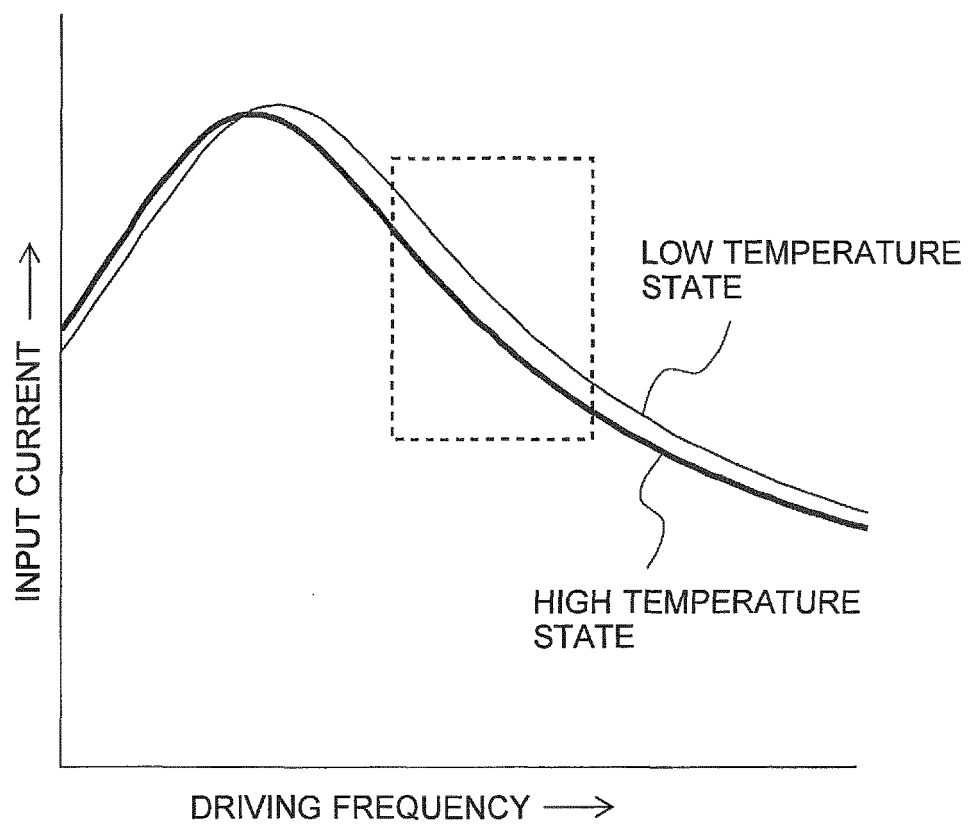


FIG. 5

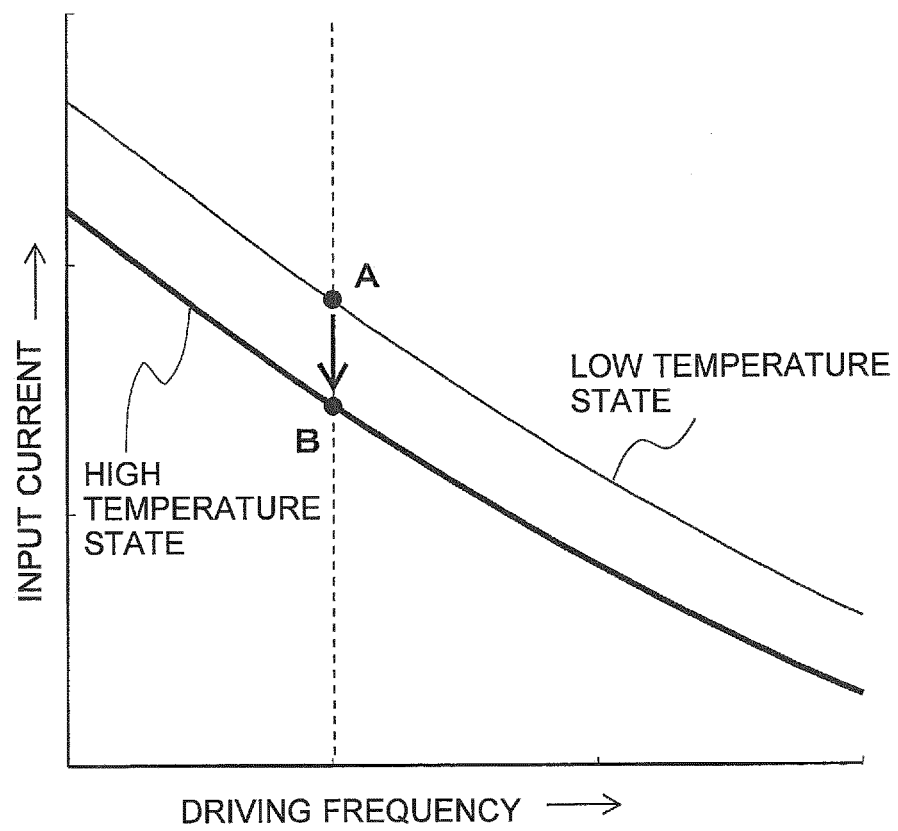


FIG. 6

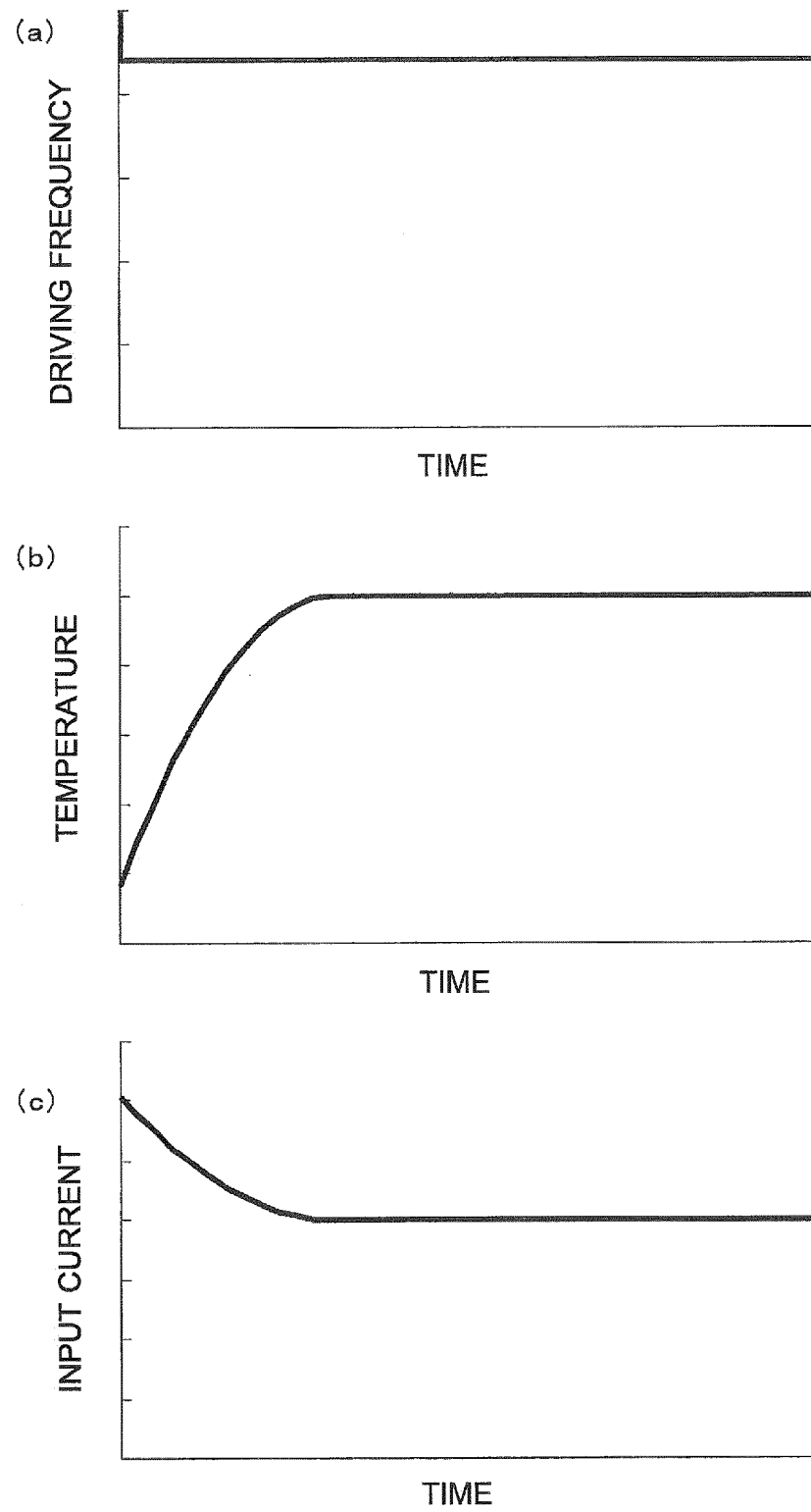


FIG. 7

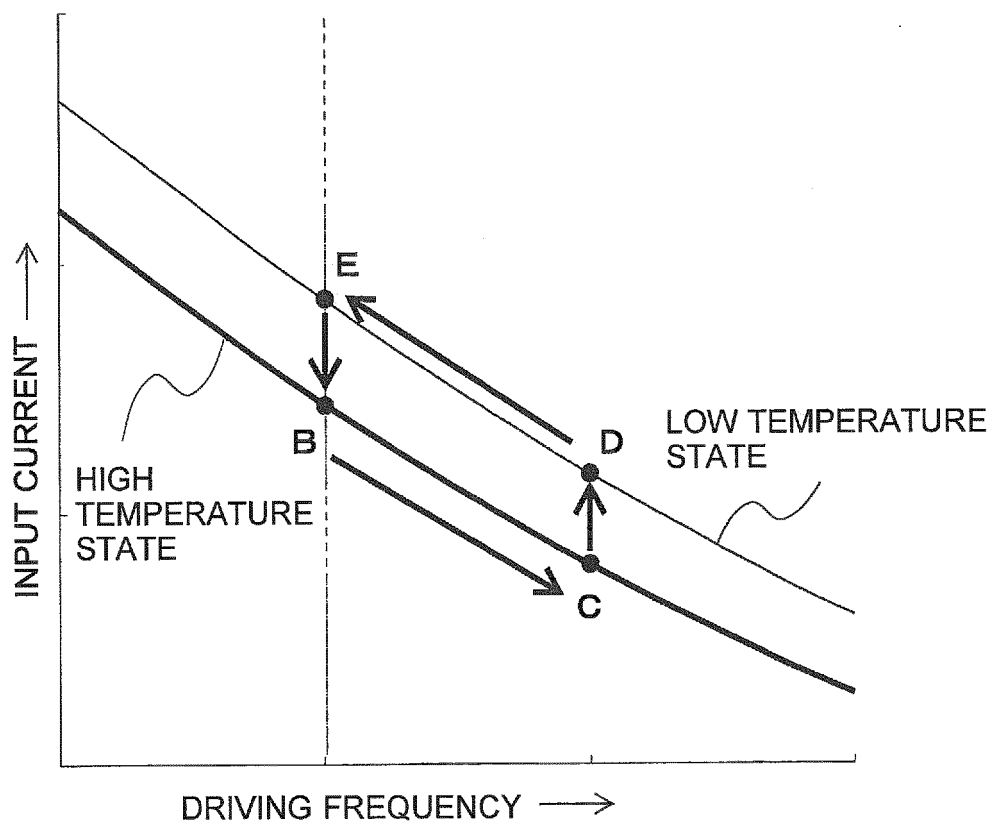


FIG. 8

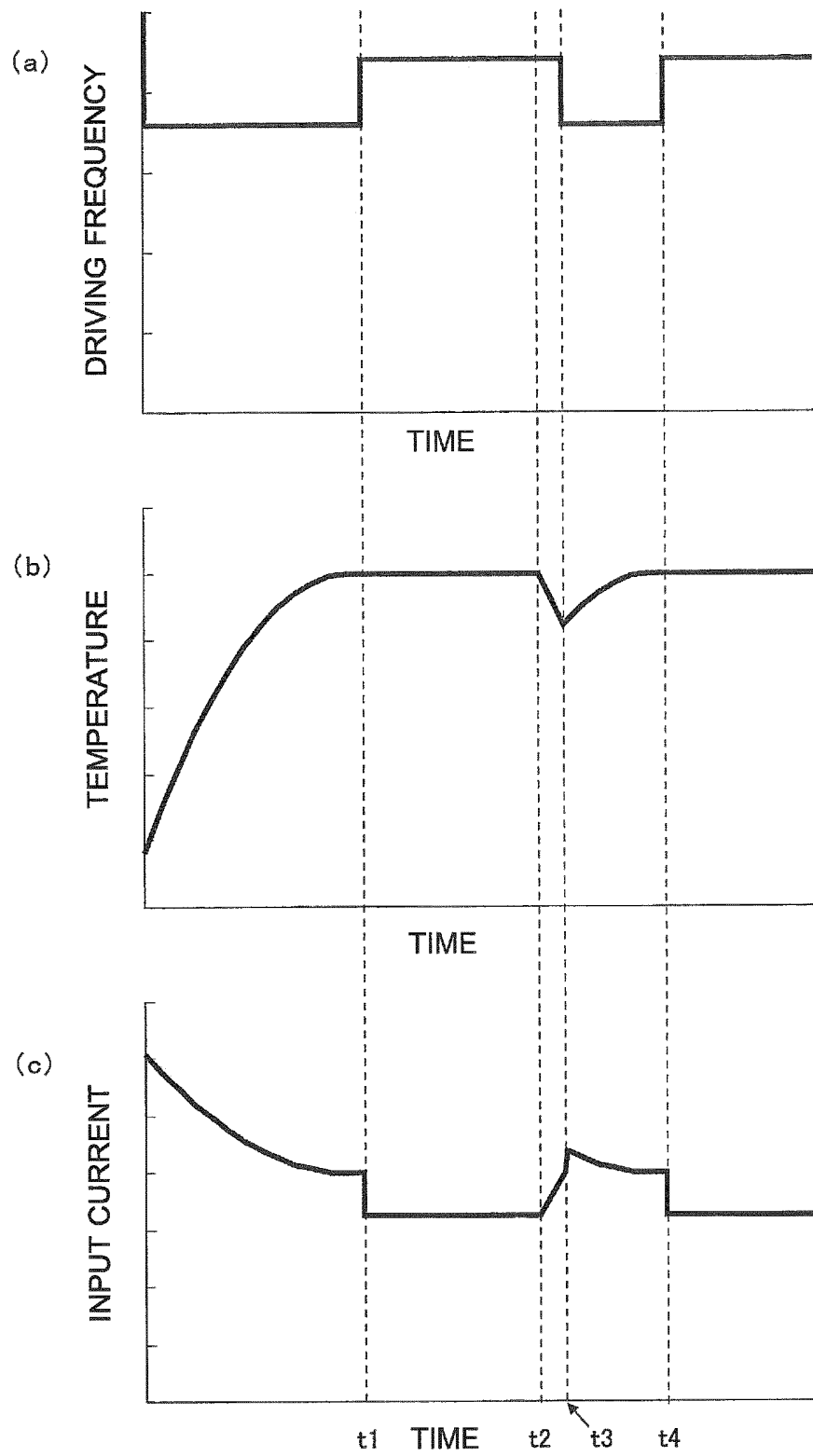


FIG. 9

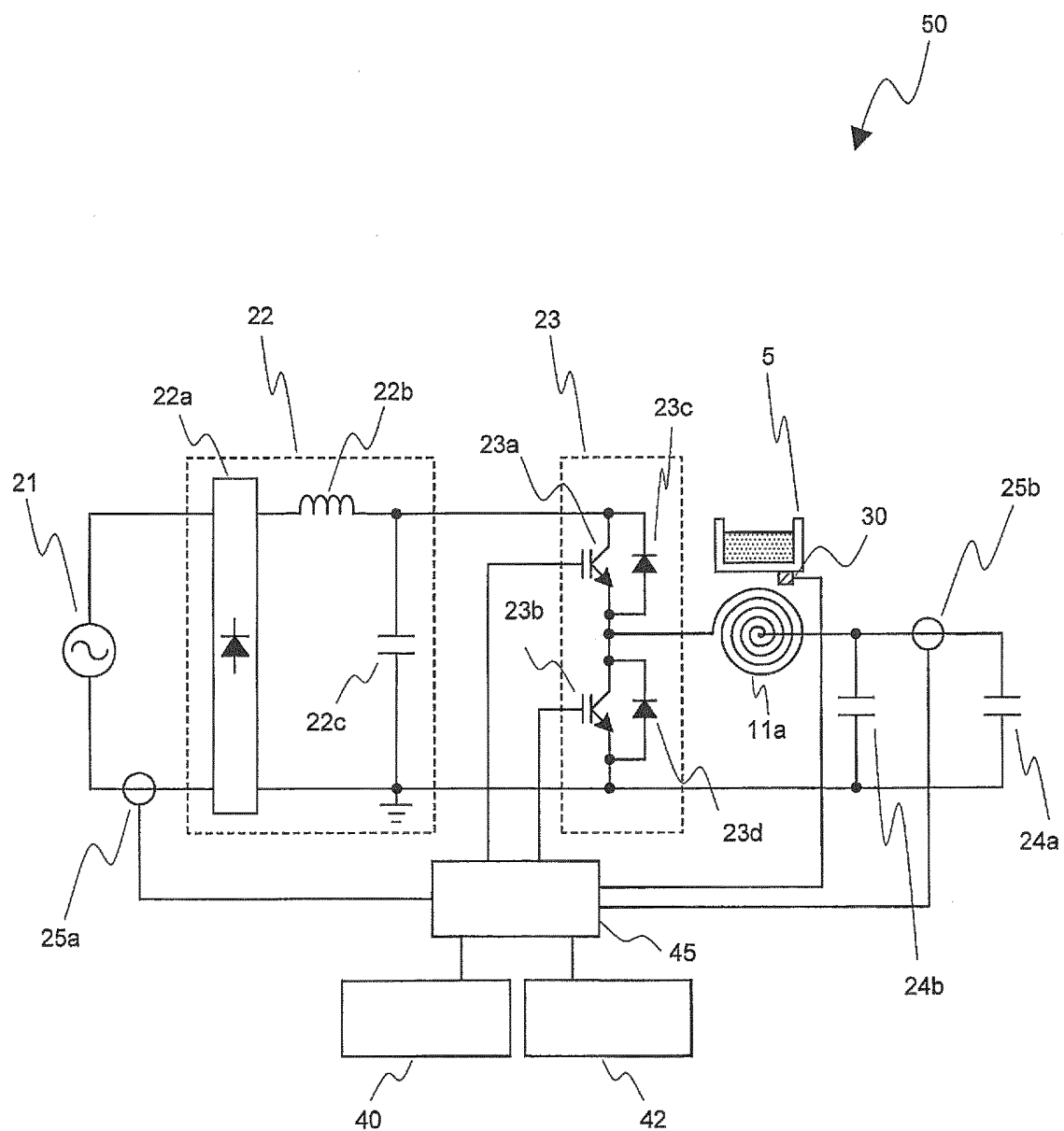


FIG. 10

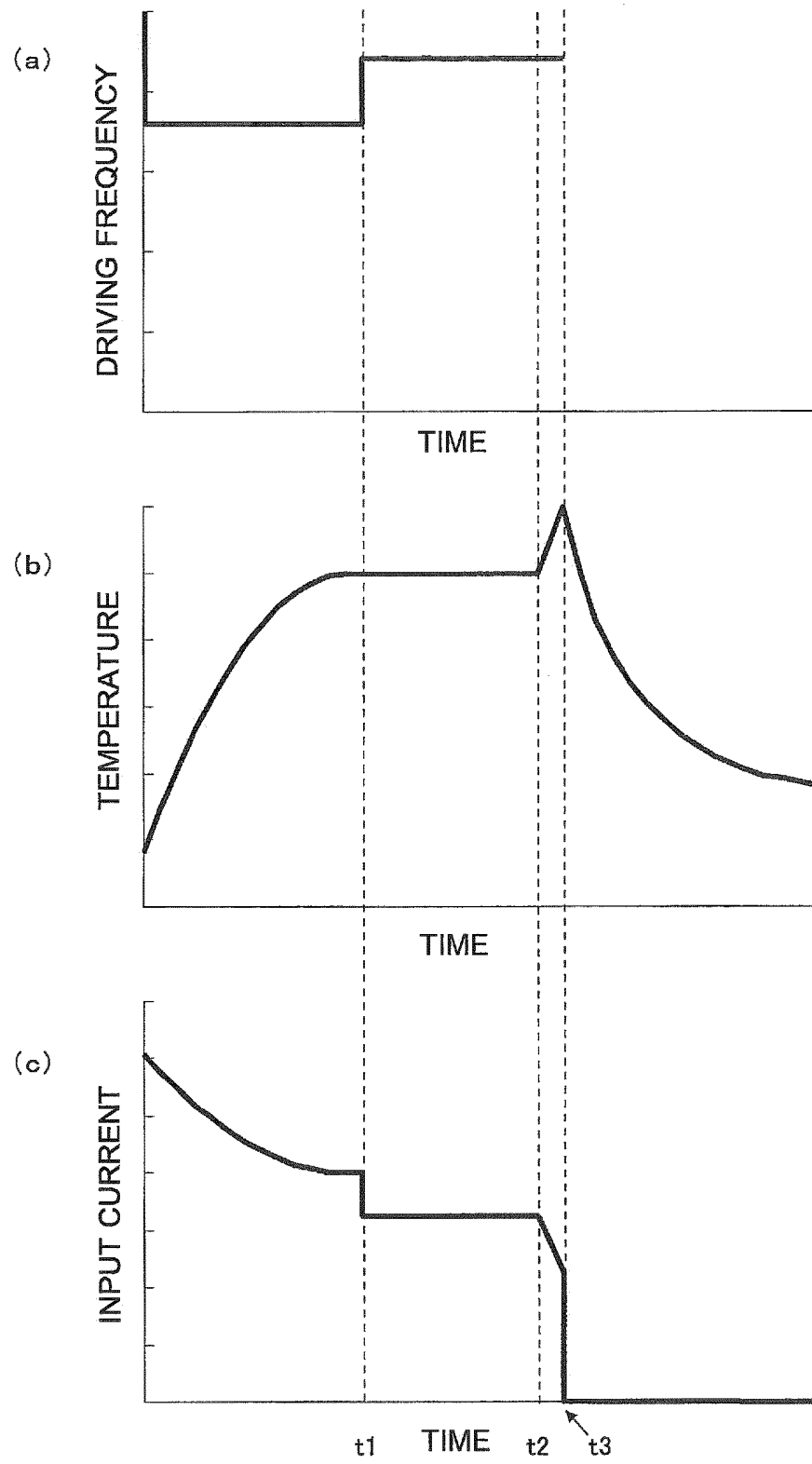


FIG. 11

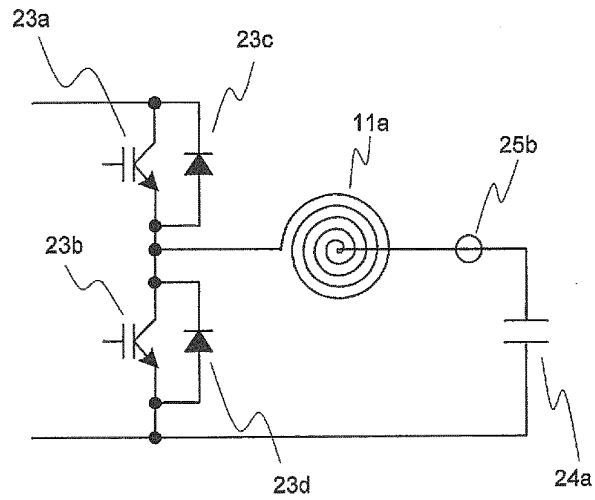


FIG. 12

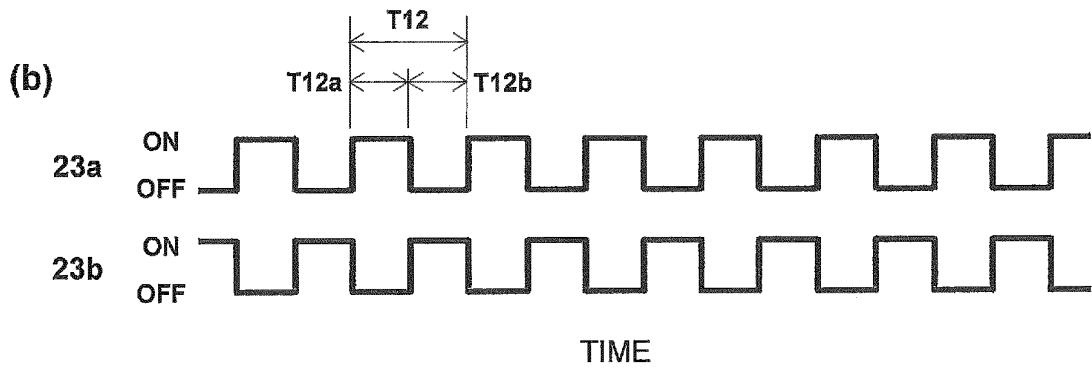
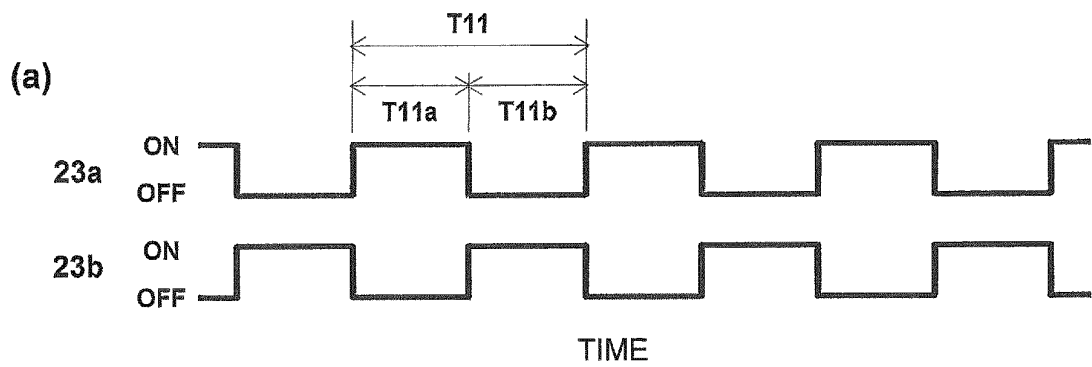


FIG. 13

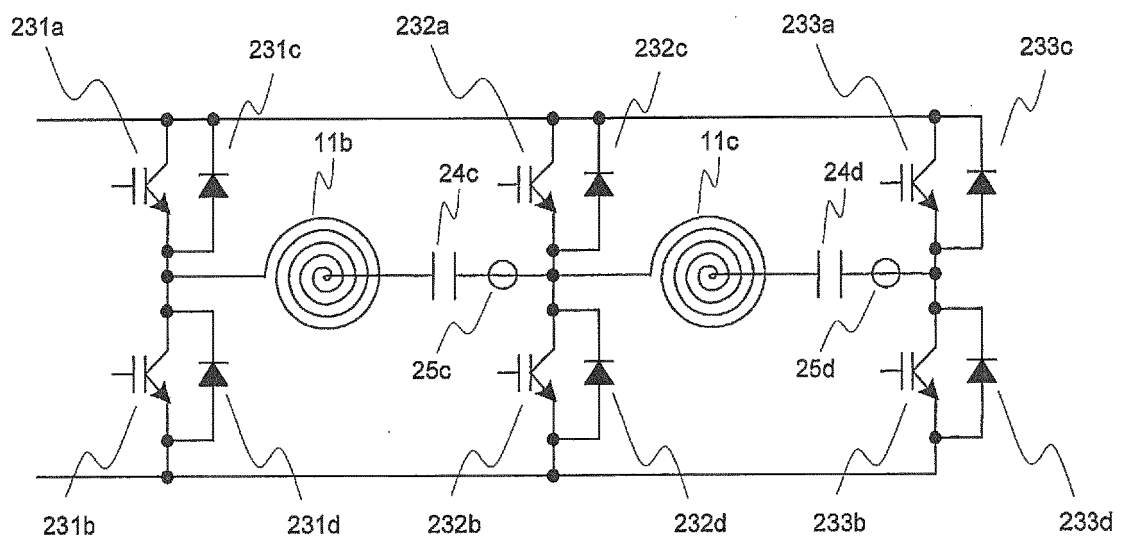
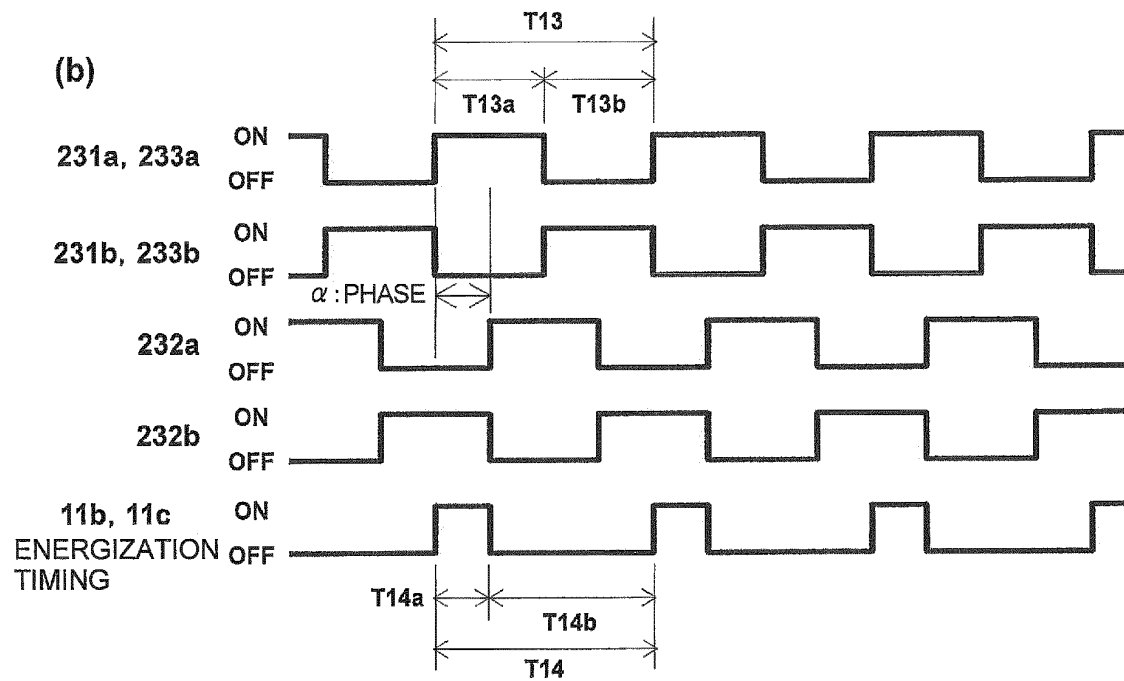
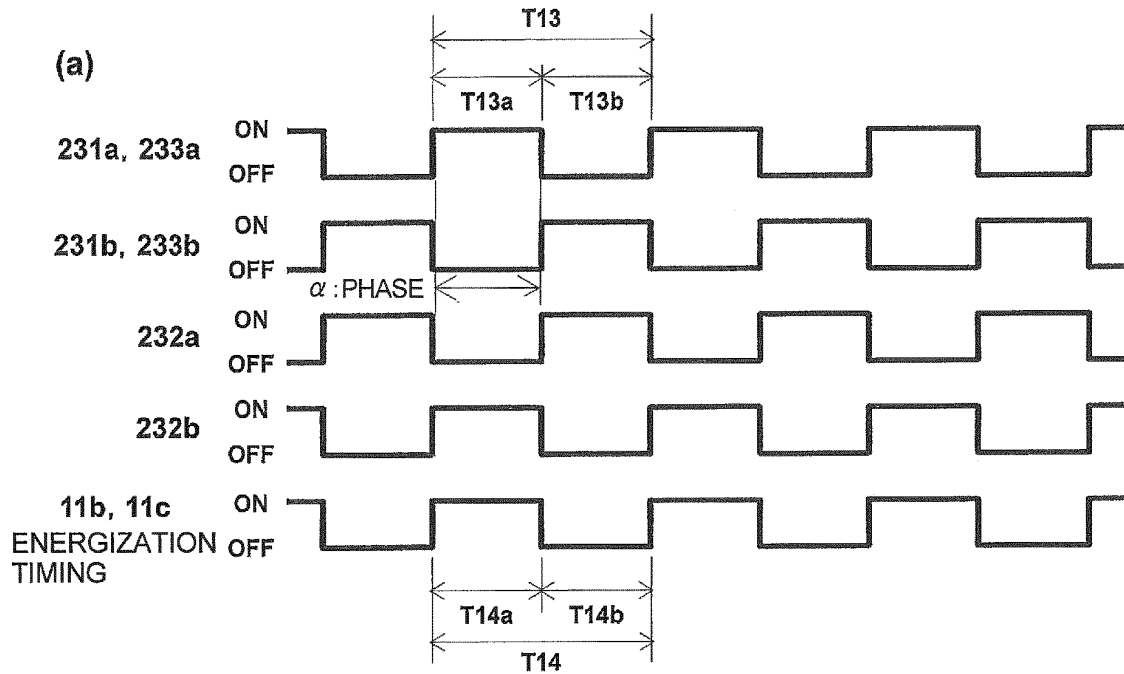


FIG. 14



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/056917

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 1996-2013

Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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 2006-114311 A (Matsushita Electric Industrial Co., Ltd.), 27 April 2006 (27.04.2006), paragraphs [0017] to [0019], [0022] to [0026] (Family: none)	1-3, 6, 9, 11-14
Y	JP 2001-155846 A (Fuji Electric Co., Ltd.), 08 June 2001 (08.06.2001), paragraphs [0035], [0036] (Family: none)	1-3, 6, 9, 11-14
Y	JP 2007-287702 A (Matsushita Electric Industrial Co., Ltd.), 01 November 2007 (01.11.2007), claim 1; paragraphs [0008] to [0011], [0029] (Family: none)	2, 3, 6, 9, 11-14

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

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Date of the actual completion of the international search

01 April, 2013 (01.04.13)

Date of mailing of the international search report

09 April, 2013 (09.04.13)

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/056917

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 11-260542 A (Toshiba Corp.), 24 September 1999 (24.09.1999), paragraph [0008]; fig. 9 (Family: none)	12-14
A	JP 5-62773 A (Zojirushi Corp.), 12 March 1993 (12.03.1993), paragraphs [0010], [0011] (Family: none)	1-14
A	JP 2003-151753 A (Matsushita Electric Industrial Co., Ltd.), 23 May 2003 (23.05.2003), paragraphs [0014] to [0017] (Family: none)	1-14
A	JP 2006-114371 A (Matsushita Electric Industrial Co., Ltd.), 27 April 2006 (27.04.2006), claim 1; paragraph [0005] (Family: none)	1-14

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008181892 A [0005]
- JP 5062773 A [0005]