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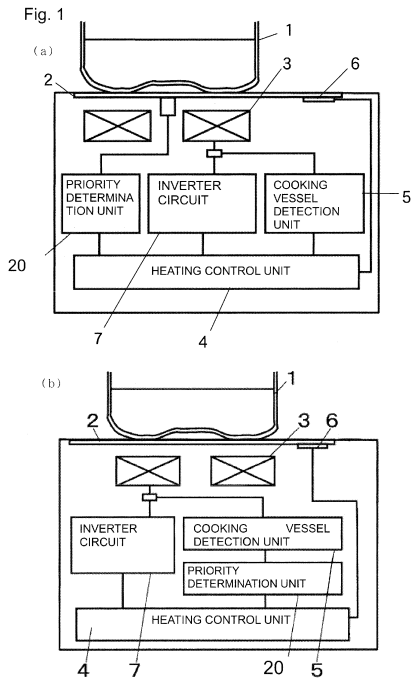
(54) INDUCTION HEATING APPARATUS

(57) An induction heating device including: a top plate on which a cooking vessel heating a cooked object; a plurality of heating coils arranged closely to each other and generating a magnetic field for heating the cooking vessel; a heating control unit that controls a high-frequency current applied to each heating coil of the plurality of the heating coils to control a heating power of the cooking vessel; a cooking vessel detection unit that performs a detection operation of a cooking vessel for detecting whether the cooking vessel is placed over the heating coils; an operation unit that displays a detection result of the cooking vessel detection unit; and a priority determination unit that determines for each heating coil of the plurality of the heating coils a priority of a heating coil for which the cooking vessel detection unit detects whether the cooking vessel is placed thereon, wherein the cooking vessel detection unit that performs for each of the heating coils a detection operation of a cooking vessel in terms of whether the cooking vessel is placed thereon, based on the priority determined by the priority determination unit.

Fig. 1



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Description

TECHNICAL FIELD

[0001] This disclosure relates to an induction heating device inductively heating a cooking vessel such as a metal cooking pot placed on a top plate.

BACKGROUND ART

[0002] An induction heating cooker typically used as an induction heating device conventionally has one or more heating coils for one heating port directly under a top plate. This typical induction heating cooker is configured to inductively heat a cooking vessel such as a metal cooking pot placed on the top plate with the heating coils.

[0003] For another induction heating cooker, a so-called multi-coil configuration is proposed that has a multiplicity of heating coils arranged in a matrix shape directly under the top plate (see. e.g., JP 2008-293871 A (Patent Document 1)).

[0004] An induction heating cooker described in JP 2008-293871 A has a configuration in which a multiplicity of heating coils is arranged closely to each other in a matrix shape entirely under a top plate such that a cooking vessel such as a cooking pot placed at any position can inductively be heated. This induction heating cooker is configured to perform display correlated with a placement position and a size of the cooking vessel on an operation unit such that each set of the heating coils is operated to heat the cooking vessel in accordance with an operation performed by a user.

PRIOR ART DOCUMENTS

Patent Documents

[0005] Patent Document 1: Japanese Laid-Open Patent Publication No. 2008-293871 A

SUMMARY OF THE INVENTION

[0006] As described above, a cooking vessel may be placed at any position on a top plate in the induction heating cooker described in JP 2008-293871 A. Therefore, a state of a cooking vessel must be displayed on a display unit both in the case of one cooking vessel and in the case of multiple cooking vessels. This enables a user to visually recognize which cooking vessel is an object of a heating instruction.

[0007] In the case of a typical induction heating cooker, each heating port has a corresponding operation unit. When a user gives a heating instruction from the operation unit, heating can be performed in optimum conditions by determining whether a heatable cooking vessel exists and what type of material the cooking vessel is, before performing a heating operation.

[0008] On the other hand, in the case of an induction heating cooker having heating coils arranged in a matrix shape and capable of heating a cooking vessel placed at any position, the placement of the cooking vessel must be detected and displayed on the operation unit before an operation of heating.

[0009] Described methods of detecting a cooking vessel include a method of applying a current to each of the heating coils at a frequency higher than that of heating so as to determine whether a load is placed thereon from a heating coil current value etc., at this time point.

[0010] However, the convention configuration has a problem that if the configuration is applied to an induction heating cooker having a multiplicity of heating coils arranged in a matrix shape, large amounts of power and time are required only for a detection operation of a cooking vessel when this operation is simultaneously performed because of the multiplicity of the heating coils.

[0011] Additionally, since a circuit is required for applying a high-frequency current such that the detection operation can be performed at the same time, the device increases in size.

[0012] Moreover, since the detection operation of a cooking vessel must always be performed, the heating coils generate more heat, leading to problems such as that the coils burn in the worst case.

[0013] If the number of inverters for applying a high-frequency current is smaller than the number of the heating coils, the inverters must be switched depending on which heating coil the high-frequency current is applied to, leading to a problem of durability of a relay required for switching.

[0014] If a high-frequency current is periodically applied to the heating coils at constant intervals to reduce the switching and the power consumption, this leads to a problem that it takes time after a load is placed until detection.

[0015] As described above, in the case of the multi-coil configuration having a multiplicity of heating coils placed entirely under a top plate, how a cooking vessel is detected is important.

[0016] This disclosure solves the conventional problems and it is an object of this disclosure to configure a heating

device easily usable for a user by displaying a cooking vessel placed on a top plate and to provide an induction heating device suppressing power consumption.

[0017] An induction heating device according to the this disclosure, including:

a top plate on which a cooking vessel heating a cooked object;
a plurality of heating coils arranged closely to each other and generating a magnetic field for heating the cooking vessel;
a heating control unit that controls a high-frequency current applied to each heating coil of the plurality of the heating coils to control a heating power of the cooking vessel;
a cooking vessel detection unit that performs a detection operation of a cooking vessel for detecting whether the cooking vessel is placed over the heating coils;
an operation unit that displays a detection result of the cooking vessel detection unit; and
a priority determination unit that determines for each heating coil of the plurality of the heating coils a priority of a heating coil for which the cooking vessel detection unit detects whether the cooking vessel is placed thereon,
wherein the cooking vessel detection unit that performs for each of the heating coils a detection operation of a cooking vessel in terms of whether the cooking vessel is placed thereon, based on the priority determined by the priority determination unit.

[0018] The induction heating device of this disclosure performs the detection operation of a cooking vessel for a heating coil with a high possibility of having a cooking vessel placed thereon based on the priority determined by the priority determination unit. Therefore, the induction heating device eliminates the need of always applying a high-frequency current to all the heating coils, eliminates the need of always performing switching even if a relay is used, and can quickly detect a cooking vessel. Thus, the induction heating device is easy to use and can suppress the power consumption.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

Fig. 1(a) and Fig. 1(b) are block diagrams of configurations of an induction heating device of this disclosure.
Fig. 2 is a block diagram of an induction heating device of a first embodiment.
Fig. 3 is a diagram of arrangement of heating coils in a typical induction heating device.
Fig. 4 is a diagram of arrangement of heating coils in the induction heating device of the first embodiment.
Fig. 5 is an appearance diagram of a display example of an operation unit of the induction heating device of the first embodiment.
Fig. 6 is a block diagram when a detection auxiliary unit of the induction heating device of the first embodiment is a temperature detection unit.
Fig. 7(a) and Fig. 7(b) are diagrams of states when a temperature detection unit of an induction heating device of a second embodiment is disposed at a center of a heating coil.
Fig. 8(a) and Fig. 8(b) are diagrams of states when the temperature detection unit of the induction heating device of the second embodiment is disposed at a center of a heating coil.
Fig. 9(a) and Fig. 9(b) are diagrams of states when the temperature detection unit of the induction heating device of the second embodiment is disposed at a center among heating coils.
Fig. 10 is a block diagram when a detection auxiliary unit of an induction heating device of a fifth embodiment is composed of an electrostatic capacity detection unit.
Fig. 11 is a diagram of a state when electrodes necessary for detection of electrostatic capacity is disposed at centers of a plurality of heating coils in an induction heating device of a sixth embodiment.
Fig. 12 is a diagram of a state when an electrode necessary for detection of electrostatic capacity is disposed at a substantial center among heating coils in an induction heating device of a seventh embodiment.
Fig. 13 is a block diagram when a detection auxiliary unit of an induction heating device of an eighth embodiment is composed of a vibration detection unit.
Fig. 14 is a block diagram when a position of a vibration source is estimated from a plurality of vibration detection units of an induction heating device of a ninth embodiment.
Fig. 15 is a block diagram when a detection auxiliary unit of an induction heating device of a tenth embodiment is composed of a distance estimation unit.
Fig. 16 is a block diagram of an induction heating device of an eleventh embodiment.
Fig. 17(a) and Fig. 17(b) are diagrams of arrangement of heating coils of an induction heating device of a twelfth embodiment.
Fig. 18(a) and Fig. 18(b) are diagrams of arrangement of a cooking vessel and the heating coils of the induction

heating device of the twelfth embodiment.
Fig. 19(a) is a diagram of addresses of the heating coils of the induction heating device of a fourteenth embodiment, and Fig. 19(b) is a diagram of use frequency of the heating coils of Fig. 19(a).
Fig. 20 is a block diagram of an induction heating device of a twentieth embodiment.

MODES FOR CARRYING OUT THE INVENTION

[0020] As an induction heating device of a first aspect of the disclosure, the induction heating device including:

a top plate on which a cooking vessel heating a cooked object;
a plurality of heating coils arranged closely to each other and generating a magnetic field for heating the cooking vessel;
a heating control unit that controls a high-frequency current applied to each heating coil of the plurality of the heating coils to control a heating power of the cooking vessel;
a cooking vessel detection unit that performs a detection operation of a cooking vessel for detecting whether the cooking vessel is placed over the heating coils;
an operation unit that displays a detection result of the cooking vessel detection unit; and
a priority determination unit that determines for each heating coil of the plurality of the heating coils a priority of a heating coil for which the cooking vessel detection unit detects whether the cooking vessel is placed thereon,
wherein the cooking vessel detection unit that performs for each of the heating coils a detection operation of a cooking vessel in terms of whether the cooking vessel is placed thereon, based on the priority determined by the priority determination unit.

[0021] According to the first aspect, the detection operation of a cooking vessel is performed for the heating coil with a high possibility of having a cooking vessel placed thereon based on the priority determined by the priority determination unit. Therefore, the cooking vessel can quickly be detected and the power consumption can be suppressed.

[0022] Fig. 1 (a) and Fig. 1 (b) are block diagrams of configurations of an induction heating device of this disclosure. This induction heating device includes a top plate 2 on which a cooking vessel 1 is placed, a plurality of closely-arranged heating coils 3, a heating control unit 4 controlling a high-frequency current applied to each heating coil of the plurality of the heating coils 3, a cooking vessel detection unit 5 performing a detection operation of the cooking vessel 1 for detecting whether the cooking vessel 1 is placed over the heating coils 3, an operation unit 6 displaying a detection result of the cooking vessel detection unit 5, and a priority determination unit 20. The priority determination unit 20 determines for each heating coil of the plurality of the heating coils 3 a priority of the heating coil 3 for which the cooking vessel detection unit 5 detects whether the cooking vessel 1 is placed thereon.

[0023] As described above, the priority determination unit 20 determines the priority of the heating coil 3 for which the cooking vessel detection unit 5 detects whether the cooking vessel 1 is placed thereon. With regard to this priority, the cooking vessel detection unit 5 may select the heating coil 3 preferentially subjected to the detection operation of the cooking vessel 1, or the cooking vessel detection unit 5 may set a detection frequency of performing the detection operation of the cooking vessel 1 for each of the heating coils 3. The priority may be set such that the detection operation is preferentially performed for the heating coil 3 with a higher detection frequency.

[0024] The disposition location of the priority determination unit 20 is not particularly limited. With regard to the disposition location of the priority determination unit 20, for example, the configurations of Fig. 1 (a).and Fig. 1(b) are available. In the case of Fig. 1(a), the priority determination unit 20 is connected to the heating control unit 4. Fig. 1 (a) corresponds to the case of the priority determination unit 20 composed of, for example, a detection auxiliary unit 21, a temperature detection unit 22, an electrostatic capacity detection unit 12, a vibration detection unit 13, a position estimation unit 14, or a distance estimation unit 17 described later. In the case of Fig. 1(b), the priority determination unit 20 is disposed between the heating control unit 4 and the cooking vessel detection unit 5. Fig. 1(b) corresponds to the case of the priority determination unit 20 composed of, for example, a detection position determination unit 23 or a detection operation determination unit 31 described later.

[0025] Further, as an induction heating device of a second aspect, in the first aspect, the priority determination unit may include a detection auxiliary unit that detects an object on the top plate. Moreover, if the detection auxiliary unit detects an object, the cooking vessel detection unit may perform the detection operation of a cooking vessel in terms of whether the cooking vessel is placed on heating coils around the detected object.

[0026] According to the second aspect, the detection auxiliary unit detects an object on the top plate in a simplified manner and, if an object is detected, the cooking vessel detection unit performs the detection operation of a cooking vessel in terms of whether a cooking vessel is placed, for the heating coils around the detected object. Therefore, since it is not necessary to always perform the operation of detecting a cooking vessel, the power consumption can be reduced. If switching must be performed by a relay etc., the durability of the relay can be improved.

[0027] Further, as an induction heating device of a third aspect, in the second aspect, the detection auxiliary unit may be composed of a temperature detection unit detecting a temperature of the object.

[0028] According to the third aspect, since the temperature detection unit is used, the object can preliminarily be detected at high speed and low power consumption. Since the heating coil is not used, switching by a relay etc. is not required and, therefore, the durability of the relay can be improved.

[0029] Further, as an induction heating device of a fourth aspect, in the third aspect, when the temperature detection unit detects a temperature change of the object, the cooking vessel detection unit may perform the detection operation of a cooking vessel only for a heating coil in the vicinity of a position of the detected temperature change.

[0030] According to the fourth aspect, since the operation of detecting a cooking vessel is performed only for the heating coil at the position where a temperature change indicative of a high possibility of placement of a cooking vessel is detected out of a multiplicity of the heating coils, a time required for the detection operation can be shortened.

[0031] Further, as an induction heating device of a fifth aspect, in the third aspect, the cooking vessel detection unit may perform the detection operation of a cooking vessel in a constant period.

[0032] According to the fifth aspect, even when a temperature of a cooking vessel is not different from a portion detected by the temperature detecting portion and a temperature change cannot be detected, the detection operation of a cooking vessel is performed in a constant period by the cooking vessel detection unit and, therefore, a state of being unable to detect a cooking vessel can be prevented from occurring.

[0033] Further, as an induction heating device of a sixth aspect, in the third aspect, the temperature detection unit may detect an infrared light to measure a temperature.

[0034] According to the sixth aspect, since whether a cooking vessel is placed can be known from a change in ambient light in addition to a change in temperature, the probability of failing to detect the placement of a cooking vessel can be reduced.

[0035] Further, as an induction heating device of a seventh aspect, in the second aspect, the detection auxiliary unit may be composed of:

an electrode disposed on a lower surface of the top plate; and
an electrostatic capacity detection unit that detects a change in electrostatic capacity generated in the electrode by placing the object on an upper surface of the top plate.

[0036] According to the seventh aspect, since it is not necessary to always perform the operation of detecting a cooking vessel, the power consumption can be reduced. If switching must be performed by a relay etc., the durability of the relay can be improved.

[0037] Further, as an induction heating device of a eighth aspect, in the seventh aspect, the electrode may be disposed in the vicinity of each of the heating coils to form a pair.

[0038] According to the eighth aspect, the cooking vessel detection operation is performed after detecting whether a cooking vessel is possibly placed for each of the heating coils, a useless cooking vessel detection operation can be reduced as far as possible.

[0039] Further, as an induction heating device of a ninth aspect, in the seventh aspect, the electrode may be disposed at a substantially center position among multiple adjacent heating coils.

[0040] According to the ninth aspect, since the number of the electrodes is reduced, an equipment configuration can be prevented from being complicated, and the equipment can inexpensively be provided to consumers.

[0041] Further, as an induction heating device of a tenth aspect, in the second aspect, the detection auxiliary unit may be composed of a vibration detection unit detecting vibrations of the top plate.

[0042] According to the tenth aspect, since the detection operation of a cooking vessel is performed by detecting vibrations generated in the top plate to detect that a cooking vessel is placed on the top plate, the number of times of the detection operation is reduced and, therefore, the power consumption can be reduced and, if switching must be performed by a relay etc., the durability of the relay can be improved.

[0043] Further, as an induction heating device of a eleventh aspect, in the tenth aspect, a plurality of the vibration detection units may be disposed, and wherein a position estimation unit is further included that estimates a position of a vibration source from a phase difference of a plurality of vibration waveforms detected by the vibration detection units.

[0044] According to the eleventh aspect, by estimating the position of the vibration source, the detection operation of a cooking vessel can be performed only for a position at which a cooking vessel is highly possibly placed. Therefore, the number of times of the detection operation of a cooking vessel can be reduced.

[0045] Further, as an induction heating device of a twelfth aspect, in the second aspect, the detection auxiliary unit may be composed of a light-emitting unit, a light-receiving unit, and a distance estimation unit that estimates a distance to an object over the light-receiving unit based on a light amount received by the light-receiving unit.

[0046] According to the twelfth aspect, the number of times of the detection operation can be reduced by determining whether a cooking vessel is placed based on a light amount of the light-receiving unit and performing the detection

operation of a cooking vessel if a cooking vessel is possibly placed.

[0047] Further, as an induction heating device of a thirteenth aspect, in the first aspect, the priority determination unit may include a detection position determination unit that determines a detection frequency in terms of a frequency at which the cooking vessel detection unit performs a detection operation of a cooking vessel for each heating coil of the plurality of the heating coils.

[0048] According to the thirteenth aspect, the time required until detection of a cooking vessel can be reduced and the number of times of the detection operation of a cooking vessel can be reduced by performing the detection operation of a cooking vessel highly frequently for the heating coil on which a cooking vessel is more likely to be placed and by performing the detection operation of a cooking vessel less frequently for the heating coil on which a cooking vessel is less likely to be placed. As a result, the consumption of the power required for the detection operation of a cooking vessel can be suppressed and, if an inverter circuit and a heating coil must be switched by using a relay, the durability of the relay can be improved.

[0049] Further, as an induction heating device of a fourteenth aspect, in the thirteenth aspect, the detection position determination unit may set a detection frequency lower for a heating coil disposed at a position defined as an outermost peripheral portion than that of a heating coil disposed at other than the outermost peripheral portion out of the plurality of the heating coils.

[0050] According to the fourteenth aspect, since the heating coils disposed in the outermost peripheral portion has adjacent heating coils arranged on the inner side on which a cooking vessel is likely to be placed together, even if the number of times of the detection operation (detection frequency) is reduced for the heating coils in the outermost peripheral portion, the usability is less affected, and the power consumption can be suppressed by reducing the number of times of detection.

[0051] Further, as an induction heating device of a fifteenth aspect, in the thirteenth aspect, if it is determined that a cooking vessel is placed over one heating coil, the cooking vessel detection unit may perform the detection operation of a cooking vessel for a heating coil adjacent to the heating coil.

[0052] According to the fifteenth aspect, if a cooking vessel is placed on one heating coil, the cooking vessel is very likely to be placed on a heating coil adjacent to the heating coil and, therefore, the detection operation of a cooking vessel is performed also for the adjacent heating coil. As a result, the accurate position and size of the cooking vessel 1 can be detected.

[0053] Further, as an induction heating device of a sixteenth aspect, in the fifteenth aspect, even when the detection frequency is set lower for the adjacent heating coil as compared to the other heating coils, the cooking vessel detection unit may immediately perform the detection operation of a cooking vessel for the adjacent heating coil.

[0054] According to the sixteenth aspect, even when it is detected that a cooking vessel is placed on one heating coil and the detection frequency is set lower for an adjacent heating coil, the cooking vessel is very likely to be placed on the adjacent heating coil and, therefore, the detection operation of a cooking vessel is immediately performed for the adjacent heating coil. As a result, the accurate position and size of the cooking vessel 1 can be detected.

[0055] Further, as an induction heating device of a seventeenth aspect, in the thirteenth aspect, the detection position determination unit may set a detection frequency for each of the heating coils based on a position of a heating coil detected as having the cooking vessel placed thereon within a predetermined period and the number of times of the detection.

[0056] According to the seventeenth aspect, the position of the frequently used heating coil can be learned from a past actual status of use within a predetermined period to set a detection frequency corresponding to a use frequency of each heating coil. Therefore, a cooking vessel can quickly be detected by frequently performing the detection operation for the heating coil with a high use frequency. Conversely, the power consumption can be suppressed by reducing the number of times of the detection operation for the heating coils at a less frequently used position.

[0057] Further, as an induction heating device of a eighteenth aspect, in the thirteenth aspect, the detection position determination unit may set a detection frequency higher for the heating coil disposed closer to the operation unit as compared to the heating coil disposed in the direction away from the operation unit.

[0058] According to the eighteenth aspect, a heating coil at a position away from the operation unit is distant from a user and therefore tends to have a low use frequency because of somewhat reduced usability. Thus, a cooking vessel can quickly be detected by performing the detection operation at a high detection frequency for a heating coil disposed closer to the operation portion, which tends to have a high use frequency.

[0059] Further, as an induction heating device of a nineteenth aspect, in the thirteenth aspect, the detection position determination unit may set a detection frequency lower for a heating coil disposed in the direction away from the operation unit relative to a heating coil being in a heating operation as compared to a heating coil disposed closer to the operation unit relative to the heating coil being in the heating operation.

[0060] According to the nineteenth aspect, it is difficult to place a cooking vessel on a heating coil disposed on the far side, i.e., in the direction away from the operation unit, relative to the heating coil being in the heating operation because a cooking vessel being heated becomes an obstacle. Therefore, the use frequency is extremely low. Thus, the power

consumption can be suppressed by lowering the detection frequency to reduce the number of times of the detection operation for the heating coil disposed in the direction away from the operation unit relative to the heating coil being in the heating operation.

[0061] Further, as an induction heating device of a twentieth aspect, in the thirteenth aspect, the detection position determination unit may set a detection frequency lower for a heating coil adjacent to a heating coil being in a heating operation as compared to the other heating coils.

[0062] According to the twentieth aspect, when it is attempted to place a cooking vessel on a heating coil adjacent to the heating coil being in the heating operation, the cooking vessel is difficult to place because a flange of the cooking vessel becomes an obstacle. Additionally because the cooking vessels are usually not heated in close contact with each other, a cooking vessel is less likely to be placed on the heating coil adjacent to the heating coil in the heating operation. Therefore, the power consumption can be suppressed by lowering the detection frequency and reducing the number of times of the detection operation for the heating coil adjacent to the heating coil being in the heating operation.

[0063] Further, as an induction heating device of a twenty-first aspect, in the thirteenth aspect, if a control value is abruptly changed in the heating control unit controlling the high-frequency current applied to a heating coil being in a heating operation, the detection position determination unit may set a detection frequency higher for a heating coil adjacent to the heating coil being in the heating operation as compared to the other heating coils.

[0064] According to the twenty-first aspect, if the cooking vessel being heated is moved and the heating control unit attempts to supply the same power as it is, a control value of a switching element such as an IGBT making up an inverter circuit must be changed. Specifically, if the power is controlled by a frequency of switching, the frequency must be made lower, or if the power is controlled by a conduction ratio, the conduction ratio must be made higher. If the cooking vessel is not moved, these control values are constant or only slowly changed. Conversely, if the cooking vessel is moved, the control values are abruptly changed. Therefore, when the control values are abruptly changed, the cooking vessel is moved and, therefore, the cooking vessel is likely to be moved and placed on a heating coil adjacent to the heating coil being heated. Therefore, the cooking vessel can quickly be detected by increasing the detection frequency.

[0065] Further, as an induction heating device of a twenty-second aspect, in the thirteenth aspect, the induction heating device may further include a power source operation unit capable of switching whether a power source is supplied to the operation unit. Also, if a predetermined time has elapsed after a user operates the power source operation unit to achieve a state of supplying the power source to the operation unit, the detection position determination unit may set the overall detection frequency lower or to zero for all of the plurality of the heating coils.

[0066] According to the twenty-second aspect, when a user operates the power source operation unit to achieve a state in which the power source is supplied, the detection operation of a cooking vessel is repeatedly performed; however, a cooking vessel may not immediately be placed because another cooking procedure is performed. Since the detection operation of a cooking vessel is performed even during this period, power is wastefully consumed. Therefore, if a cooking vessel is not placed even after a predetermined time has elapsed, the frequency of performing the detection operation of a cooking vessel can be reduced to suppress the power consumption.

[0067] Further, as an induction heating device of a twenty-third aspect, in the first aspect, the priority determination unit may include a detection operation determination unit determining whether the cooking vessel detection unit performs a detection operation of a cooking vessel for each of the plurality of the heating coils.

[0068] According to the twenty-third aspect, since the detection operation of a cooking vessel is performed at the timing when a cooking vessel is likely to be place or a cooking vessel is likely to be moved, the cooking vessel can quickly be detected and the number of times of the unnecessary detection operation can be reduced.

[0069] Further, as an induction heating device of a twenty-fourth aspect, in the twenty-third aspect, if a predetermined time has elapsed after a user operates the operation unit last time, the detection operation determination unit may set the overall detection frequency lower or to zero for all of the plurality of the heating coils.

[0070] According to the twenty-fourth aspect, since a cooking vessel is less likely to be place or a cooking vessel is less likely to be moved, the number of times of the detection operation can be reduced during this period to reduce the use power and improve the durability of the relay.

[0071] Further, as an induction heating device of a twenty-fifth aspect, in the twenty-third aspect, the induction heating device may further include a human body detection unit detecting a human body. Also, if the human body detection unit detects a human, the cooking vessel detection unit may start a detection operation of a cooking vessel.

[0072] According to the twenty-fifth aspect, if a user is present near the induction heating device, a cooking vessel is likely to be placed or moved and, therefore, the detection operation of a cooking vessel can be started to quickly detect a cooking vessel.

[0073] Further, as an induction heating device of a twenty-sixth aspect, in the twenty-fifth aspect, if the human body detection unit does not detect a human, the cooking vessel detection unit may stop a detection operation of a cooking vessel.

[0074] According to the twenty-sixth aspect, if a user is not present near the induction heating device, a cooking vessel is not placed or moved and, therefore, the detection operation of a cooking vessel can be stopped to reduce the power

consumption and improve the durability of the relay.

[0075] Embodiments of this disclosure will now be described in detail with reference to the drawings. For example, detailed description of already well-known items and redundant description of substantially the same constituent element may not be made. This is because of avoiding redundancy of the following description and facilitating the understanding by those skilled in the art.

[0076] The present inventor provides the accompanying drawings and the following description for sufficient understanding of this disclosure by those skilled in the art and it is not intended to limit the subject of the claims thereto.

[0077] Although the induction heating device of the following embodiments will be described in terms of an induction heating cooker, this configuration is illustrative and this disclosure is not limited to the configurations described in the following embodiments and includes an induction heating device having the technical features of this disclosure. This disclosure includes appropriately combining arbitrary configurations described in the following embodiments and the combined configurations produce the respective effects.

(First Embodiment)

[0078] Fig. 2 is a schematic block diagram of a state in which a cooking vessel is placed on an induction heating device of a first embodiment. Fig. 2 depicts a state in which the cooking vessel 1 is placed on a built-in type induction heating cooker.

[0079] The cooking vessel 1 depicted in Fig. 2 is a vessel in which an object to be cooked such as a foodstuff is contained, and is a pot, a frying pan, a kettle, etc.

[0080] The cooking vessel 1 is placed on the top plate 2 forming a portion of a contour of the induction heating cooker. Although the top plate 2 is often made of crystallized glass, this is not a limitation.

[0081] The heating coil 3 generates magnetic flux from a high-frequency current supplied in accordance with an instruction of the heating control unit 4 to inductively heat the cooking vessel 1 on the top plate 2.

[0082] The heating control unit 4 is connected to the operation unit 6, an inverter circuit 7, the detection auxiliary unit 21, and the cooking vessel detection unit 5. The heating control unit 4 is connected to the operation unit 6 for allowing a user of the induction heating cooker to give an instruction for a heating power, supplies a power to the inverter circuit 7 in accordance with the heating instruction from the user, and controls the power supplied by the heating control unit 4 to achieve the thermal power intended by the user.

[0083] The cooking vessel detection unit 5 is configured to determine whether the inductively heatable cooking vessel 1 is present on the heating coil 3 such that the heating control unit 4 can receive the result to operate only the heating coil 3 having the cooking vessel 1 located thereon.

[0084] The cooking vessel detection unit 5 may be a means provided with a coil for detection to detect a change in inductance or a means using the heating coil 3 and the inverter circuit 7 to apply a current to the heating coil 3 at a frequency higher than that of heating so as to determine whether a load is placed from a heating coil current value at this time point. The cooking vessel detection unit 5 is not limited to the means described above and may be implemented by using any means.

[0085] Although the heating control unit 4 is often implemented as a microcomputer, a DSP, or a custom IC, this is not a limitation. All or some of the functions of the heating control unit 4, the detection auxiliary unit 21, and the cooking vessel detection unit 5 may be implemented by the same unit.

[0086] Fig. 3 is a diagram of arrangement of heating coils in a typical induction heating device. Fig. 4 is a diagram of arrangement of heating coils in the induction heating device of the first embodiment.

[0087] Although the heating coil 3 is depicted as one heating coil in Fig. 3, the heating coil 3 may be composed of a plurality of smaller coils in the same arrangement.

[0088] The operation of the typical induction heating cooker will be described. A user places the cooking vessel 1 on the top plate 2 to directly face the heating coil 3. Since the typical induction heating device cannot heat the cooking vessel 1 unless the cooking vessel 1 directly faces the heating coil 3, the position of the heating coil 3 is typically displayed on the top plate 2.

[0089] The user operates the operation unit 6 corresponding to the heating coil 3 having the cooking vessel 1 placed thereon to determine a heating power etc., and input an instruction for a heating start.

[0090] The operation unit 6 corresponding to the heating coil 3 may be an operation unit 6a for operating a heating coil 3a and, similarly, as in the case of a heating coil 3b and an operation unit 6b as well as a heating coil 3c and an operation unit 6c, the heating coils 3 and the operation units 6 often correspond respectively to each other.

[0091] Otherwise, i.e., even if the heating coils 3 and the operation units 6 do not necessarily correspond to each other, for example, it is conceivable that operation buttons corresponding to the respective heating coils 3 are prepared in the one operation unit 6 or that a method is used for switching whether the heating coil 3a is defined as an control object or the heating coil 3a is defined as an control object. Such a means can be used because only three types of the heating coils 3 exist in the case of Fig. 3.

[0092] The heating control unit 4 gives a command for performing a detection operation of the cooking vessel 1 to the cooking vessel detection unit 5, and the cooking vessel detection unit 5 detects the cooking vessel 1. It is determined whether the heatable cooking vessel 1 is placed and what material the cooking vessel 1 is made of through the detection operation of the cooking vessel detection unit 5, and the determination result is sent out to the heating control unit 4.

[0093] The heating control unit 4 changes a heating method depending on the result. Specifically, if a load cannot be heated, this is indicated by display on the operation unit 6 and the operation frequency of the inverter circuit 7 is changed depending on a material of the cooking vessel 1 to perform the heating with the heating power instructed from the user.

[0094] As described above, the reason for performing the detection operation of the cooking vessel 1 in the typical induction heating cooker is to heat the cooking vessel 1 in an optimum state, and the detection operation of the cooking vessel 1 may be performed after receiving the heating instruction from the user and before the heating.

[0095] The operation and action of the induction heating cooker of the first embodiment will be described. A user places the cooking vessel 1 at an arbitrary position on the top plate 2. The user must place the cooking vessel 1 on at least one or more of the heating coils 3. The user may place a plurality of the cooking vessels 1.

[0096] When the user attempts to heat the certain cooking vessel 1 in this case, the operation unit 6 cannot prepare the operation unit corresponding to the cooking vessel 1 in advance because it is not known what size the cooking vessel 1 is and which position the cooking vessel 1 is placed at.

[0097] Therefore, the heating control unit 4 causes the cooking vessel detection unit 5 to perform the detection operation of the cooking vessel 1 to detect what size the cooking vessel 1 is and which position the cooking vessel 1 is placed at, and causes the operation unit 6 to display the result.

[0098] If a plurality of the cooking vessels 1 is detected, the operation unit 6 may display that a plurality of the cooking vessels 1 is present. If one cooking vessel 1 is selected from a plurality of the cooking vessels 1, the correlation between the display on the operation unit 6 and the actual cooking vessel 1 may be known from lighting around the selected cooking vessel 1 etc. The size of the cooking vessel 1 may not necessarily be reflected on the display. In particular, it is only necessary to display the information required for giving a heating instruction through the operation unit 6 for the certain cooking vessel 1 that the user desires to heat.

[0099] Specifically, as depicted in Fig. 5, for example, a display 8 corresponding to the cooking vessel 1 may be indicated by the operation unit 6. Fig. 5 is an appearance diagram of a display example of the operation unit 6 of the induction heating device of the first embodiment. The display 8 is an example of indicating that the one cooking vessel 1 is placed on the left near side relative to the center. As the number of the placed cooking vessels 1 increases, the number of the displays 8 accordingly increases.

[0100] For example, an operation object is specified by selecting the display 8 corresponding to the cooking vessel 1 desired to be set as an object to be heated, and the heating instruction can be input.

[0101] In the induction heating cooker having a multiplicity of the heating coils 3 adjacently arranged such that the cooking vessel 1 can be placed and heated at an arbitrary position, it is not sufficient to perform the detection operation of the cooking vessel 1 before starting the heating operation. In particular, the display 8 indicative of the cooking vessel 1 cannot be displayed on the operation unit 6 unless the detection operation of the cooking vessel 1 is always performed, and the user cannot input the heating instruction.

[0102] The position of placement of the cooking vessel 1 must also be detected for the heating control unit 4 to determine which of the heating coils 3 should be operated.

[0103] As described above, a difference between the conventional induction heating cooker and the induction heating cooker of this disclosure is that, while the heating coils 3 and the operation units 6 are clearly correlated in the conventional induction heating cooker, the heating coils 3 and the operation unit 6 are changed depending on a placement position of the cooking vessel 1 in the induction heating cooker 1 of the first embodiment. The detection operation of the cooking vessel 1 must preliminarily be performed for corresponding to a change in the placement position of the cooking vessel 1.

[0104] For the detection operation of the cooking vessel 1, as described above, the most effective method is to apply to the heating coil 3 a current at a frequency higher than that of heating so as to determine whether a load is placed from a heating coil current value etc. at this time point. When this method is used for performing the detection operation of the cooking vessel 1 for all the heating coils 3 at the same time, although each of the heating coils 3 consumes a small power, a power of several tens of watts is continuously consumed in total since a multiplicity of the heating coils 3 exists.

[0105] To perform the detection operation of the cooking vessel 1 for all the heating coils 3 at the same time, the inverter circuit 7 is required for applying a current to each of the heating coil 3 at a frequency higher than that of heating, resulting in a problem that equipment becomes larger in size and expensive.

[0106] Therefore, it is conceivable that a plurality of the heating coils 3 is switched by a relay etc. for the one inverter circuit 7 to apply a high-frequency current sequentially to a multiplicity of the heating coil 3 so as to detect the cooking vessel 1. Since this method eliminates the need of providing the inverter circuits 7 as many as the number of the heating coils 3, the equipment can be reduced in size and price.

[0107] A plurality of the inverter circuits 7 may be provided such that the heating coils 3 connected to the respective

inverter circuits 7 are divided. As a result, the detection operations of the cooking vessel 1 can be performed at the same time as mane as the number of the inverter circuits 7.

[0108] However, in the case of such a configuration, the relay must frequently be switched, resulting in a problem of the durability of the relay. Additionally, since the detection operation of the cooking vessel 1 is performed by switching the inverter circuits 7, the detection may immediately or not immediately be performed depending on the timing of placing the cooking vessel 1 and the timing of performing the detection operation.

[0109] Specifically, assuming that the detection operation takes 0.2 seconds for each of the heating coils 3 and that the one inverter circuit 7 is switched for the five heating coils 3 to perform the detection operation of the cooking vessel 1, it takes up to one second from the placement of the cooking vessel 1 until detection. If a blank time, for example, a blank time of 0.2 seconds, is provided between the detection operations of the heating coils 3, one cycle of the detection operation requires about two seconds.

[0110] As the number of the heating coils 3 connected to each of the inverter circuits 7 more increases, the time required for detection is elongated and a time lag is made larger from the placement of the cooking vessel 1 until display on the operation unit 6, giving a feeling of difference to a user and making it hard to use.

[0111] Therefore, the first embodiment includes the detection auxiliary unit 21 detecting an object on the top plate 2 in a simplified manner. This detection auxiliary unit 21 detects an object present on the top plate 2 and may detect an object other than the cooking vessel 1. The detection auxiliary unit 21 may not be able to accurately detect the cooking vessel 1 as in the case of the cooking vessel detection unit 5 and may detect any objects on the top plate 2 in a simplified manner. The detection auxiliary unit 21 depends on a detection mechanism thereof and therefore may not be able to detect all the objects on the top plate 2. The detection auxiliary unit 21 may be, for example, the temperature detection unit 22, an electrostatic capacity detection unit, a vibration detection unit, a distance estimation unit, a detection position determination unit, or a detection operation determination unit described later. By providing the detection auxiliary unit 21, the detection operation of the cooking vessel 1 by the cooking vessel detection unit 5 may be controlled to be turned on/off. As a result, if a possibility of placement of the cooking vessel 1 is small, the detection operation by the cooking vessel detection unit 5 can be stopped (turned off), thereby reducing the power consumption and improving the durability of the relay. If the detection auxiliary unit 21 detects a possibility of placement of the cooking vessel 1, the detection operation by the cooking vessel detection unit 5 can be started (turned on) to perform the detection operation of the cooking vessel 1 for the heating coil 3 at the position where the cooking vessel 1 is possibly placed, thereby reducing the power consumption and improving the durability of the relay.

[0112] Fig. 6 is a block diagram when the detection auxiliary unit of the induction heating device of the first embodiment is the temperature detection unit 22. In the first embodiment, the temperature detection unit 22 detecting a temperature of the cooking vessel 1 is disposed as the detection auxiliary unit 21 as depicted in Fig. 6. If a temperature detected by the temperature detection unit 22 is changed, the detected temperature change may be attributable to the placement of the cooking vessel 1. Therefore, by performing the detection operation of the cooking vessel 1 only after a temperature change is detected, the detection operation is performed only when the cooking vessel 1 is placed. This enables the reduction in time after placement of the cooking vessel 1 until detection and the elimination of problems such as a durability problem of the relay and an increase in power consumption due to repeating the unnecessary detection operation. Thus, the easy-to-use induction heating cooker can be achieved.

(Second Embodiment)

[0113] An induction heating device of a second embodiment will hereinafter be described. The induction heating device of the second embodiment is different from the induction heating device of the first embodiment in that the detection operation of the cooking vessel 1 is performed only for the heating coil 3 in the vicinity of the temperature detection unit 22 having a temperature change.

[0114] First, the temperature detection unit 22 is a unit detecting the temperature of the cooking vessel 1, and two types of the disposition method thereof are mainly available. One method is the case of disposing the temperature detection unit 22 at the substantial center of the heating coil 3 and includes the disposition depicted in Figs. 7 and 8, for example.

[0115] The other method is the case of disposing the temperature detection unit 22 at the substantial center among the adjacent heating coils 3 and includes the disposition depicted in Fig. 9, for example. Although only the one or four temperature detection units 22 are depicted in each of Figs. 7 to 9, the temperature detection units 22 are actually disposed at the substantial centers, or at the substantial centers among the heating coils 3, of all or a portion of the heating coils.

[0116] The second embodiment will first be described with reference to Fig. 7. Fig. 7(a) is a diagram of a range in which the detection operation of the cooking vessel 1 is performed when the temperature detection unit 22 of the induction heating device of the second embodiment is disposed at the center of the heating coil 3. Fig. 7(b) is a diagram of a range in which the detection operation of the cooking vessel 1 is performed when the temperature detection unit 22 of the

induction heating device of the second embodiment is disposed at the center of the heating coil 3.

[0117] Description will be made of the case that a change occurs in temperature detected by the temperature detection unit 22 on a second row from the left and a second row from the bottom when the induction heating hooker is viewed from a top surface. In this case, it is considered that the cooking vessel 1 is very likely to be placed on the temperature detection unit 22 detecting the temperature change.

[0118] Therefore, the detection operation of the cooking vessel 1 must be performed for the heating coil 3 around the temperature detection unit 22 detecting the temperature change.

[0119] On the other hand, even if no change occurs in the heating coil 3 surrounding the temperature detection unit 22 detecting the temperature change and the cooking vessel 1 cannot be detected on the heating coil 3, the cooking vessel 1 may be present on the heating coil 3 around that heating coil 3. Therefore, the detection operation of the cooking vessel 1 may be performed for the left, right, upper, and lower heating coils 3 adjacent to the heating coil 3 around the temperature detection unit 22 detecting the temperature change.

[0120] In particular, the detection operation of the cooking vessel 1 is performed for the five heating coils 3 surrounded by a dot-line of Fig. 7(a). As a result, the size and the placement position of the cooking vessel 1 can accurately be detected.

[0121] Considering a broader possibility, as depicted in Fig. 7(b), the detection operation of the cooking vessel 1 may be performed for the heating coils 3 located diagonally from the temperature detection unit 22 detecting a temperature change to perform the detection operation of the cooking vessel 1 for the nine heating coils 3 surrounded by a dot-line.

[0122] The case of a temperature change occurring in a plurality of the temperature detection units 22 will be described with reference to Fig. 8. Fig. 8(a) is a diagram of a range in which the detection operation of the cooking vessel 1 is performed when the temperature detection unit 22 of the induction heating device of the second embodiment is disposed at the center of the heating coil 3. Fig. 8(b) is a diagram of a range in which the detection operation of the cooking vessel 1 is performed when the temperature detection unit 22 of the induction heating device in the second embodiment is disposed at the center of the heating coil 3. Fig. 8 depicts only the temperature detection units 22 assumed as having a temperature change.

[0123] As described above, since the cooking vessel 1 is likely to be placed on the heating coils 3 around the temperature detection units 22 having the temperature change, the detection operation of the cooking vessel 1 is performed for these heating coils 3.

[0124] Since the cooking vessel 1 may overlap with the adjacent heating coils 3, the adjacent range is included in the detection operation of the cooking vessel 1. In this case, the detection operation of the cooking vessel 1 is performed for the 12 heating coils 3 surrounded by a dot-line of Fig. 8(a).

[0125] Considering a broader possibility, the detection operation of the cooking vessel 1 may be performed for the 16 heating coils 3 surrounded by a dot-line of Fig. 8(b).

[0126] Since the detection operation of the cooking vessel 1 is performed for the narrowed-down heating coils 3 in the vicinity of the temperature detection units 22 having the temperature change, the problem of durability of the relay and the problem such as an increase in power consumption can be eliminated.

[0127] By detecting the placement of the cooking vessel 1 from a temperature change and limiting the number of the heating coils 3 subjected to the detection operation, the detection operation can quickly be completed.

[0128] Figs. 9(a) and 9(b) in the case of disposing the temperature detection unit 22 at the substantial center among the heating coils 3 will be described. Fig. 9(a) is a diagram of a range in which the detection operation of the cooking vessel 1 is performed when the temperature detection unit 22 of the induction heating device of the second embodiment is disposed at the substantial center among the adjacent heating coils 3. Fig. 9(b) is a diagram of a range in which the detection operation of the cooking vessel 1 is performed when the temperature detection unit 22 of the induction heating device of the second embodiment is disposed at the substantial center among the adjacent heating coils 3.

[0129] Also in this case, the range of the detection operation of the cooking vessel 1 may be determined based on the same idea as when the temperature detection unit 22 is disposed at substantially the center of the heating coil 3. For example, if one of the temperature detection units 22 has a temperature change, as depicted in Fig. 9(a), the detection operation of the cooking vessel 1 may be performed for the four heating coils 3 in a dot-line including the heating coils 3 surrounding the one temperature detection unit 22 having the temperature change. If the multiple temperature detection units 22, i.e., the four temperature detection units 22, have a temperature change, as depicted in Fig. 9(b), the detection operation of the cooking vessel 1 may be performed for the heating coils 3 in a dot-line including the heating coils 3 surrounding the four temperature detection units 22 having the temperature change.

(Third Embodiment)

[0130] An induction heating device of a third embodiment will hereinafter be described. The induction heating device of the third embodiment is different from the induction heating device of the first embodiment in that the detection operation of the cooking vessel 1 is performed in a constant period.

[0131] In the first embodiment, it is described that since the cooking vessel 1 is likely to be placed only when the

temperature detection units 22 have a temperature change, the detection operation of the cooking vessel 1 is performed for the heating coils 3 thereof to acquire the effect such as a reduction in power consumption.

[0132] However, the effect is exerted only when the temperature of the cooking vessel 1 is different from the temperature detected by the temperature detection unit 22.

[0133] Therefore, if the temperature of the cooking vessel 1 is the same as the temperature detected by the temperature detection unit 22, no temperature change occurs and, therefore, the detection operation of the cooking vessel 1 is not performed. The display indicative of the placement of the cooking vessel 1 is not displayed on the operation unit 6. This causes a problem that the cooking vessel 1 cannot be heated.

[0134] It is not certain that the cooking vessel 1 always has a temperature different from the temperature detected by the temperature detection unit 22 and, if the cooking vessel 1 cannot be detected, a user must change the temperature of the cooking vessel 1 by any means, resulting in the induction heating cooker that is very hard to use.

[0135] To avoid such a situation, in the third embodiment, the detection operation of the cooking vessel 1 is performed in a constant period separately from the timing of the detection operation of the cooking vessel 1 described in the first embodiment so that such a situation can be avoided.

[0136] However, since the effect of reducing the problem of durability of the relay and the power consumption decreases if the detection operation of the cooking vessel 1 is frequently performed, the frequency must be minimized. For example, a detection period is determined from the number of the heating coils 3, a time required for the detection operation of the cooking vessel 1, product specifications, etc., and, for example, the detection operation may be performed every five seconds.

(Fourth Embodiment)

[0137] An induction heating device of a fourth embodiment will hereinafter be described. The induction heating device of the fourth embodiment is different from the induction heating device of the first embodiment in that an infrared sensor is used for the temperature detection units 22.

[0138] A problem caused by the temperature of the cooking vessel 1 same as the detection temperature of the temperature detection units 22 is described in the third embodiment. If the temperature detection unit 22 is composed of a thermistor, a heat capacity of the top plate 2 causes a problem that a time lag occurs after the cooking vessel 1 is placed until the temperature detection units 22 detects a change in temperature.

[0139] To solve these problems, it is effective to use an infrared sensor for the temperature detection units 22. The infrared sensor directly receives infrared light emitted from the cooking vessel 1 and therefore is excellent in responsiveness as compared to the thermistor.

[0140] Thus, the detection temperature of the temperature detection unit 22 immediately changes when the cooking vessel 1 is placed and, therefore, a shift to the detection operation of the cooking vessel 1 can immediately be made. As a result, a time can be reduced after the placement of the cooking vessel 1 until the display 8 indicative of the cooking vessel 1 is displayed on the operation unit 6.

[0141] Since the infrared sensor must receive the infrared light emitted from the cooking vessel 1, print applied to the top plate 2 is typically changed in a portion of a field of view receiving the infrared light in the infrared sensor so as to facilitate the transmission of the infrared light in general. Conversely, the portion other than the field of view receiving the light in the infrared sensor is desirably composed a material not transmitting the infrared light.

[0142] In such a configuration, if the cooking vessel 1 is not placed in the portion of the field of view of the infrared sensor, the infrared light contained in the sunlight and the lighting enters the infrared sensor, and the temperature calculated from the output of the infrared sensor normally indicates a temperature higher than an original temperature.

[0143] If the cooking vessel 1 is placed on the portion of the field of view of the infrared sensor from such a state, since the light such as the sunlight and the lighting is blocked, the infrared sensor no longer receives the infrared light contained in the sunlight and the lighting, and the infrared light received by the infrared sensor is only the infrared light emitted from the cooking vessel 1 so that the temperature of the cooking vessel 1 can be detected.

[0144] In particular, since a state of entering of ambient light such as the sunlight and the lighting changes depending on whether the cooking vessel 1 is placed, the detection operation of the cooking vessel 1 may be performed if a change occurs in the state of entering of ambient light.

[0145] Although it is very rare, if the infrared energy of the ambient light such as the sunlight and the lighting is equivalent to the infrared energy emitted from the cooking vessel 1, or if the ambient light such as the sunlight and the lighting is completely free of infrared energy and the infrared energy emitted from the cooking vessel 1 is in an amount corresponding to the detection temperature of the temperature detection unit 22, no change occurs in the energy amount received by the infrared sensor and a shift to the detection operation of the cooking vessel 1 cannot be made.

[0146] Therefore, even if the temperature detection unit 22 is the infrared sensor, it is effective to perform the detection operation of the cooking vessel 1 in a constant period as described in the third embodiment.

(Fifth Embodiment)

[0147] An induction heating device of a fifth embodiment will hereinafter be described. The induction heating device of the fifth embodiment is different from the induction heating device of the first embodiment in that an electrode 11 and the electrostatic capacity detection unit 12 detecting a change in electrostatic capacity are used for the detection auxiliary unit 21.

[0148] Fig. 10 is a block diagram when the detection auxiliary unit of the induction heating device of the fifth embodiment is composed of the electrostatic capacity detection unit 12.

[0149] The electrode 11 is a conductive body formed by application or adhesion and is disposed on the back surface of the top plate 2, and the electrostatic capacity detection unit 12 detects a change in an electrostatic capacity of a capacitor formed with the cooking vessel 1 that is a conductive body placed on the top plate 2 facing the electrode 11. Since the electrostatic capacity detection unit 12 operates independently of the cooking vessel detection unit 5 and the switching of the relay etc. is not required, a change in the electrostatic capacity can always be detected.

[0150] Since nothing is normally present on the top plate 2, air plays a role of an insulator necessary for forming the capacitor. However, if another thing such as the cooking vessel 1, a finger, water, and an object to be cooked is present on the top plate 2, a change occurs in the electrostatic capacity because the relative permittivity thereof is different from air. This change in the electrostatic capacity is detected by the electrostatic capacity detection unit 12. The electrostatic capacity detection unit 12 often converts a change in the electrostatic capacity into a change in DC voltage for detection, this is not a limitation.

[0151] In the case of a method of detecting a change in the electrostatic capacity, a change also occurs in the electrostatic capacity due to a thing other than a cooking vessel, for example, a wet dish cloth, and therefore, even if a change occurs in the electrostatic capacity, the cooking vessel 1 may not necessarily be placed.

[0152] When the cooking vessel 1 is detected with such a method, a problem of false detection occurs. Therefore, such a method is used as a trigger for the most effective method of detecting the cooking vessel 1, i.e., the method in which a current with a frequency higher than that of heating is applied to the heating coil 3 so as to determine whether a load is placed from a heating coil current value at this time point in the induction heating cooker of this disclosure. Since the detection operation is performed only for the heating coil 3 likely to have the cooking vessel 1 placed thereon, this enables the reduction in time after placement until detection and the elimination of problems such as a durability problem of the relay and an increase in power consumption due to repeating the unnecessary detection operation. Thus, the easy-to-use induction heating cooker can be achieved.

(Sixth Embodiment)

[0153] An induction heating device of a sixth embodiment will hereinafter be described. The induction heating device of the sixth embodiment is different from the induction heating device of the fifth embodiment in that an electrode is disposed in the vicinity of each heating coil to form a pair.

[0154] In the fifth embodiment, it is described that the detection operation of the cooking vessel 1 is performed only when a change occurs in the electrostatic capacity in the electrostatic capacity detection unit 12, so as to acquire the effect of power consumption reduction etc.

[0155] The detection accuracy of the cooking vessel 1 varies depending on how the electrodes 11 necessary for detection of the electrostatic capacity are arranged.

[0156] In the induction heating cooker of this disclosure having a multiplicity of heating coils closely arranged in a matrix shape, it must be detected whether the cooking vessel 1 is placed on each of the heating coils 3 and whether the heating coil 3 can be operated.

[0157] Therefore, the heating coil 3 and the electrode 11 necessary for detecting the electrostatic capacity are desirably disposed as a pair as depicted in Fig. 11. Although the electrode 11 necessary for detecting the electrostatic capacity is composed of three electrodes 11 a, 11 b, and 11c for one of the heating coils 3 in Fig. 11, the number of the electrodes is not limited to three.

[0158] As described above, by arranging the electrodes 11 around the heating coils 3, the detection of the cooking vessel 1 can be assisted and the cooking vessel 1 can more quickly and accurately be detected.

(Seventh Embodiment)

[0159] An induction heating device of a seventh embodiment will hereinafter be described. The induction heating device of the seventh embodiment is different from the induction heating device of the sixth embodiment in that the electrode 11 is disposed at a position that is the center among the multiple adjacent heating coils.

[0160] In the sixth embodiment, the induction heating cooker having an electrode disposed to form a pair with each heating coil is described. The induction heating cooker with such a configuration has a problem that the number of the

electrodes 11 increases and makes the configuration complicated although the cooking vessel 1 is quickly be detected.

[0161] Therefore, in the seventh embodiment, the electrode 11 necessary for detection of the electrostatic capacity is disposed at a position that is the substantial center of the multiple adjacent heating coils 3 (heating coils 3a, 3b, 3c, and 3d) as depicted in Fig. 12 to reduce the number of the electrodes 11 so that the equipment configuration can be made simplified and inexpensive.

[0162] If a change occurs in the electrostatic capacity, the detection operation of the cooking vessel 1 can be performed for the heating coils 3 around the position where the change occurs in the electrostatic capacity as described in the second embodiment, so as to quickly and accurately detect the cooking vessel 1.

(Eighth Embodiment)

[0163] An induction heating device of an eighth embodiment will hereinafter be described. The induction heating device of the eighth embodiment is different from the induction heating device of the first embodiment in that the vibration detection unit 13 detecting vibrations of the top plate 2 is used for the detection auxiliary unit 21.

[0164] In the eighth embodiment, Fig. 13 is a block diagram of the induction heating device when the detection auxiliary unit is composed of the vibration detection unit 13 according to the eighth embodiment. The vibration generated in the cooking vessel 1 propagates to the top plate 2. The vibration detection unit 13 detects the vibration of the top plate 2.

[0165] The vibration detection unit 13 is desirably configured to be brought into contact with the back surface of the top plate 2. The vibration detection unit 13 may be configured such that the adhesion between the top plate 2 and the vibration detection unit 13 is increased or that the vibration detection unit 13 is further pressed against the top plate 2 by using a spring etc.

[0166] The vibration detection unit 13 only needs to detect the vibration of the top plate 2 and, therefore, for example, even if the vibration detection unit 13 is disposed on the heating coil 3 brought into contact with the top plate 2, the vibration of the top plate 2 can be detected. As a result, the equipment configuration can be simplified.

[0167] Although a vibration detection level is reduced in this case and, therefore, amplification must further be performed by using an amplifier etc., which may deteriorate an SN ratio, any configuration may be available as long as the vibration of the top plate 2 can be detected.

[0168] Although a piezoelectric element is often used for the vibration detection unit 13, this is not a limitation. The vibration detection unit 13 is connected to the heating control unit 4 and the heating control unit 4 can detect a possibility of placement of the cooking vessel 1 from the vibration generated in the top plate 2. As a result, the heating control unit 4 can instruct the cooking vessel detection unit 5 to start the detection operation and can detect the cooking vessel 1.

[0169] Although the vibration generated in the top plate 2 is not limited to the case of placement of the cooking vessel 1, the number of times of the detection operation can drastically be reduced as compared to the convention method in which the detection operation of the cooking vessel 1 must always be performed and, therefore, the easy-to-use induction heating cooker can be achieved that can eliminate the problems such as the durability problem of the relay and the increase in power consumption due to repeating the unnecessary detection operation.

[0170] It may be determined from a vibration waveform of the vibration detection unit 13 whether a vibration waveform is that of placement of the cooking vessel 1 by using the patterns of waveforms in the case of placement of the cooking vessel 1 and in the other cases, and the detection operation of the cooking vessel 1 may be performed only when it is determined that the cooking vessel 1 is placed. As a result, a further power consumption reduction etc. can be achieved.

(Ninth Embodiment)

[0171] An induction heating device of a ninth embodiment will hereinafter be described. The induction heating device of the ninth embodiment is different from the induction heating device of the eighth embodiment in that a plurality of the vibration detection units 13 detecting vibrations is provided so as to use the position estimation unit 14 estimating a position of a vibration source from a phase difference of the vibration waveforms thereof.

[0172] In the ninth embodiment, Fig. 14 is a block diagram of the induction heating device when a position of a vibration source is estimated from a plurality of the vibration detection units 13 according to the ninth embodiment.

[0173] A plurality of the vibration detection units 13 detecting the vibrations of the top plate 2 is provided. The plurality of the vibration detection units 13 can be arranged such that the vibrations of the top plate 2 are detected at positions away from each other to facilitate the estimation of the position of the vibration source.

[0174] A vibration waveform is the output of each of the vibration detection units 13 and is sent to the position estimation unit 14. The position estimation unit 14 estimates the position of the vibration source from a phase difference of the vibration waveforms of the respective vibration detection units 13 and a positional relationship of the vibration detection units 13.

[0175] For example, if no phase difference exists, it is revealed that the cooking vessel 1 is placed at a position equidistant from the respective vibration detection units 13 and, therefore, the detection operation of the cooking vessel

1 may be performed for the heating coil 3 corresponding to the position.

[0176] Since the distances from the respecting vibration detection units 13 are estimated from a relationship between the vibration propagation speed of the top plate 2 and the phase difference, the detection operation of the cooking vessel 1 may be performed for the heating coil 3 corresponding to the position satisfying these distances.

[0177] Although the position estimation unit 14 may be the same unit as the heating control unit 4 and the cooking vessel detection unit 5 and is often implemented as a microcomputer, a DSP, or a custom IC, this is not a limitation.

(Tenth Embodiment)

[0178] An induction heating device of a tenth embodiment will hereinafter be described. The induction heating device of the tenth embodiment is different from the induction heating device of the first embodiment in that a light-emitting unit 15, a light-receiving unit 16, and the distance estimation unit 17 estimating a distance to an object on the light-receiving unit 16 based on a light amount received by the light-receiving unit 16 are used for the detection auxiliary unit 21.

[0179] In the tenth embodiment, Fig. 15 is a block diagram of the induction heating device when the detection auxiliary unit according to the tenth embodiment is composed of the distance estimation unit 17.

[0180] The light-emitting unit 15 emits light toward the upper surface of the top plate 2 and the light may be visible light or infrared light. The light-emitting unit 15 is connected to the distance estimation unit 17 or the heating control unit 4 and emits light when a light-emitting instruction is given.

[0181] The light emitted by the light-emitting unit 15 is reflected by any object and the light-receiving unit 16 receives the reflected light. Therefore, the light-reception sensitive wavelength of the light-receiving unit 16 must include the emission wavelength of the light-emitting unit 15. The light-receiving unit 16 performs an output corresponding to a received energy amount and the output is sent to the distance estimation unit 17.

[0182] The distance estimation unit 17 estimates a distance to an object based on how much the light emitted by the light-emitting unit 15 was reflected by the object and could be received by the light-receiving unit 16. Although the estimation of the distance may be based on a triangulation method, this is not a limitation.

[0183] The result estimated by the distance estimation unit 17 is sent to the heating control unit 4 and if it is determined that the cooking vessel 1 is placed, the detection operation of the cooking vessel 1 is performed for the corresponding heating coil 3. This enables the reduction in time after placement until detection and the elimination of problems such as a durability problem of the relay and an increase in power consumption due to repeating the unnecessary detection operation. Thus, the easy-to-use induction heating cooker can be achieved.

[0184] Although the distance estimation unit 17 may be the same unit as the heating control unit 4 and the cooking vessel detection unit 5 and is often implemented as a microcomputer, a DSP, or a custom IC, this is not a limitation.

[0185] In the tenth embodiment configured as described above, the detection operation of the cooking vessel is performed only when needed in the induction heating device having a multiplicity of heating coils adjacently arranged such that the cooking vessel placed at any position can be heated. This enables a reduction in the power consumption and an improvement in the durability of the relay that is a switching component, and a user can perform a heating operation immediately after placing a cooking vessel. Thus, the easy-to-use induction heating device can be achieved.

(Eleventh Embodiment)

[0186] Fig. 16 is a schematic block diagram of a state in which the cooking vessel 1 is placed on an induction heating device of an eleventh embodiment and depicts a state in which the cooking vessel 1 is placed on the built-in type induction heating cooker.

[0187] In this disclosure, the detection position determination unit 23 increases a frequency of the detection operation of the heating coil 3 at a position where the cooking vessel 1 is more likely to be placed. Therefore, the cooking vessel detection unit 5 frequently performs the detection operation for the corresponding heating coil 3. On the other hand, a frequency of performing the detection operation is reduced for the heating coil 3 at a position where the cooking vessel 1 is less likely to be placed. This enables a reduction in the power consumption and an improvement in the durability of the relay.

[0188] The detection position determination unit 23 is connected to the heating control unit 4 and the cooking vessel detection unit 5. The detection position determination unit 23 determines the heating coil 3 for which the detection operation is performed based on information from the heating control unit 4 and causes the cooking vessel detection unit 5 to perform the detection operation of the cooking vessel 1. The detection result of the cooking vessel detection unit 5 is sent to the detection position determination unit 23, and the detection position determination unit 23 further sends the detection result to the heating control unit 4. The heating control unit 4 updates the contents displayed on the operation unit 6, or makes a determination such as performing the detection operation of the cooking vessel 1 again, based on the detection result.

[0189] Although the cooking vessel detection unit 5 is connected via the detection position determination unit 23 to

the heating control unit 4 in this description, the cooking vessel detection unit 5 and the detection position determination unit 23 may directly be connected to the heating control unit 4. The detection position determination unit 23 is often implemented as a microcomputer, a DSP, a custom IC, etc., this is not a limitation and all or some of the functions of the heating control unit 4, the cooking vessel detection unit 5, and the detection position determination unit 23 may be implemented by the same unit.

[0190] The detection position determination unit 23 sets the detection frequency of the cooking vessel 1 higher for the heating coil 3 on which the cooking vessel 1 is more likely to be placed, and sets the detection frequency of the cooking vessel 1 lower for the heating coil 3 on which the cooking vessel 1 is less likely to be placed. Therefore, the cooking vessel detection unit 5 more frequently performs the detection operation of the cooking vessel 1 for the heating coil 3 on which the cooking vessel 1 is more likely to be placed, and less frequently performs the detection operation of the cooking vessel 1 for the heating coil 3 on which the cooking vessel 1 is less likely to be placed. This enables suppression of a time required until detection of the cooking vessel 1 and a reduction of the number of times of the detection operation of the cooking vessel 1. As a result, the power consumption necessary for the detection operation of the cooking vessel 1 can be suppressed, and the durability of the relay can be improved if the device is configured such that the inverter circuit 7 and the heating coils 3 are switched by using the relay.

[0191] The frequency of performing the detection operation will be described. If the detection operation of the cooking vessel 1 is performed at the same frequency for all the heating coils 3, for example, it is assumed that the detection operation is performed once every three seconds. On the other hand, it is assumed that the detection operation is performed once every second for the heating coil 3 determined by the detection position determination unit 23 as being more likely to have the cooking vessel 1 placed thereon. In contrast, it is assumed that the detection operation is performed once every five seconds for the heating coil 3 determined by the detection position determination unit 23 as being less likely to have the cooking vessel 1 placed thereon. As a result, the cooking vessel 1 can quickly be detected and the power consumption can be reduced. To further reduce the power consumption, the detection operation is stopped (which corresponds to the detection frequency of zero) for the heating coil 3 determined by the detection position determination unit 23 as being less likely to have the cooking vessel 1 placed thereon.

(Twelfth Embodiment)

[0192] An induction heating device of a twelfth embodiment will hereinafter be described. The induction heating device of the twelfth embodiment is different from the induction heating device of the eleventh embodiment in that the heating coils 3 disposed at positions defined as an outermost peripheral portion is set by the detection position determination unit 23 to have a detection frequency lower than that of the heating coils 3 disposed at other than the outermost peripheral portion out of a plurality of the heating coils.

[0193] The heating coils 3 defined as the outermost peripheral portion will first be described. Figs. 17(a) and 17(b) are diagrams of arrangement of the heating coils of the induction heating device of the twelfth embodiment. Fig. 17(a) depicts the case that the heating coils 3 are not disposed on the sides of the operation unit 6 and Fig. 17(b) depicts the case that the heating coils 3 are disposed also on the sides of the operation unit 6.

[0194] The heating coils 3 defined as the outermost peripheral portion are the heating coils 3 in a shaded area surrounded by dot-lines in Figs. 17(a) and 17(b) and correspond to 24 heating coils in Fig. 17(a) and 26 heating coils in Fig. 17(b).

[0195] Fig. 18(a) depicts an example of placing the cooking vessel 1 only on the heating coils 3 located in the outermost peripheral portion. Figs. 18(a) and 18(b) are diagrams of arrangement of the cooking vessel 1 and the heating coils 3 of the induction heating device in the twelfth embodiment.

[0196] If the cooking vessel 1 is placed as depicted in Fig. 18(a), the cooking vessel 1 protrudes from the induction heating device and, since only the two heating coils 3 are present immediately under the cooking vessel 1, it takes time to cook.

[0197] Therefore, the cooking vessel 1 is normally not placed in this way and is often placed such that the more heating coils 3 are present immediately under the cooking vessel 1 as depicted in Fig. 18(b). In this case, the cooking vessel 1 is placed also over a heating coil 3d at a position other than the outermost peripheral portion. The detection operation of the cooking vessel 1 is performed for the heating coil 3d in a normal period (in a period of three second in the example of the eleventh embodiment) and the cooking vessel 1 is first detected on the heating coils 3. As a result, the detection operation of the cooking vessel 1 is further performed in the periphery thereof, i.e., for the heating coils 3 adjacent to the heating coil 3d, and the accurate position and size of the cooking vessel 1 can be detected.

[0198] As described above, since the cooking vessel 1 is less likely to be placed only on the heating coils 3 in the outermost peripheral portion, it is considered that the frequency of performing the detection operation of the cooking vessel 1 may be reduced for the heating coils 3 defined as the outermost peripheral portion without a significant practical problem.

[0199] However, since the cooking vessel 1 may be small in some cases, if the detection operation of the cooking

vessel 1 is completely stopped (which corresponds to the detection frequency of zero) for the heating coils 3 defined as the outermost peripheral portion, a problem occurs that the cooking vessel 1 is not detected and, therefore, these must be taken into considerations when the detection period (or the detection frequency as the reciprocal) of the cooking vessel 1 is determined for the heating coils 3 defined as the outermost peripheral portion.

(Thirteenth Embodiment)

[0200] An induction heating device of a thirteenth embodiment will hereinafter be described. The induction heating device of the thirteenth embodiment is different from the induction heating device of the eleventh embodiment in that, if it is detected that the cooking vessel 1 is placed over the one heating coil 3, the detection operation of the cooking vessel 1 is performed also for the heating coils 3 adjacent to the heating coil 3. As a result, the accurate position and size of the cooking vessel 1 can be detected.

[0201] Even when it is detected that the cooking vessel 1 is placed on the one heating coil 3 and any of the adjacent heating coils 3 has a frequency of performing the detection operation set lower as compared to the other heating coils 3, the detection operation of the cooking vessel 1 may immediately be performed for the adjacent heating coil 3. Alternatively, the priority of performing the detection operation of the cooking vessel 1 may be set to be increased for the heating coil 3 having the frequency of performing the detection operation set lower as compared to the other heating coils 3. In this case, only the priority may be increased, or the priority may be increased while the detection frequency is made higher.

[0202] As described in the twelfth embodiment, for example, the frequency of performing the detection operation of the cooking vessel 1 is set lower for heating coils 3e, 3f, 3g, 3h, and 3i defined as the outermost peripheral portion.

[0203] It is assumed that the heating coil 3d is detected as having the cooking vessel 1 placed thereon. In this case, the cooking vessel 1 is possibly placed also on the adjacent heating coils 3e, 3f, 3g, 3h, and 3i (Fig. 18(b)). On the other hand, as described above, the detection frequency is set lower for the heating coils 3e, 3f, 3g, 3h, and 3i defined as the outermost peripheral portion out of the adjacent heating coils.

[0204] However, even if it is detected that the cooking vessel 1 is placed on the heating coil 3d and the adjacent heating coils 3 include the heating coils 3e, 3f, 3g, 3h, and 3i having the detection frequency set lower, the cooking vessel 1 is highly possibly placed also on these heating coils 3e, 3f, 3g, 3h, and 3i and, therefore, the detection operation of the cooking vessel 1 is performed. As a result, the accurate position and size of the cooking vessel 1 can be detected.

(Fourteenth Embodiment)

[0205] An induction heating device of a fourteenth embodiment will hereinafter be described. The induction heating device of the fourteenth embodiment is different from the induction heating device of the eleventh embodiment in that the detection position determination unit 23 determines the frequency of performing the detection operation of the cooking vessel 1 for the heating coils 3 based on the positions and the numbers of times of the heating coils 3 having the cooking vessel 1 placed thereon within a predetermined period.

[0206] Figs. 19(a) and 19(b) are diagrams of a use history of the heating coils of the induction heating device of the fourteenth embodiment. Fig. 19(a) is a diagram of addresses of the heating coils 3. Fig. 19(b) is a diagram of use frequency of the heating coils 3 of Fig. 19(a). In Fig. 19, only the nine heating coils 3 are extracted and the others are not depicted.

[0207] The use frequency depicted in Fig. 19(b) is the number of times of placement of the cooking vessel 1 on each of the heating coils 3 within a predetermined period. The predetermined period may be, for example, the use of past one month, the use of past 100 times, or from the beginning of use to the last use. The detection position determination unit 23 determines which place is more frequently used within these periods to set a high frequency of performing the detection operation for the heating coils 3 at positions of a high use frequency and set a low frequency of performing the detection operation for the heating coils 3 at positions of a low use frequency.

[0208] Specifically, a high frequency of performing the detection operation is set for the heating coils 3p, 3q, 3s, and 3t associated with a high use frequency, and a low frequency of performing the detection operation is set for the heating coils 3j, 3k, 3m, 3n, and 3r associated with a low use frequency. By learning from a past actual status, the cooking vessel 1 can quickly be detected without excessively increasing the number of times of the detection operation (the detection frequency) of the cooking vessel 1 for the induction device, and the power consumption required for the detection operation can also be reduced.

(Fifteenth Embodiment)

[0209] An induction heating device of a fifteenth embodiment will hereinafter be described. The induction heating device of the fifteenth embodiment is different from the induction heating device of the eleventh embodiment in that the

detection position determination unit 23 sets the detection frequency higher for the heating coils 3 disposed closer to the operation unit 6 as compared to the heating coils 3 disposed in the direction away from the operation unit 6.

[0210] in this disclosure, since the multi-coil configuration is employed that has a multiplicity of the heating coils 3 arranged under the top plate 2, the cooking vessel 1 may be placed at any positions. However, easily usable positions and the other positions exist in reality. For example, if a wall is on the left of the induction heating device and a cooking table and a sink are on the right, the right side from the center of the induction heating device is more frequently used and a use frequently becomes lower on the left side.

[0211] Similarly, between the near side and the far side from the operation unit 6, the use frequency tends to become high in the heating coils on the near side from the operation unit 6 as compared to the far side from the operation unit 6. This is considered to be because the cooking vessel 1 containing foodstuffs becomes heavy and therefore tends to be placed near. Thus, by making the frequency of the detection operation of the cooking vessel 1 higher for the heating coils 3 disposed closer to the operation unit 6 as compared to the heating coils 3 disposed in the direction away from the operation unit 6, the overall power consumption required for the detection operation can also be reduced.

(Sixteenth Embodiment)

[0212] An induction heating device of a sixteenth embodiment will hereinafter be described. The induction heating device of the sixteenth embodiment is different from the induction heating device of the eleventh embodiment in that the detection position determination unit 23 sets the detection frequency lower for the heating coils 3 disposed in the direction away from the operation unit 6 relative to the heating coils 3 being in the heating operation as compared to the other heating coils 3.

[0213] If the cooking vessel 1 being heated already exists, it is difficult to place the cooking vessel 1 on the heating coil 3 disposed on the far side, i.e., in the direction away from the operation unit 6, relative to the heating coils 3 being in the heating operation because the cooking vessel 1 being heated becomes an obstacle. This is because the cooking vessel 1 containing foodstuffs is heavy as described above and, if a user accidently touches the cooking vessel 1 being heated due to the cooking vessel 1 being heated becoming an obstacle, the user may get burned.

[0214] Therefore, with regard to the heating coils 3 located in the direction away from the operation unit 6 relative to the heating coils 3 being in the heating operation, the possibility of use is extremely low. Thus, the power consumption can be suppressed by reducing the number of times of the detection operation, i.e., lowering the detection frequency, for the heating coils as compared to the heating coils 3 closer to the operation unit 6.

(Seventeenth Embodiment)

[0215] An induction heating device of a seventeenth embodiment will hereinafter be described. The induction heating device of the seventeenth embodiment is different from the induction heating device of the eleventh embodiment in that the detection position determination unit 23 sets the detection frequency lower for the heating coils 3 adjacent to the heating coils 3 being in the heating operation as compared to the other heating coils 3.

[0216] When it is attempted to place the cooking vessel 1 on the heating coils 3 adjacent to the heating coils 3 being in the heating operation and the cooking vessel 1 is a pot, the cooking vessel is difficult to place because a flange etc. become an obstacle.

[0217] Additionally because the cooking vessels 1 are usually not heated in close contact with each other, the cooking vessel 1 is less likely to be placed on the heating coils 3 adjacent to the heating coils 3 in the heating operation. Therefore, the power consumption can be suppressed by reducing the number of times of the detection operation, i.e., lowering the detection frequency, for the heating coils 3 adjacent to the heating coils 3 being in the heating operation.

[0218] Although it is described that the detection frequency of the object heating coils 3 is made lower than the other heating coils 3, the detection frequency may be set lower than the previous frequency. In particular, the heating coils 3 adjacent to the heating coils 3 being in the heating operation may have the detection frequency set lower than the detection frequency before the heating operation is performed.

(Eighteenth Embodiment)

[0219] An induction heating device of an eighteenth embodiment will hereinafter be described. The induction heating device of the eighteenth embodiment is different from the induction heating device of the eleventh embodiment in that if a control value is abruptly changed in the heating control unit 4 controlling the high-frequency current of the heating coils 3 being in the heating operation, the detection position determination unit 23 sets the detection frequency higher for the heating coils 3 adjacent to the heating coils 3 being in the heating operation as compared to the other heating coils 3.

[0220] If the cooking vessel 1 being heated is moved and the heating control unit 4 attempts to supply the same power as it is, a control value of a switching element such as an IGBT making up the inverter circuit 7 must be changed.

[0221] Specifically, if the cooking vessel 1 being heated is moved and the power is controlled by a frequency of switching, the frequency must be made lower, or if the power is controlled by a conduction ratio, the conduction ratio must be made higher. In contrast, if the cooking vessel 1 is not moved, these control values are constant or only slowly changed.

[0222] Conversely, if the cooking vessel is moved, the control values are abruptly changed. Therefore, when the control values are abruptly changed, the cooking vessel 1 is highly possibly moved. As a result, the cooking vessel is likely to be moved and placed on the heating coils 3 adjacent to the heating coils 3 being heated. Therefore, the cooking vessel 1 can quickly be detected by increasing the detection frequency.

[0223] Although it is described that the detection frequency of the object heating coils 3 is made higher than the other heating coils 3, the detection frequency may be set higher than the previous frequency. In particular, if a control value is abruptly changed in the heating control unit 4 controlling the high-frequency current of the heating coils 3 being in the heating operation, the heating coils 3 adjacent to the heating coils 3 being in the heating operation may have the frequency set higher than the previous frequency of performing the detection operation.

(Nineteenth Embodiment)

[0224] An induction heating device of a nineteenth embodiment will hereinafter be described. The induction heating device of the nineteenth embodiment is different from the induction heating device of the eleventh embodiment in that the power source operation unit 24 capable of switching whether a power source is supplied to the operation unit 6 etc. is included and that if a predetermined time has elapsed after a user operates the power source operation unit 24 to achieve a state of supplying the power source to the operation unit 6 etc., the detection position determination unit 23 sets the frequency of performing the detection operation of the heating coils 3 lower or to zero (corresponding to a stop of the detection operation).

[0225] The power source operation unit 24 is a unit switching whether the power source is supplied to those making up the induction heating device such as the operation unit 6 and is a so-called power switch. If a user operates the power source operation unit 24 to achieve a state in which the power source is supplied, the detection operation of the cooking vessel 1 is repeatedly performed; however, the cooking vessel 1 may not immediately be placed because the user is performing another cooking procedure. Since the detection operation of the cooking vessel 1 is performed even during this period, power is wastefully consumed. Therefore, if the cooking vessel 1 is not placed even when a predetermined time has elapsed after the power source operation unit 24 is operated to start supplying the power source, the frequency of performing the detection operation of the cooking vessel 1 can be set lower to suppress the power consumption.

[0226] In the eleventh to nineteenth embodiments configured as described above, the frequency of performing the detection operation is set higher for the heating coils 3 disposed at positions at which the cooking vessel 1 is more likely to be placed in the induction heating device having a multiplicity of the heating coils 3 adjacently arranged such that the cooking vessel 1 placed at any position can be heated. Conversely, the frequency of performing the detection operation is set lower for the heating coils 3 on which the cooking vessel 1 is less likely to be placed. This enables a reduction in the power consumption and an improvement in the durability of the relay that is a switching component. Thus, the easy-to-use induction heating device can be achieved such that a user can perform the heating operation with the operation unit 6 as soon as the cooking vessel 1 is placed.

(Twentieth Embodiment)

[0227] Fig. 20 is a schematic block diagram of a state in which the cooking vessel 1 is placed on an induction heating device of a twentieth embodiment of this disclosure. Fig. 20 depicts a state in which the cooking vessel 1 is placed on the built-in type induction heating cooker.

[0228] In this disclosure, the detection operation determination unit 31 frequently performs the detection operation of the cooking vessel 1 when the cooking vessel 1 is more likely to be placed, and reduces the frequency of performing the detection operation of the cooking vessel 1 when the cooking vessel 1 is less likely to be placed. This enables a reduction in the power consumption and an improvement in the durability of the relay.

[0229] The detection operation determination unit 31 is connected to the heating control unit 4 and the cooking vessel detection unit 5. The detection operation determination unit 31 determines a period of performing the detection operation (or the detection frequency that is the reciprocal thereof) of the cooking vessel 1 based on the information from the heating control unit 4 and causes the cooking vessel detection unit 5 to perform the detection operation of the cooking vessel 1.

[0230] The detection result of the cooking vessel detection unit 5 is sent to the detection operation determination unit 31, and the detection operation determination unit 31 further sends the detection result to the heating control unit 4. The heating control unit 4 updates the contents displayed on the operation unit 6, or makes a determination such as performing the detection operation of the cooking vessel 1 again, based on the detection result.

[0231] Although the cooking vessel detection unit 5 is connected via the detection operation determination unit 31 to the heating control unit 4 in this description, the cooking vessel detection unit 5 and the detection operation determination unit 31 may directly be connected to the heating control unit 4.

[0232] The detection operation determination unit 31 is often implemented as a microcomputer, a DSP, a custom IC, etc., this is not a limitation and all or some of the functions of the heating control unit 4, the cooking vessel detection unit 5, and the detection operation determination unit 31 may be implemented by the same unit.

[0233] The detection operation determination unit 31 determines the cases of high and low possibilities that the cooking vessel 1 is placed or the placement position is changed. In the case of a high possibility that the cooking vessel 1 is placed, the detection operation determination unit 31 immediately performs the detection operation of the cooking vessel 1 or reduces a time required until the detection of the cooking vessel 1 by making the execution period of the detection operation shorter, i.e., making the detection frequency higher.

[0234] On the other hand, in the case of a low possibility that the cooking vessel 1 is placed, the detection operation determination unit 31 can make the execution period of the detection operation longer or stop the detection operation to reduce the power consumption and improve the durability of the relay. As a result, the easy-to-use induction heating cooker can be achieved.

(Twenty-First Embodiment)

[0235] An induction heating device of a twenty-first embodiment will hereinafter be described. The induction heating device of the twenty-first embodiment is different from the induction heating device of the twentieth embodiment in that if a predetermined time has elapsed after a user operates the operation unit 6 last time, the detection operation determination unit 31 sets the frequency of performing the detection operation of the cooking vessel 1 lower or to zero (corresponding to a stop of the detection operation).

[0236] Typically, the induction heating cooker often has a power source switching unit not depicted. The power source switching unit is a unit switching whether a power source is supplied to the units of the induction heating cooker. If the power source is not supplied, power is not consumed and, therefore, energy saving is achieved.

[0237] On the other hand, if the power source is supplied, since the display must be performed on the operation unit 6 and the cooking vessel detection unit 5 must repeat the operation of detecting whether the cooking vessel 1 is placed, the power required for the detection operation is wastefully consumed in a sense if the induction heating cooker is not used. Particularly, if the heating operation is terminated and a user is already performing an operation such as dishing, the user may forget to operate the power source switching unit to achieve a state in which the power source is not supplied. In such a case, the detection operation determination unit 31 considers that the induction heating cooker is possibly used again, and performs the detection operation of the cooking vessel 1 to wastefully consume the power.

[0238] In such a case, the user does not operate the operation unit 6 after using the operation unit 6 to input a heating stop instruction. Therefore, if a predetermined time has elapsed after the user operates the operation unit 6 last time, it can be determined that the possibility of performing the heating operation again is not high and the detection operation determination unit 31 can make the execution period of the detection operation longer to reduce the power consumption. Alternatively, if the possibility of performing the heating operation is extremely low, the heating operation may be stopped. In this case, an operation is required such as operating the operation unit 6 again to resume the detection operation of the cooking vessel 1 or supplying the power source again after once stopping the supply of the power source by the power source supply switching unit.

[0239] The predetermined time after the last operation of the operation unit 6 by the user until changing the execution period of the detection operation (the reciprocal of the detection frequency) should be determined from the usability for the user etc., and may be set to about five minutes, for example. With regard to the frequency of performing the detection operation of the cooking vessel 1, for example, when it is assumed that a period of three seconds is used during the normal time such as immediately after power-on, a period of ten seconds may be set when no operation is performed, and any period may be used as long as the period is longer than that of the normal time. Although lower power consumption is achieved by making the execution period of the detection operation of the cooking vessel 1 longer, when the heating is performed again, a longer time is required until being reflected on the display of the operation unit 6 depending on timing and the induction heating cooker becomes hard to use. Therefore, by providing the setting for returning the detection operation of the cooking vessel 1 to an original period etc., the execution period may be set to the extent that the usability for a user is not deteriorated.

(Twenty-Second Embodiment)

[0240] An induction heating device of a twenty-second embodiment will hereinafter be described. The induction heating device of the twenty-second embodiment is different from the induction heating device of the twentieth embodiment in that a human body detection unit 32 detecting a human body is included and that if the human body detection unit 32

detects a human, the cooking vessel detection unit 5 immediately starts the detection operation of the cooking vessel 1. As a result, if a human is detected, the detection operation of the cooking vessel 1 can be performed at least once at an early stage. In particular, even when the detection operation of the cooking vessel 1 is already performed, a blank time may be included between the detection operations of the heating coils 3. Even in such a case, if the human body detection unit 32 detects a human, the detection operation of the cooking vessel 1 is immediately be started and, therefore, the cooking vessel 1 is more quickly be detected.

[0241] Instead of or in addition to starting the detection operation of the cooking vessel 1 by the cooking vessel detection unit 5, the detection operation determination unit 31 may set the overall frequency of performing the detection operation of the cooking vessel higher when the human body detection unit 32 detects a human as compared to when a human is not detected.

[0242] In Fig. 20, when a user comes in front of the induction heating cooker, this is detected by the human body detection unit 32. Although, for example, a pyroelectric element detecting a change in infrared light is often used for the human body detection unit 32, this is not a limitation.

[0243] The human body detection unit 32 is connected to the heating control unit 4, and the detection result of the human body detection unit 32 is sent to the detection operation determination unit 31. If the human body detection unit 32 detects that a user is present near the induction heating cooker, the detection operation determination unit 31 can determine that the heating operation is likely to be subsequently performed. Therefore, even if the frequency of the detection operation of the cooking vessel 1 is reduced as depicted in, for example, the twenty-first embodiment, the overall frequency of performing the detection operation of the cooking vessel is set higher. As a result, the cooking vessel 1 can quickly be detected by performing the detection operation of the cooking vessel 1 at least once in a short period. In this case, the detection frequency may be set higher for a certain period.

[0244] Since it is well conceivable that the heating operation is not immediately performed, the detection operation determination unit 31 can give an instruction for continuously performing the detection operation of the cooking vessel 1 so as to quickly detect the cooking vessel 1.

[0245] Conversely, if the human body detection unit 32 detects that a user is not present, the detection operation of the cooking vessel 1 is not required since the cooking vessel 1 is not placed or moved. Therefore, in such a case, the cooking vessel detection unit 5 stops the detection operation of the cooking vessel 1. As a result, wasteful power consumption can be suppressed. Moreover, if the induction heating device is configured such that the connection of the inverter circuit 7 and the heating coils 3 is switched by using the relay, the number of times of driving the relay can be reduced to improve the durability of the relay.

[0246] Instead of or in addition to stopping the detection operation of the cooking vessel 1 by the cooking vessel detection unit 5, the detection operation determination unit 31 may set the frequency of performing the detection operation of the cooking vessel 1 lower or to zero (corresponding to a stop of the detection operation).

[0247] In the induction heating device of this disclosure configured as described above, the detection operation of the cooking vessel 1 can be performed only when needed in the induction heating device having a multiplicity of the heating coils 3 adjacently arranged such that the cooking vessel placed at any position can be heated. This enables a reduction in the power consumption and an improvement in the durability of the relay that is a switching component, and a user can perform the heating operation with the operation unit 6 immediately after placing the cooking vessel 1. Thus, the easy-to-use induction heating device can be achieved.

INDUSTRIAL APPLICABILITY

[0248] As described above, the induction heating device according to this disclosure provides a highly reliable and safe induction heating device having excellent commercial value and is useful in uses of various types of equipment performing induction heating such as an induction heating cooker.

EXPLANATIONS OF LETTERS OR NUMERALS

[0249]

1	cooking vessel
2	top plate
3, 3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, 3j, 3k, 3m, 3n, 3p, 3q, 3r, 3s, 3t	heating coil
4	heating control unit
5	cooking vessel detection unit
6, 6a, 6b, 6c,	operation unit
7	inverter circuit
8	display

11, 11a, 11b, 11c	electrode
12	electrostatic capacity detection unit
13	vibration detection unit
14	position estimation unit
15	light-emitting unit
16	light-receiving unit
17	distance estimation unit
20	priority determination unit
21	detection auxiliary unit
22	temperature detection unit
23	detection position determination unit
24	power source operation unit
31	detection operation determination unit
32	human body detection unit

Claims

1. An induction heating device comprising:

a top plate on which a cooking vessel heating a cooked object;
a plurality of heating coils arranged closely to each other and generating a magnetic field for heating the cooking vessel;
a heating control unit that controls a high-frequency current applied to each heating coil of the plurality of the heating coils to control a heating power of the cooking vessel;
a cooking vessel detection unit that performs a detection operation of a cooking vessel for detecting whether the cooking vessel is placed over the heating coils;
an operation unit that displays a detection result of the cooking vessel detection unit; and
a priority determination unit that determines for each heating coil of the plurality of the heating coils a priority of a heating coil for which the cooking vessel detection unit detects whether the cooking vessel is placed thereon,
wherein the cooking vessel detection unit that performs for each of the heating coils a detection operation of a cooking vessel in terms of whether the cooking vessel is placed thereon, based on the priority determined by the priority determination unit.

2. The induction heating device of claim 1, wherein
the priority determination unit includes a detection auxiliary unit that detects an object on the top plate, wherein
if the detection auxiliary unit detects an object, the cooking vessel detection unit performs the detection operation of a cooking vessel in terms of whether the cooking vessel is placed on heating coils around the detected object.

3. The induction heating device of claim 2, wherein the detection auxiliary unit is composed of a temperature detection unit detecting a temperature of the object.

4. The induction heating device of claim 3, wherein when the temperature detection unit detects a temperature change of the object, the cooking vessel detection unit performs the detection operation of a cooking vessel only for a heating coil in the vicinity of a position of the detected temperature change.

5. The induction heating device of claim 3, wherein the cooking vessel detection unit performs the detection operation of a cooking vessel in a constant period.

6. The induction heating device of claim 3, wherein the temperature detection unit detects an infrared light to measure a temperature.

7. The induction heating device of claim 2, wherein
the detection auxiliary unit is composed of:

an electrode disposed on a lower surface of the top plate; and
an electrostatic capacity detection unit that detects a change in electrostatic capacity generated in the electrode by placing the object on an upper surface of the top plate.

8. The induction heating device of claim 7, wherein the electrode is disposed in the vicinity of each of the heating coils to form a pair.

9. The induction heating device of claim 7, wherein the electrode is disposed at a substantially center position among multiple adjacent heating coils.

10. The induction heating device of claim 2, wherein the detection auxiliary unit is composed of a vibration detection unit detecting vibrations of the top plate.

11. The induction heating device of claim 10, wherein a plurality of the vibration detection units is disposed, and wherein a position estimation unit is further included that estimates a position of a vibration source from a phase difference of a plurality of vibration waveforms detected by the vibration detection units.

12. The induction heating device of claim 2, wherein the detection auxiliary unit is composed of a light-emitting unit, a light-receiving unit, and a distance estimation unit that estimates a distance to an object over the light-receiving unit based on a light amount received by the light-receiving unit.

13. The induction heating device of claim 1, wherein the priority determination unit includes a detection position determination unit that determines a detection frequency in terms of a frequency at which the cooking vessel detection unit performs a detection operation of a cooking vessel for each heating coil of the plurality of the heating coils.

14. The induction heating device of claim 13, wherein the detection position determination unit sets a detection frequency lower for a heating coil disposed at a position defined as an outermost peripheral portion than that of a heating coil disposed at other than the outermost peripheral portion out of the plurality of the heating coils.

15. The induction heating device of claim 13, wherein if it is determined that a cooking vessel is placed over one heating coil, the cooking vessel detection unit performs the detection operation of a cooking vessel for a heating coil adjacent to the heating coil.

16. The induction heating device of claim 15, wherein even when the detection frequency is set lower for the adjacent heating coil as compared to the other heating coils, the cooking vessel detection unit immediately performs the detection operation of a cooking vessel for the adjacent heating coil.

17. The induction heating device of claim 13, wherein the detection position determination unit sets a detection frequency for each of the heating coils based on a position of a heating coil detected as having the cooking vessel placed thereon within a predetermined period and the number of times of the detection.

18. The induction heating device of claim 13, wherein the detection position determination unit sets a detection frequency higher for the heating coil disposed closer to the operation unit as compared to the heating coil disposed in the direction away from the operation unit.

19. The induction heating device of claim 1, wherein the detection position determination unit sets a detection frequency lower for a heating coil disposed in the direction away from the operation unit relative to a heating coil being in a heating operation as compared to a heating coil disposed closer to the operation unit relative to the heating coil being in the heating operation.

20. The induction heating device of claim 13, wherein the detection position determination unit sets a detection frequency lower for a heating coil adjacent to a heating coil being in a heating operation as compared to the other heating coils.

21. The induction heating device of claim 13, wherein if a control value is abruptly changed in the heating control unit controlling the high-frequency current applied to a heating coil being in a heating operation, the detection position determination unit sets a detection frequency higher for a heating coil adjacent to the heating coil being in the heating operation as compared to the other heating coils.

22. The induction heating device of claim 13, further comprising a power source operation unit capable of switching whether a power source is supplied to the operation unit, wherein
if a predetermined time has elapsed after a user operates the power source operation unit to achieve a state of supplying the power source to the operation unit, the detection position determination unit sets the overall detection

frequency lower or to zero for all of the plurality of the heating coils.

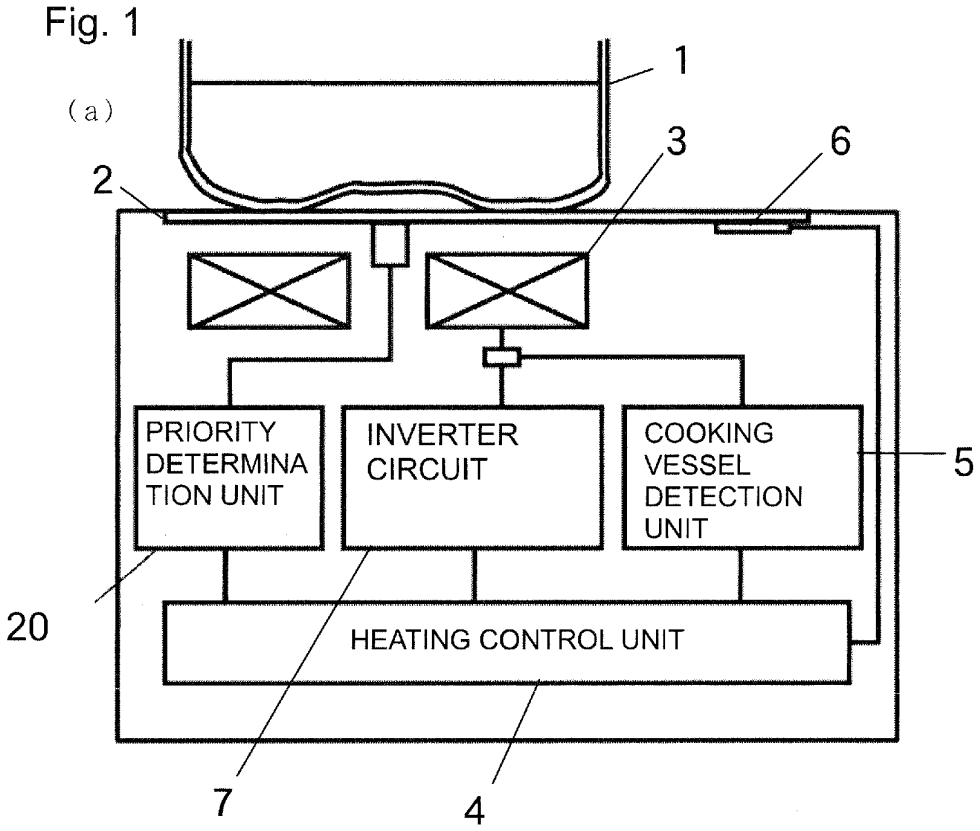
23. The induction heating device of claim 1, wherein the priority determination unit includes a detection operation determination unit determining whether the cooking vessel detection unit performs a detection operation of a cooking vessel for each of the plurality of the heating coils.

24. The induction heating device of claim 23, wherein if a predetermined time has elapsed after a user operates the operation unit last time, the detection operation determination unit sets the overall detection frequency lower or to zero for all of the plurality of the heating coils.

25. The induction heating device of claim 23, further comprising a human body detection unit detecting a human body, wherein
if the human body detection unit detects a human, the cooking vessel detection unit starts a detection operation of a cooking vessel.

26. The induction heating device of claim 23, wherein if the human body detection unit does not detect a human, the cooking vessel detection unit stops a detection operation of a cooking vessel.

Fig. 1


(a)
1
2
3
6
PRIORITY DETERMINATION UNIT
INVERTER CIRCUIT
COOKING VESSEL DETECTION UNIT
5
20
HEATING CONTROL UNIT
7
4

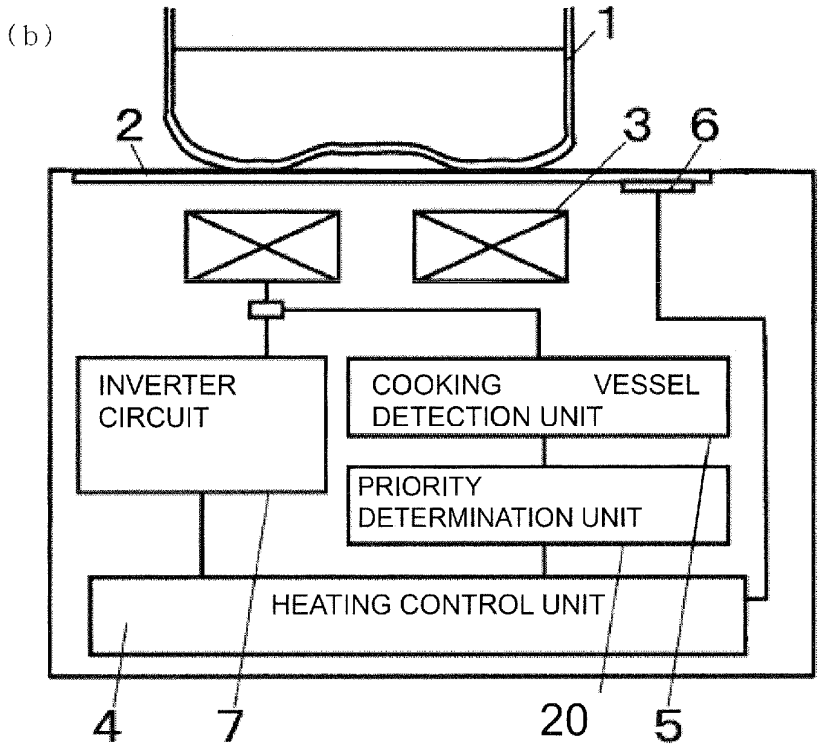
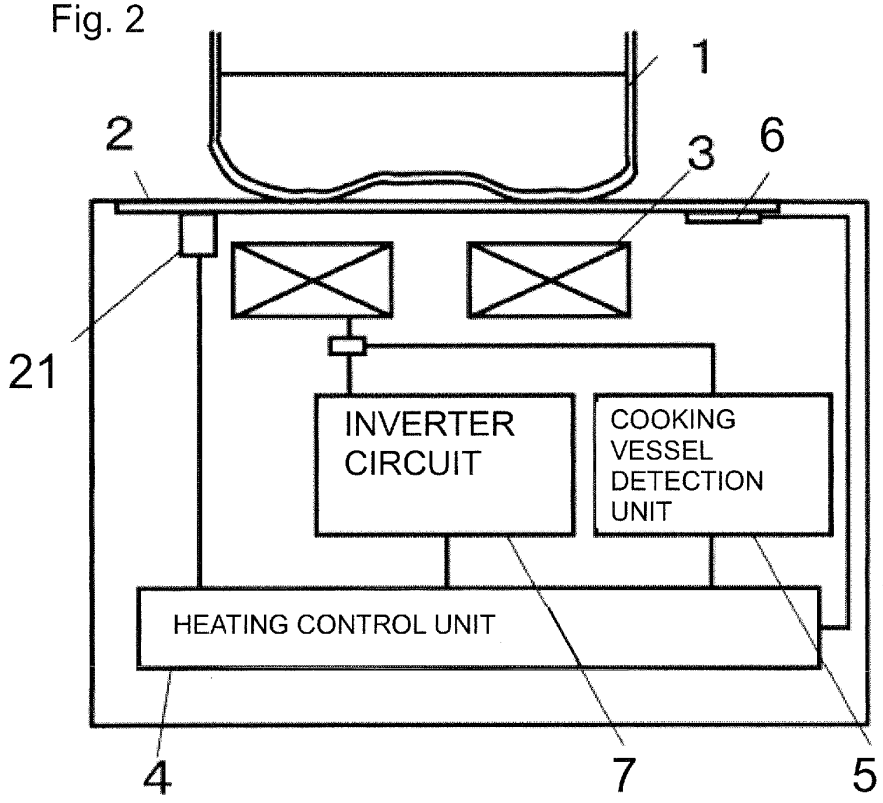

(b)
1
2
3
6
INVERTER CIRCUIT
COOKING VESSEL DETECTION UNIT
PRIORITY DETERMINATION UNIT
HEATING CONTROL UNIT
4
7
20
5

Fig. 2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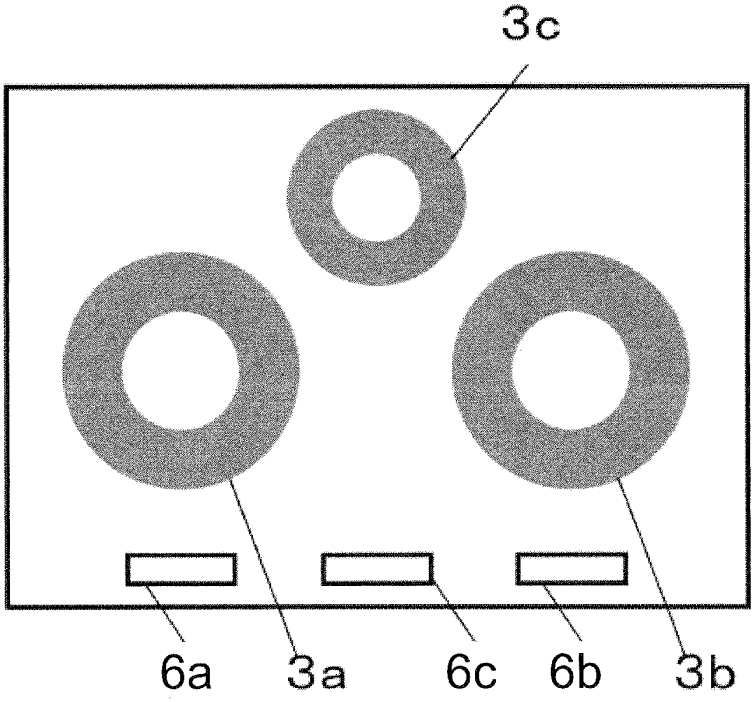
21
INVERTER CIRCUIT
COOKING VESSEL DETECTION UNIT
HEATING CONTROL UNIT
4
7
5

Fig. 3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6a
3a
6c
6b
3b

Fig. 4

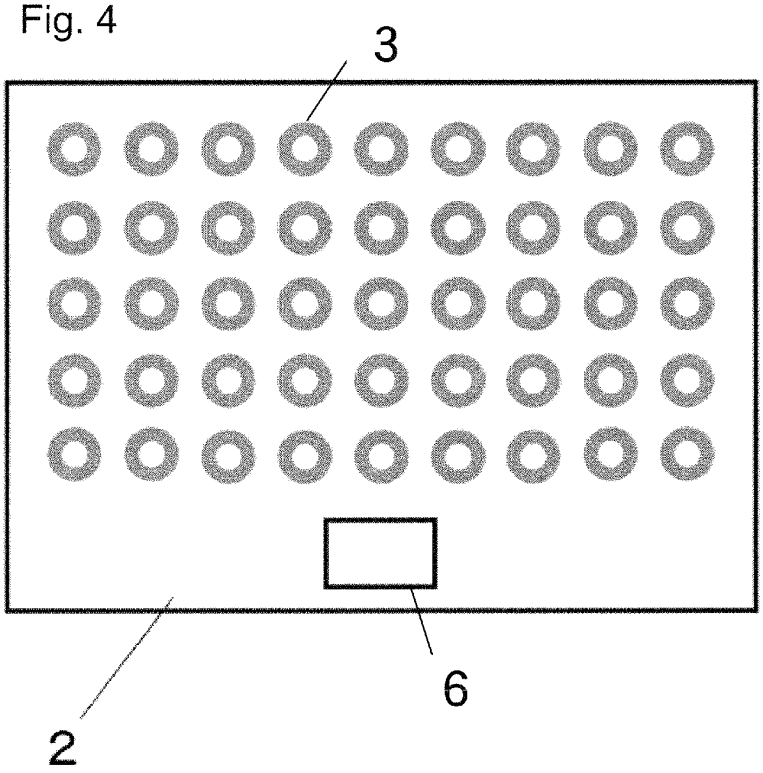


Fig. 5

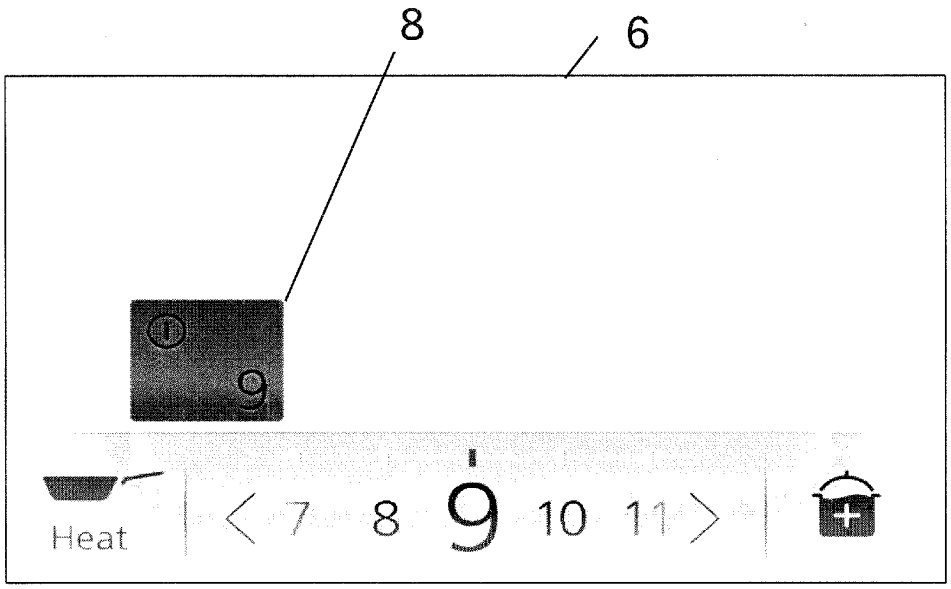


Fig. 6

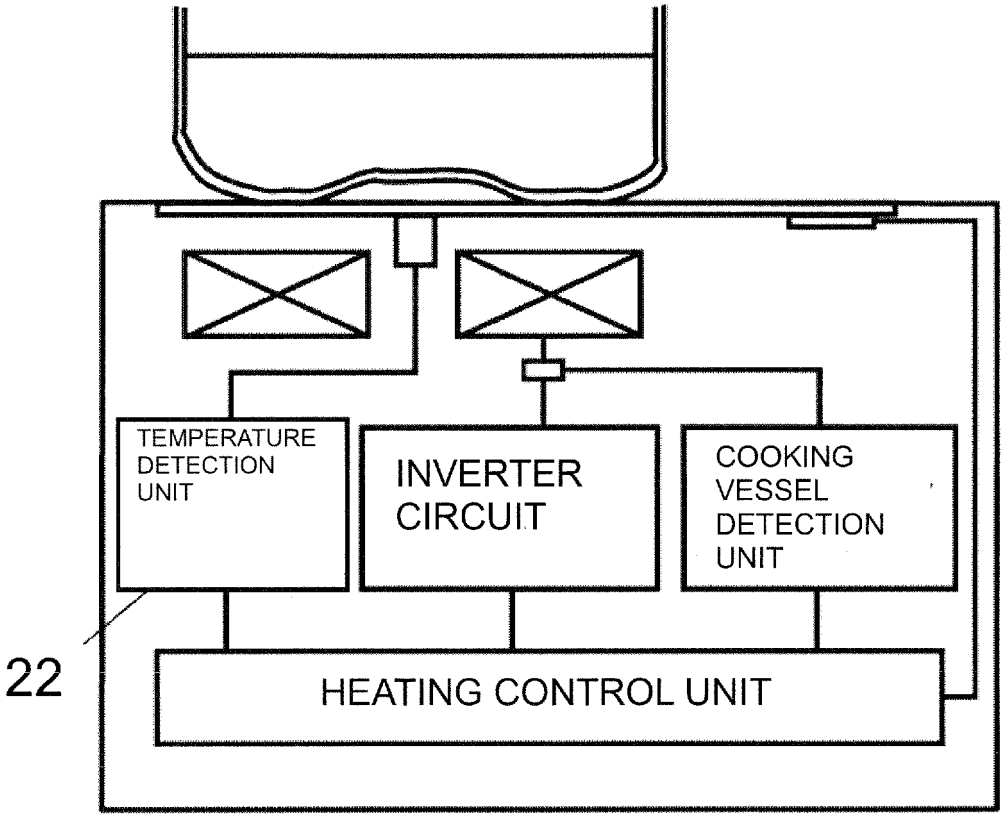

TEMPERATURE DETECTION UNIT
INVERTER CIRCUIT
COOKING VESSEL DETECTION UNIT
22
HEATING CONTROL UNIT

Fig. 7

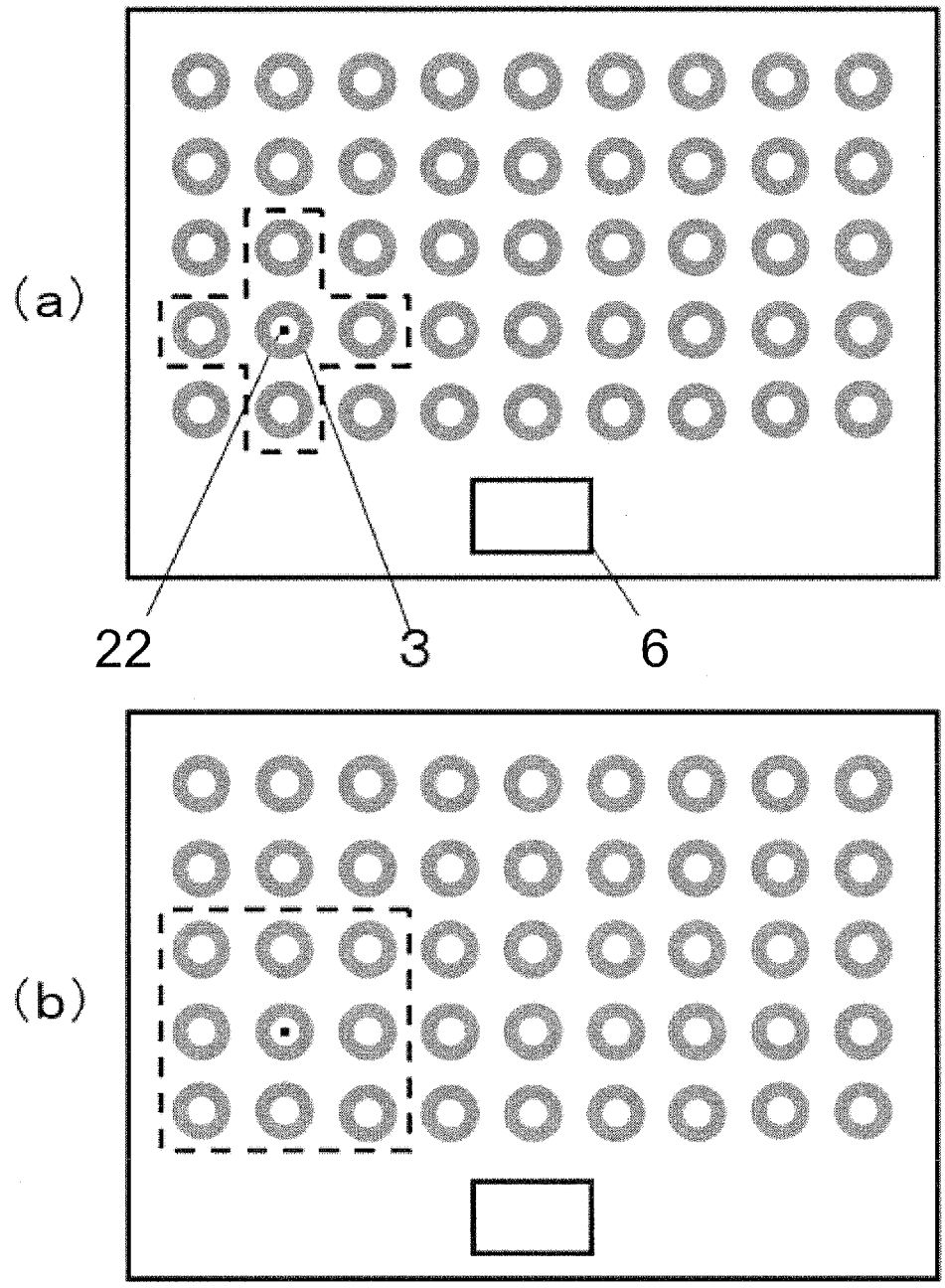


Fig. 8

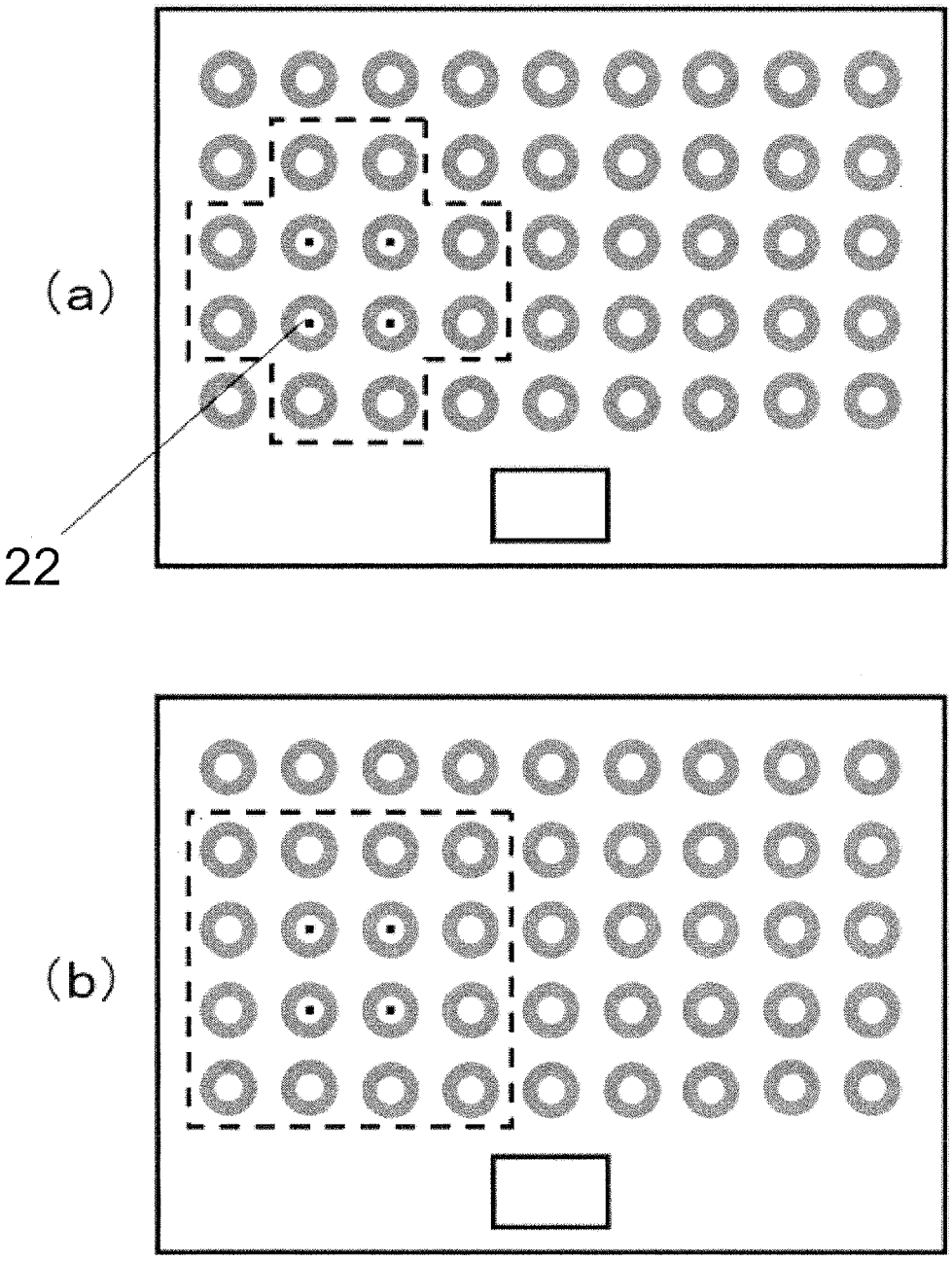
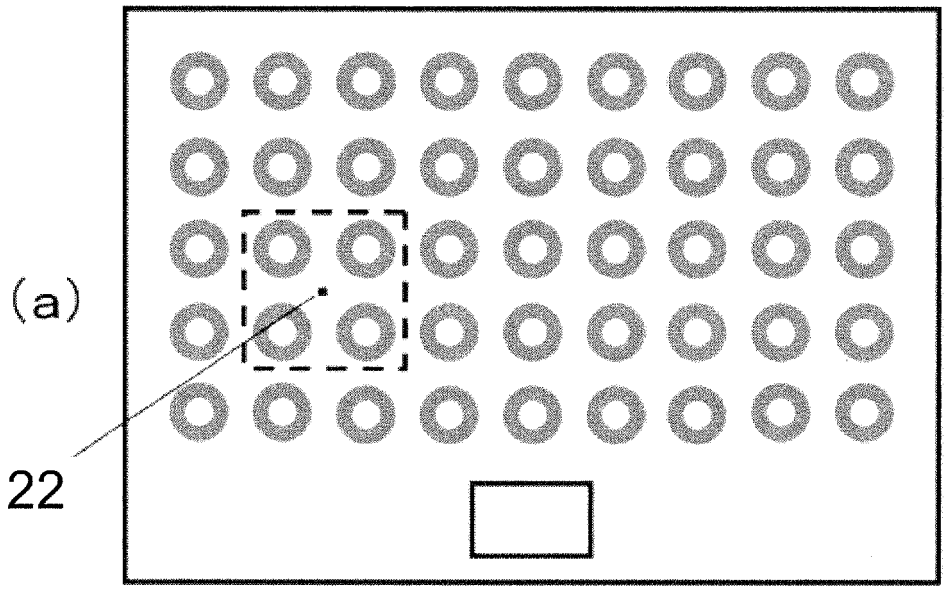


Fig. 9

(a)



(b)

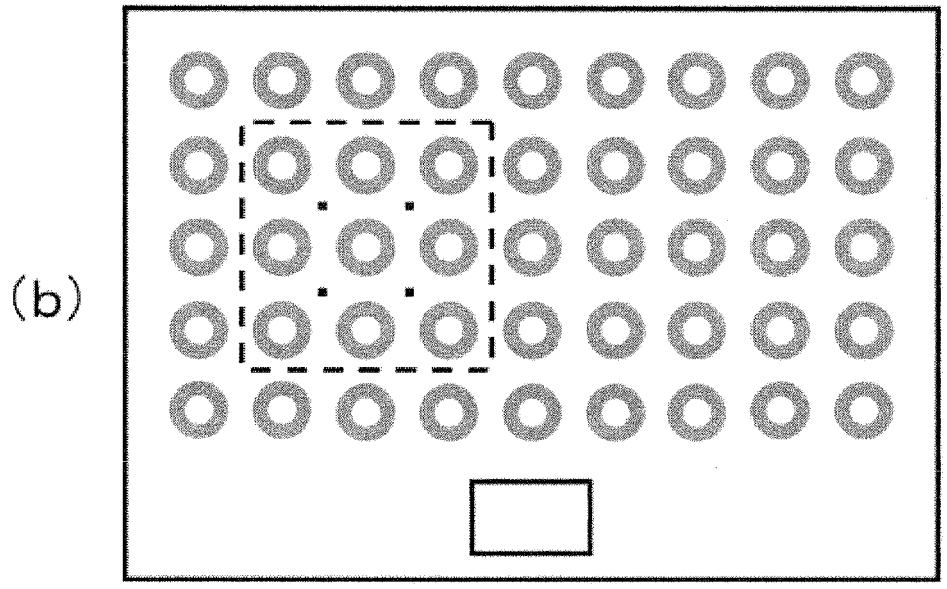
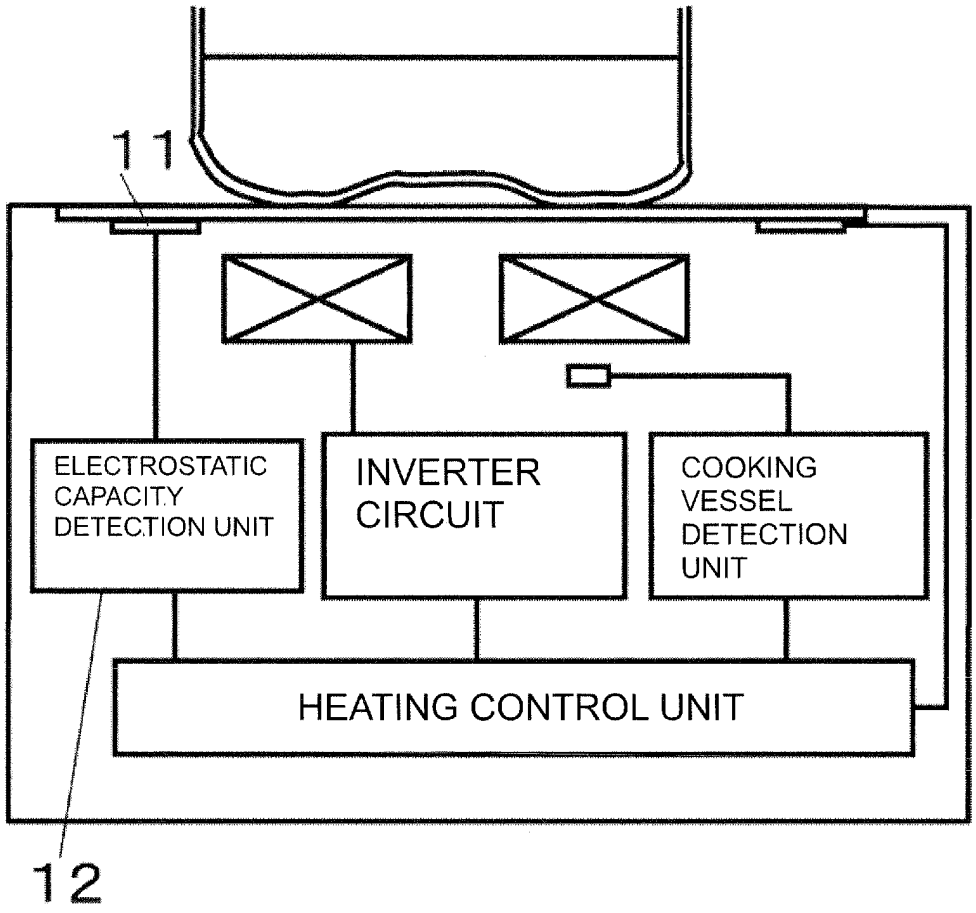


Fig. 10


11
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INVERTER CIRCUIT
COOKING VESSEL DETECTION UNIT
HEATING CONTROL UNIT
12

Fig. 11

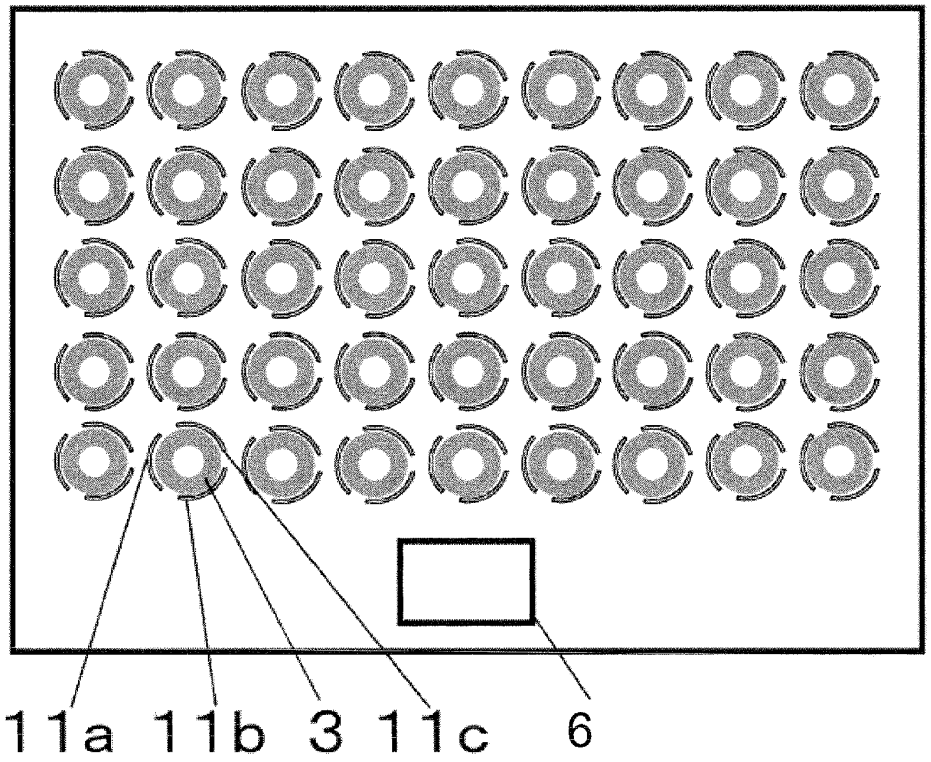


Fig. 12

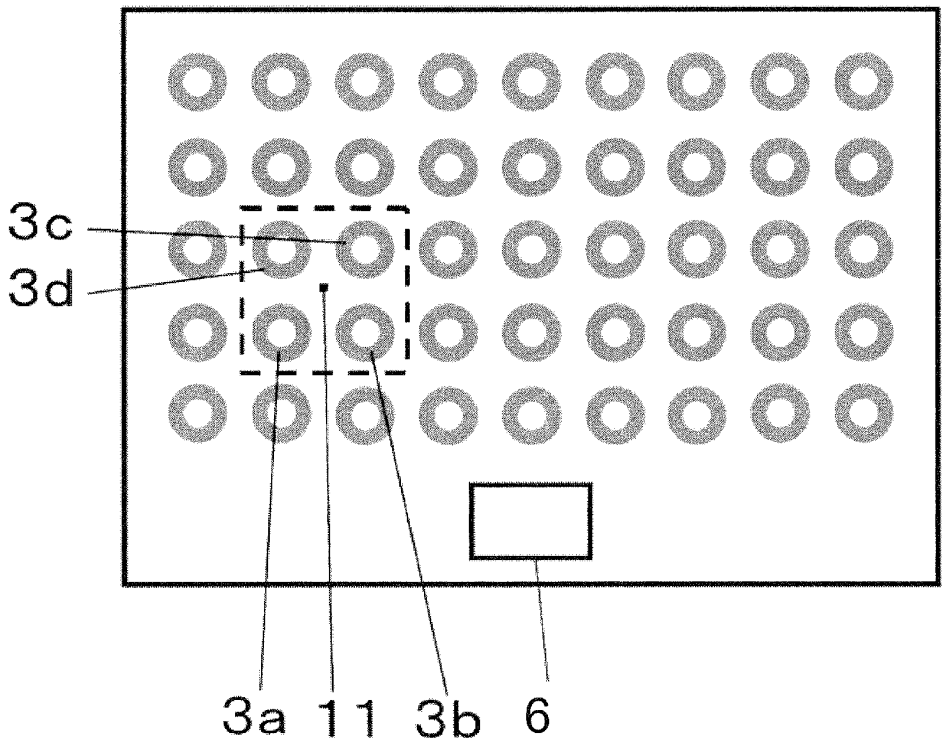


Fig. 13

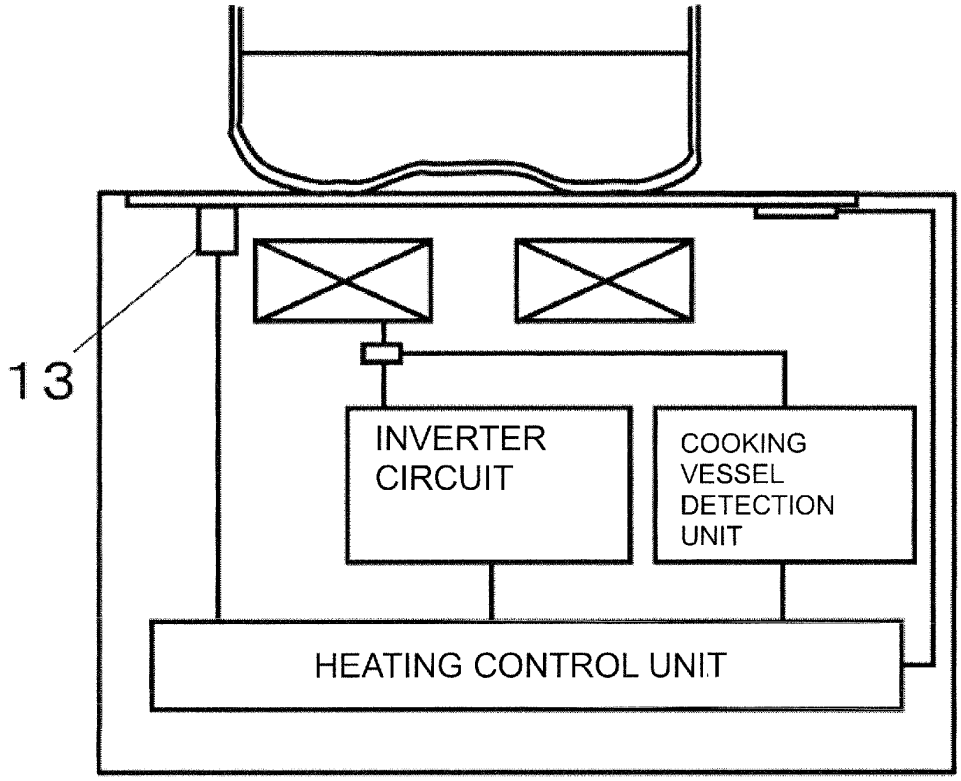
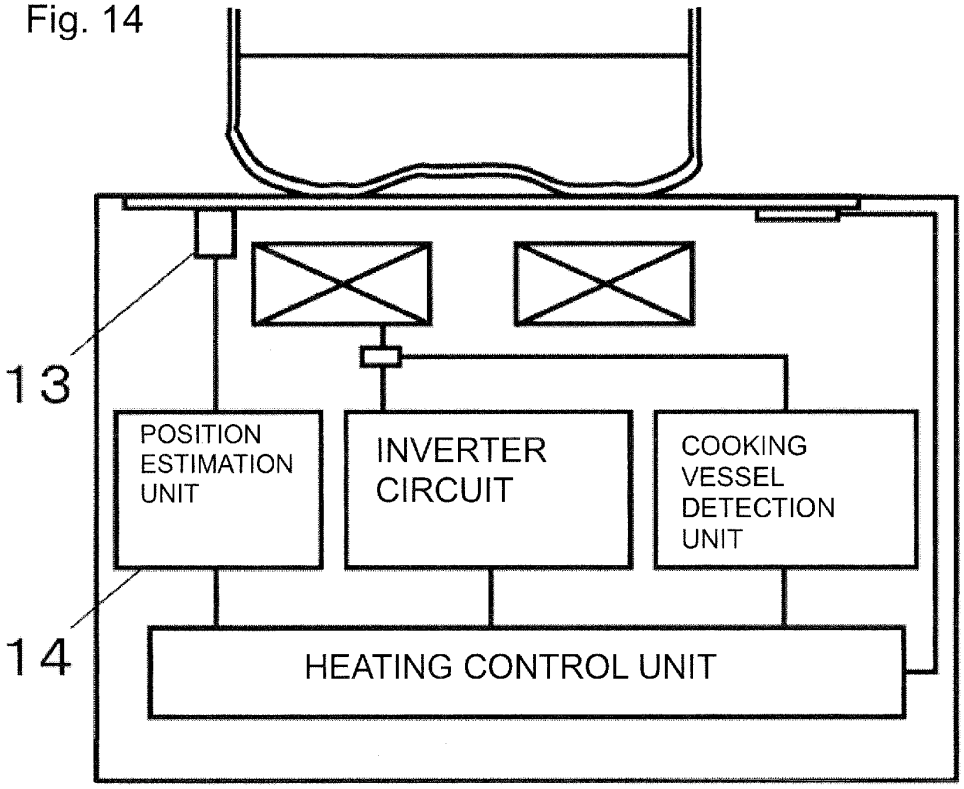

13
INVERTER CIRCUIT
COOKING VESSEL DETECTION UNIT
HEATING CONTROL UNIT

Fig. 14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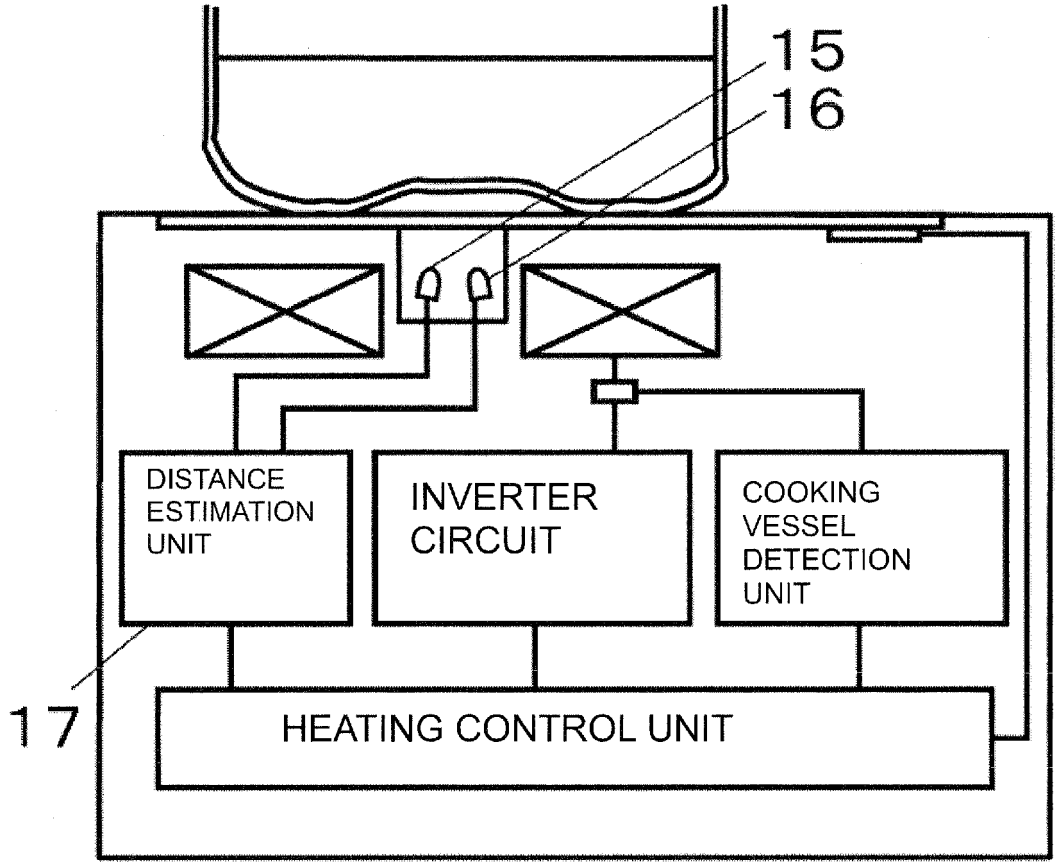
POSITION ESTIMATION UNIT
INVERTER CIRCUIT
COOKING VESSEL DETECTION UNIT
14
HEATING CONTROL UNIT

Fig. 15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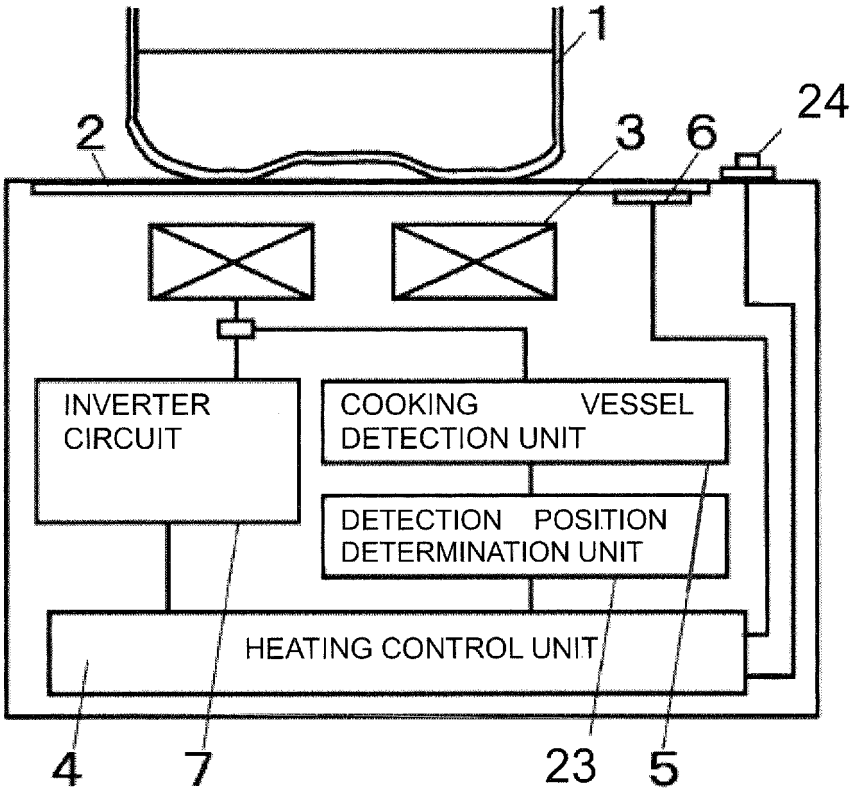
DISTANCE ESTIMATION UNIT
INVERTER CIRCUIT
COOKING VESSEL DETECTION UNIT
17
HEATING CONTROL UNIT

Fig. 16


1
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24
INVERTER CIRCUIT
COOKING VESSEL DETECTION UNIT
DETECTION POSITION DETERMINATION UNIT
HEATING CONTROL UNIT
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Fig. 17

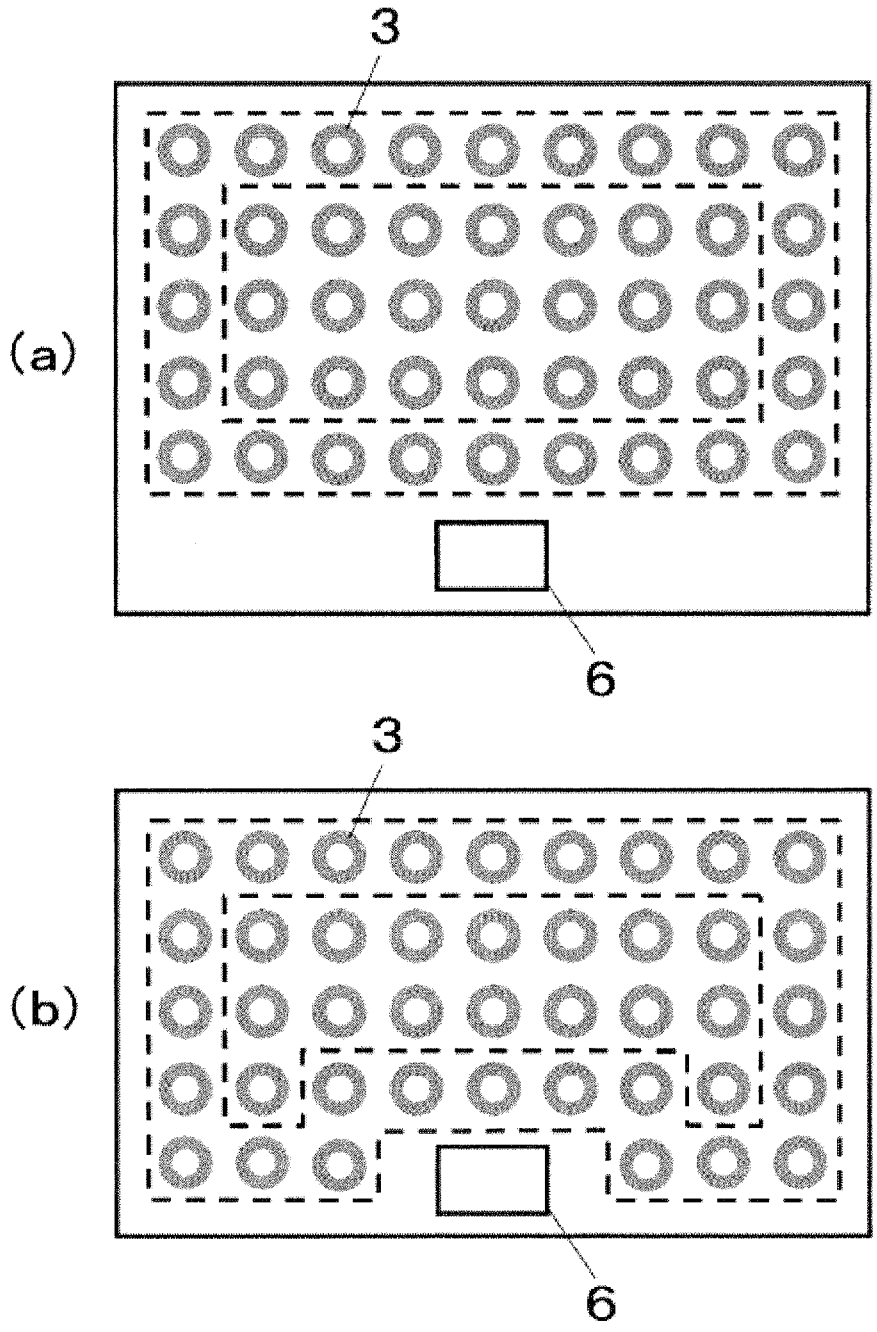


Fig. 18

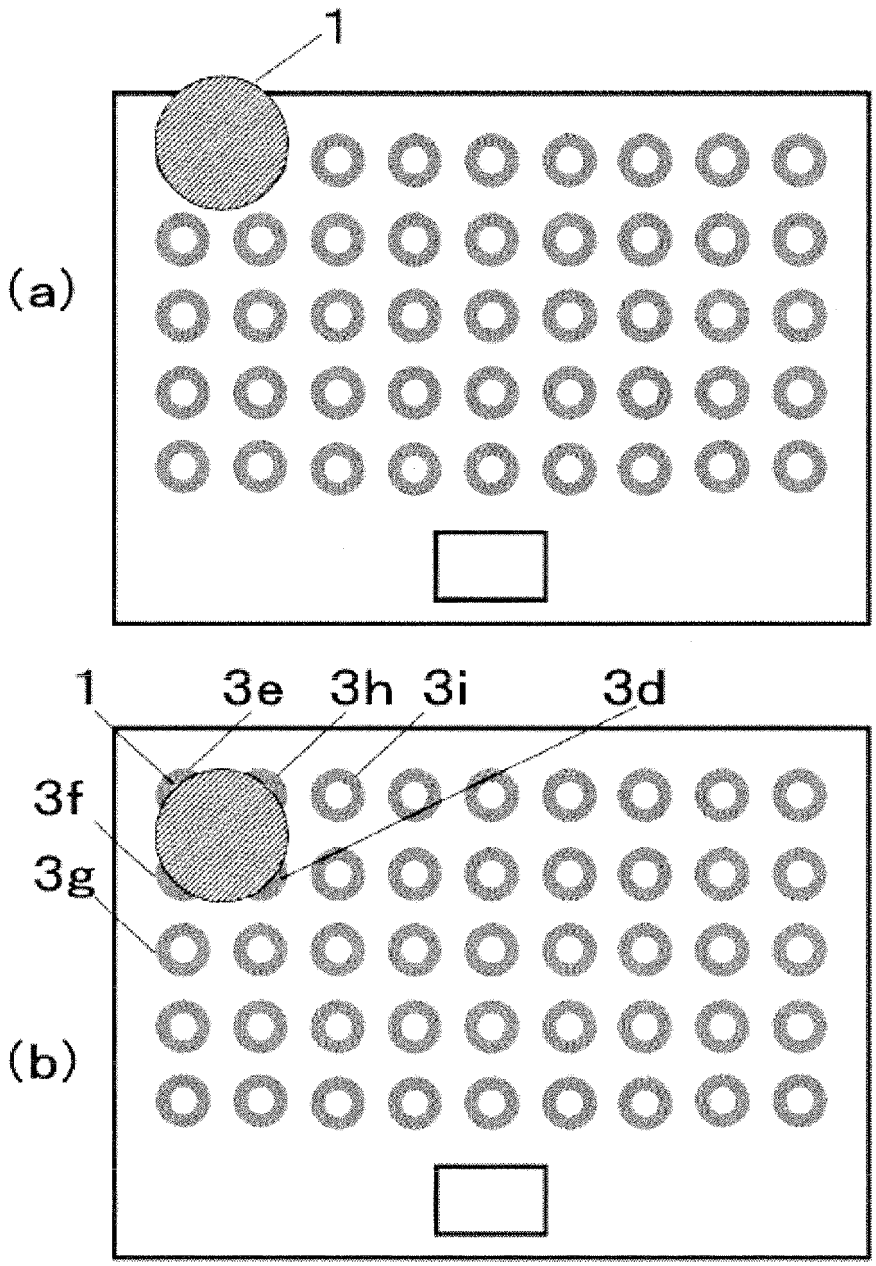
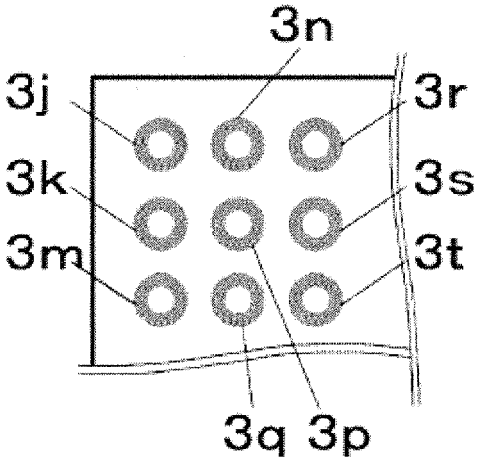


Fig. 19

(a)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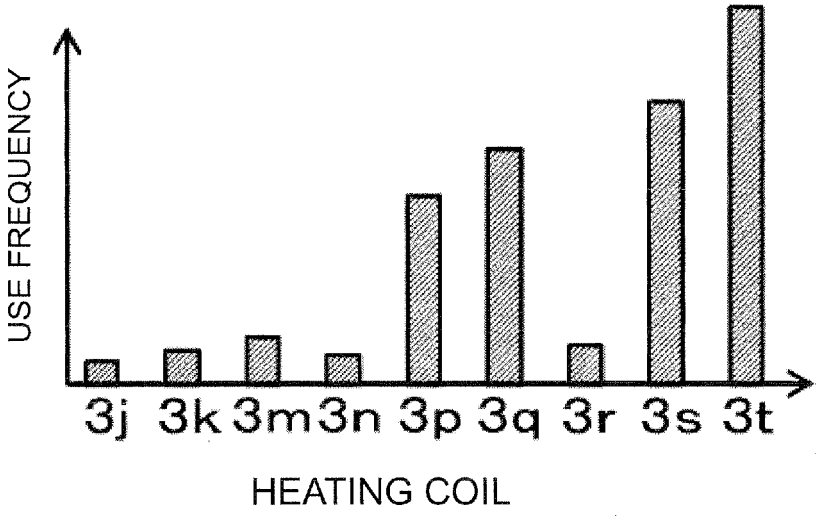
(b)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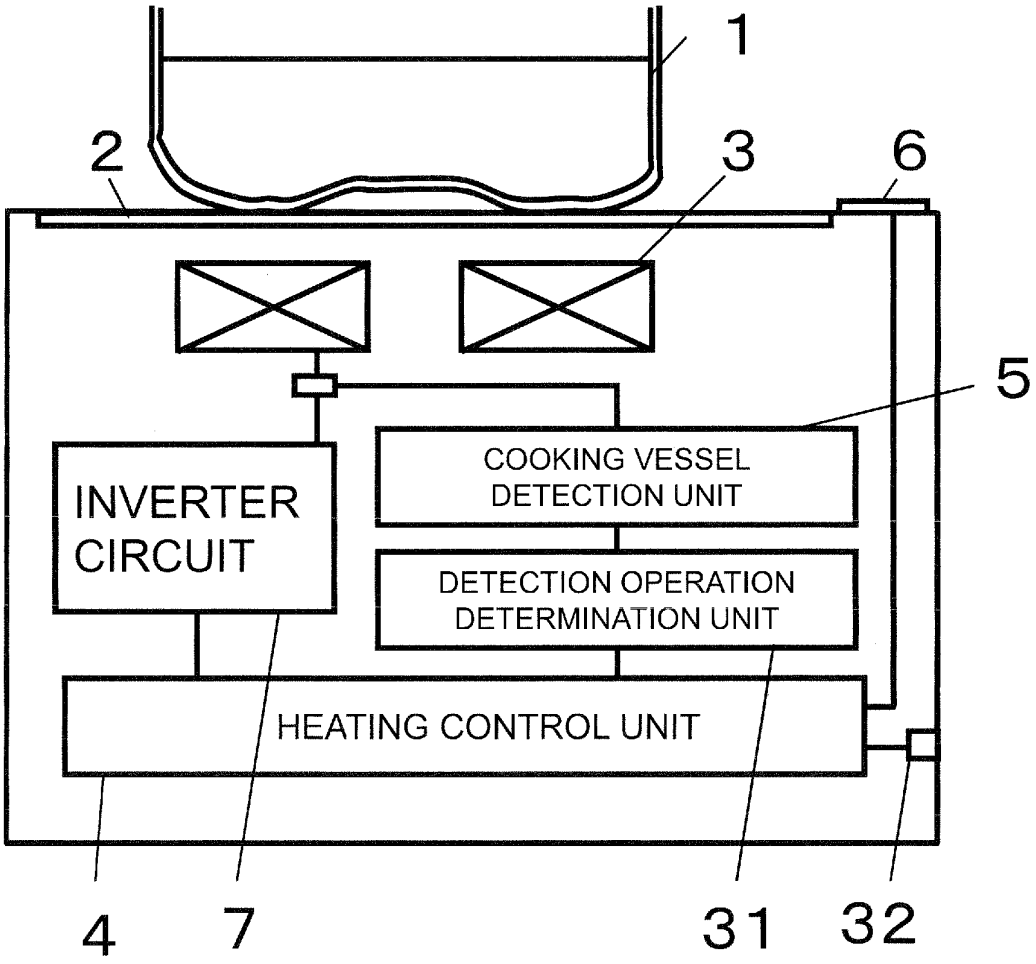
3s
3t
HEATING COIL

Fig. 20


1
2
3
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5
INVERTER CIRCUIT
COOKING VESSEL DETECTION UNIT
DETECTION OPERATION DETERMINATION UNIT
HEATING CONTROL UNIT
4
7
31
32

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/006266

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 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2010-267635 A (Mitsubishi Electric Corp.), 25 November 2010 (25.11.2010), paragraphs [0029] to [0033]; fig. 9 (Family: none)	1,2 3-26
A	JP 2011-90985 A (Panasonic Corp.), 06 May 2011 (06.05.2011), paragraphs [0020] to [0022] (Family: none)	1-26
A	JP 2010-205590 A (Mitsubishi Electric Corp.), 16 September 2010 (16.09.2010), paragraph [0019] (Family: none)	1-26

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

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"O" document referring to an oral disclosure, use, exhibition or other means
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 January, 2014 (06.01.14)	14 January, 2014 (14.01.14)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/006266

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2012-178369 A (Mitsubishi Electric Corp.), 13 September 2012 (13.09.2012), paragraph [0168] (Family: none)	1-26
A	JP 2010-86740 A (Panasonic Corp.), 15 April 2010 (15.04.2010), paragraphs [0064] to [0068] (Family: none)	1-26

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Patent documents cited in the description

- JP 2008293871 A **[0003] [0004] [0005] [0006]**