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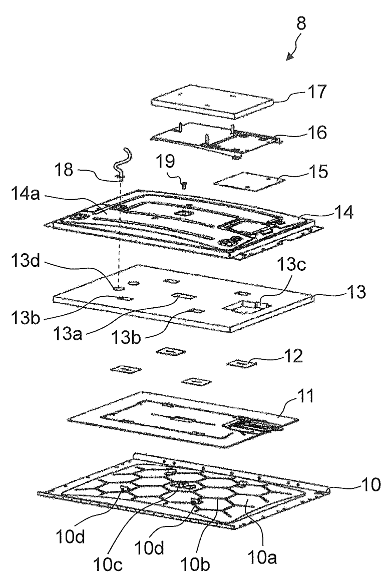
(54) **THERMAL COOKING DEVICE**

(57) A thermal cooking device according to the present disclosure includes: a heating compartment in which a cooking object is heated; a plane heater provided above a ceiling wall of the heating compartment, the plane heater being one heat source formed of an inner heater disposed right above a central portion of the ceiling wall, and an outer heater surrounding the inner heater; and a controller that controls the inner heater and the outer heater of the plane heater. The ceiling wall of the heating compartment has a three-dimensional curved surface concavely facing the heating compartment. The plane heater is fixed to make close contact with the ceiling wall throughout its entire area.

FIG. 5



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a thermal cooking device that thermally cooks food to be cooked in a heating compartment, and more particularly, to a thermal cooking device that heats a cooking object with a plane heater provided above a ceiling wall of the heating compartment.

BACKGROUND ART

[0002] Thermal cooking means of a thermal cooking device include an infrared heater unit that directly heats food by radiating heat waves, a microwave heating unit that heats food by microwave irradiation, a steam heating unit that heats food with water vapor, and a hot-air circulation unit that heats food by circulating hot air in a heating compartment.

[0003] As another thermal cooking means of the thermal cooking device, there is also a plane heater that is provided above a ceiling wall of a heating compartment, which has the shape of a rectangular parallelepiped, to heat the ceiling wall for indirect heating of an interior of the heating compartment through the ceiling wall (refer to PTLs 1 and 2).

Citation List

Patent Literatures

[0004]

PTL 1: Unexamined Japanese Patent Publication No. H03-103206

PTL 2: Unexamined Japanese Patent Publication No. 2010-054124

SUMMARY OF THE INVENTION

[0005] The thermal cooking device described above is structured to select an appropriate cooking means in order to perform, according to a dish, optimum thermal cooking of food to be cooked in the heating compartment. When the thermal cooking device is used to heat or cook, it is important that the interior of the heating compartment should reach a preset cooking temperature (preset temperature) within a short period of time and that this preset temperature should be held constant for a predetermined period of time in order to make a dish delicious and to shorten a length of cooking time.

[0006] With use of the plane heater as the thermal cooking means that is provided above the ceiling wall in the thermal cooking device, the ceiling wall is heated, and the interior of the heating compartment is heated to the preset temperature by heat radiated by the heated ceiling wall. As such, highly efficient transfer of heat from the plane heater to the interior of the heating compartment is required. However, the ceiling wall is caused by the heat of the plane heater to repeatedly experience expansion and contraction, so that it is difficult to always maintain close contact between a ceiling wall surface and the plane heater. A clearance (air layer) is thus caused between the ceiling wall surface and the plane heater, and there is a problem of deteriorated efficiency of heat transfer from the plane heater to the ceiling wall.

[0007] A heat source (heater wire) of the plane heater is covered by an electrically insulating member. The heat from the heat source of the plane heater is transmitted to the ceiling wall through the electrically insulating member, thus heating the ceiling wall, and the heat of the heated ceiling wall raises an internal temperature of the heating compartment to the preset temperature. In the conventional thermal cooking device, the internal compartment temperature is detected by a temperature detecting means, and based on this detected internal compartment temperature, on and off control of the plane heater is performed such that the interior of the heating compartment reaches the preset temperature. In cases where the heating compartment of such a conventional thermal cooking device is heated by the plane heater until its internal temperature reaches the preset temperature, the plane heater reaches a higher temperature than the preset temperature by the time the internal compartment temperature reaches the preset temperature. In some cases, the temperature of the plane heater may exceed its heat resisting temperature. As such, safety and reliability are taken into consideration in the conventional thermal cooking device. The plane heater is once turned off far ahead of a time when the internal compartment temperature reaches the preset temperature, and an on and off operation of the plane heater is repeated thereafter to gradually bring the internal compartment temperature closer to the preset temperature. As described above, in the conventional thermal cooking device, the plane heater is controlled based on the detected internal compartment temperature until the internal compartment temperature reaches the preset temperature, so that the preset temperature is difficult to reach with high accuracy, and a length of time is required until the preset temperature is reached.

[0008] In the conventional thermal cooking device, because the control that maintains the internal compartment temperature at the preset temperature is the repetition of the simple on and off operation of the plane heater, the internal compartment temperature rises and falls, thus being difficult to maintain at the constant temperature.

[0009] Rated power is specified for, for example, the thermal cooking device that is intended for general home use, thus problematically limiting input power. Accordingly, heat sources provided in the thermal cooking device must be designed within the rated power. Particularly in cases where the plane heater is used as the thermal cooking means, the interior of the heating compartment is difficult to rapidly start up with consumption of desired power for thermal cooking when the other thermal cooking means are taken into consideration.

[0010] The present disclosure aims to provide a thermal cooking device that is capable of rapidly raising an internal temperature of a heating compartment to a preset temperature and maintaining the internal compartment temperature at the preset temperature when performing thermal cooking using at least a plane heater as a thermal cooking means.

[0011] A thermal cooking device according to one aspect of the present disclosure includes: a heating compartment in which a cooking object is heated; a plane heater provided above a ceiling wall of the heating compartment, the plane heater being one heat source formed of an inner heater disposed right above a central portion of the ceiling wall, and an outer heater surrounding the inner heater; and a controller that controls the inner heater and the outer heater of the plane heater. The ceiling wall of the heating compartment has a three-dimensional curved surface concavely facing the heating compartment. The plane heater is fixed to make close contact with the ceiling wall throughout its entire area.

[0012] According to the present disclosure, use of at least the plane heater as a thermal cooking means enables an internal compartment temperature to reach a preset temperature within a short period of time and to be held at the preset temperature without fail. As such, the thermal cooking device that can be provided is capable of performing thermal cooking that is desired by a user within a short period of time.

BRIEF DESCRIPTION OF DRAWINGS

[0013]

FIG. 1 is an external perspective view of a thermal cooking device according to an exemplary embodiment of the present disclosure.

FIG. 2 is a perspective view illustrating the thermal cooking device with a door opened according to the exemplary embodiment.

FIG. 3 is a perspective view illustrating the thermal cooking device with an outer cover removed according to the exemplary embodiment.

FIG. 4 is a front elevational view illustrating in section an upper portion of the thermal cooking device according to the exemplary embodiment.

FIG. 5 is an exploded perspective view of a plane heater unit of the thermal cooking device according to the exemplary embodiment.

FIG. 6A is a plan view of an upper heating compartment plate of the plane heater unit in the thermal cooking device according to the exemplary embodiment.

FIG. 6B is an end elevational view taken along line 6B-6B of FIG. 6A.

FIG. 6C is an end elevational view taken along line 6C-6C of FIG. 6A.

FIG. 7 is an exploded perspective view of a plane heater in the thermal cooking device according to the exemplary embodiment.

FIG. 8 is a plan view of a heater in the thermal cooking device according to the exemplary embodiment.

FIG. 9 is a top plan view of the plane heater in the thermal cooking device according to the exemplary embodiment.

FIG. 10 is a rear view of the plane heater in the thermal cooking device according to the exemplary embodiment.

FIG. 11 is a perspective view illustrating the plane heater mounted to the upper heating compartment plate in the thermal cooking device according to the exemplary embodiment.

FIG. 12A is a plan view of a keep plate in the thermal cooking device according to the exemplary embodiment.

FIG. 12B is an end elevational view taken along line 12B-12B of FIG. 12A.

FIG. 12C is an end elevational view taken along line 12C-12C of FIG. 12A.

FIG. 13 is a sectional view describing a method of mounting the keep plate to the upper heating compartment plate of the thermal cooking device according to the exemplary embodiment.

FIG. 14 is a sectional view illustrating a mounted condition of the keep plate with respect to the upper heating compartment plate that is highly heated in the thermal cooking device according to the exemplary embodiment.

FIG. 15 is an enlarged sectional view illustrating a mounted condition of a heater temperature sensor in the thermal cooking device according to the exemplary embodiment.

FIG. 16 is a perspective view of the plane heater unit of the thermal cooking device according to the exemplary embodiment.

FIG. 17A is a plan view of the plane heater unit of the thermal cooking device according to the exemplary embodiment.

FIG. 17B is a sectional view taken along line 17B-17B of FIG. 17A.

FIG. 17C is a sectional view taken along line 17C-17C of FIG. 17A.

FIG. 18 is a circuit diagram for control of thermal cooking means of the thermal cooking device according to the exemplary embodiment.

FIG. 19 is a perspective view of a heat-generating pan that is used in the thermal cooking device according to the exemplary embodiment.

FIG. 20 is a plan view of the heat-generating pan shown in FIG. 19.

DESCRIPTION OF EMBODIMENT

[0014] A thermal cooking device according to a first aspect of the present disclosure includes: a heating compartment in which a cooking object is heated; a plane heater provided above a ceiling wall of the heating compartment, the plane heater being one heat source formed of an inner heater disposed right above a central portion of the ceiling wall, and an outer heater surrounding the inner heater; and a controller that controls the inner heater and the outer heater of the plane heater. The ceiling wall of the heating compartment has a three-dimensional curved surface concavely facing the heating compartment. The plane heater is fixed to make close contact with the ceiling wall throughout its entire area.

[0015] According to the first aspect, the thermal cooking device thus formed enables, through use of the plane heater as a thermal cooking means, an internal compartment temperature (a temperature of an upper plate) to reach a preset temperature within a short period of time and to be held without fail at the preset temperature.

[0016] In a thermal cooking device according to a second aspect of the present disclosure, the three-dimensional curved surface of a ceiling wall surface of the heating compartment of the first aspect may be rectangular when viewed in a plane and may have a longitudinal curvature and a transverse curvature that are different from each other.

[0017] In a thermal cooking device according to a third aspect of the present disclosure, the ceiling wall of the heating compartment of the first aspect may include a plurality of areas that each absorb deformation force resulting from expansion or contraction that is caused by heat of the plane heater.

[0018] In a thermal cooking device according to a fourth aspect of the present disclosure, the ceiling wall of the heating compartment of the first aspect may include a plurality of areas that each absorb deformation force resulting from expansion or contraction that is caused by heat of the plane heater, and the plurality of areas may be identical in shape.

[0019] In a thermal cooking device according to a fifth aspect of the present disclosure, the ceiling wall of the heating compartment of the first aspect may include a plurality of polygonal areas that each absorb deformation force resulting from expansion or contraction that is caused by heat of the plane heater.

[0020] In a thermal cooking device according to a sixth aspect of the present disclosure, the ceiling wall of the heating compartment of the first aspect may include a plurality of honeycomb-shaped areas that each absorb deformation force resulting from expansion or contraction that is caused by heat of the plane heater.

[0021] In a thermal cooking device according to a seventh aspect of the present disclosure, the plane heater of the first aspect may be held, via a heat insulator, by a keep plate that is mounted to the ceiling wall to have a movable range and has a three-dimensional curved surface.

[0022] In a thermal cooking device according to an eighth aspect of the present disclosure, the keep plate of the seventh aspect may be formed with, in areas respectively facing the inner heater and the outer heater, pressing parts that project toward the inner heater and the outer heater, and the pressing parts may press the inner heater and the outer heater via the heat insulator.

[0023] In a thermal cooking device according to a ninth aspect of the present disclosure, a total of respective maximum heater outputs of the inner heater and the outer heater of the first aspect may exceed rated power of the thermal cooking device. The controller may control power that is input to the inner heater to prevent a total of respective heater outputs of the inner heater and the outer heater from exceeding the rated power of the thermal cooking device.

[0024] A thermal cooking device according to a tenth aspect of the present disclosure may include a heater temperature sensor that detects a temperature of an area that undergoes direct heating by the inner heater of the first aspect. Based on heater temperature information detected by the heater temperature sensor, the controller may perform control that starts up the inner heater to cause the inner heater to reach a temperature (including its proximity) that is preset for the heating compartment.

[0025] In a thermal cooking device according to an eleventh aspect of the present disclosure, at least a plane-heater-end surface of the ceiling wall of the first aspect's heating compartment may have a black silicon film.

[0026] In a thermal cooking device according to a twelfth aspect of the present disclosure, at least the ceiling wall of the first aspect's heating compartment may have a self-cleaning film at its heating-compartment-end surface.

[0027] With reference to the accompanying drawings, a description is hereinafter provided of, as an exemplary embodiment of the thermal cooking device of the present disclosure, a thermal cooking device that uses at least a plane heater as a thermal cooking means. It is to be noted that the thermal cooking device of the present disclosure is not limited in structure to the thermal cooking device that is described in the following exemplary embodiment and includes a structure of any thermal cooking device that is equivalent to a technical concept described in the following exemplary embodiment. The exemplary embodiment that is described below exemplifies the present disclosure, so that structures, functions, operations, and others that are described in the exemplary embodiment are given as examples and are not restrictive of the present disclosure. Among constituent elements in the following exemplary embodiment, constituent elements not recited in the independent claim that indicates the most generic concept are described as constituent elements of choice.

[0028] The thermal cooking device according to the exemplary embodiment of the present disclosure is described below with reference to the accompanying drawings. FIG. 1 is an external perspective view of the thermal cooking device according to the present exemplary embodiment.

FIG. 2 is a perspective view illustrating the thermal cooking device of FIG. 1 with a door opened according to the present exemplary embodiment.

[0029] As shown in FIGS. 1 and 2, heating compartment 4 provided inside main body 1 of the thermal cooking device has a front opening that can be exposed and closed by door 2. Handle 3 is provided at an upper end of door 2. A user holds handle 3 and rotates door 2, whereby the front opening of heating compartment 4 is exposed or closed upwardly. As door 2 is closed, an interior of heating compartment 4 is substantially sealed, so that a cooking object to be heated disposed in heating compartment 4 is thermally cooked in a substantially sealed condition.

[0030] As shown in FIG. 1, the thermal cooking device is provided with, at its front face of door 2 that opens upwardly, setting part 5 where various cooking conditions including a cooking temperature and a length of cooking time are set for thermal cooking. Setting part 5 provided at the front face of the thermal cooking device has, for example, a display that displays the various cooking conditions, a heating condition during thermal cooking, and others.

[0031] Thermal cooking means used in the thermal cooking device according to the present exemplary embodiment include, in addition to a plane heater, a microwave heating unit that heats food by microwave irradiation, a steam heating unit that heats food with water vapor, and a hot-air circulation unit that heats food by circulating hot air in heating compartment 4. The microwave heating unit is provided with, below a bottom wall of heating compartment 4, an antenna that radiates microwaves. The antenna has directivity and radiates the microwaves in a desired direction toward the interior of heating compartment 4. The steam heating unit has a water tank inside main body 1 and intensively ejects into heating compartment 4 water vapor that is generated by heating water to a high temperature by means of steam heaters of a boiler. The hot-air circulation unit sucks air from heating compartment 4, heats the air by means of a rear heater provided behind heating compartment 4, and supplies the heated air to the interior of heating compartment 4.

[0032] The thermal cooking device according to the present exemplary embodiment is provided with the plurality of thermal cooking means. An appropriate thermal cooking means is selected when the user selects a desired thermal cooking means or a cooking content.

The user places food to be cooked in heating compartment 4 of the thermal cooking device, closes door 2, sets the thermal cooking means or the cooking content by means of setting part 5, and presses a start button to start a cooking operation.

[0033] As shown in FIG. 2, heating compartment 4 of the thermal cooking device of the present exemplary embodiment can accommodate heat-generating pan 6 on which a heating object is placed. Both side walls of heating compartment 4 are formed with steps that can slidably support heat-generating pan 6, so that heat-generating pan 6 is disposed at a top level, a middle level, or a bottom level inside heating compartment 4. A heat generator (not shown) is embedded at mounting surface 33 of heat-generating pan 6. This heat generator absorbs microwaves to generate heat, and ferrite is used as an example of the heat generator.

[0034] While the present exemplary embodiment is described using the example in which ferrite is embedded as the heat generator in heat-generating pan 6, the heat generator may be anything that absorbs microwaves to generate heat and may be applied to a back surface of the heat-generating pan. A main material of heat-generating pan 6 may be anything with excellent heat conduction and may be a metal or ceramic.

[0035] While the present exemplary embodiment is described with heat-generating pan 6 supported by the steps on the side walls of heating compartment 4, heat-generating pan 6 may be suspended from a ceiling wall or may be provided with downwardly projecting legs to be mounted on the bottom wall of heating compartment 4.

[0036] It is to be noted that the antenna (not shown) that radiates microwaves toward the interior of heating compartment 4 is disposed underneath a substantially central position of the bottom wall of heating compartment 4. In the present exemplary embodiment, the antenna has the directivity in the microwave radiating direction and is capable of radiating circularly polarized waves upwardly of the antenna. As such, the antenna is provided with a rotary mechanism in the present exemplary embodiment to uniformly radiate the microwaves toward the interior of the heating compartment 4 with its radiation port being rotated. In the present exemplary embodiment, the antenna radiates, for dielectric heating, the circularly polarized waves even toward the heat generator of heat-generating pan 6 that is disposed right above the antenna.

[0037] The bottom wall of heating compartment 4 is formed of material that transmits the microwaves from the antenna. A steel or stainless steel (SUS) plate that is plated with aluminum is used for the other walls of heating compartment 4, that is to say, the side walls, the rear wall, and the ceiling wall. Each of the walls may be formed with a non-adhesive film layer of, for example, fluororesin or silicon resin. With the formation of such a film layer, dirt that is scattered during cooking, such as oil, fat, or cooking bits, can be prevented from adhering to the film layer, and even the adhered dirt is wiped off with ease. Each of the walls of heating compartment 4 may be formed with a film layer with a self-cleaning function that effects automatic cleaning by decomposing the oil and the fat that are scattered during cooking through heating that is performed for the cooking. An example that may be used as a method of making the film layer have the self-cleaning function is a method of incorporating into the film layer a manganese oxide catalyst species or the like that promotes an oxidative decomposition effect or a method of adding platinum that exhibits a marked effect in oxidative decomposition at low temperatures or palladium that is highly active in a medium-to-high temperature range. As another alternative, a method of adding, for example, cerium that has an absorptive effect may be used.

[0038] While a heating object (food) that is placed on heat-generating pan 6 accommodated by heating compartment 4 is thermally cooked by heat-generating pan 6 that is highly heated by the heat of the heat generator undergoing microwave dielectric heating as described above, an upper surface of the heating object (food) placed on heat-generating pan 6 is heated, in the present exemplary embodiment, by plane heater unit 8 that is provided above the ceiling wall of heating compartment 4.

[0039] FIG. 3 is a perspective view illustrating the thermal cooking device with an outer cover removed from main body 1 according to the present exemplary embodiment. As shown in FIG. 3, main body 1 of the thermal cooking device is provided with plane heater unit 8 at its ceiling, namely, in its part including the ceiling wall of heating compartment 4. FIG. 4 is a front elevational view illustrating in section an upper portion of the thermal cooking device according to the present exemplary embodiment. As shown in FIG. 4, a part above heating compartment 4 of the thermal cooking device is formed of plane heater unit 8. Internal compartment temperature sensor 9 such as a thermistor is provided as an internal compartment temperature detecting means at a right-hand rear corner of heating compartment 4 to detect an internal temperature of heating compartment 4. Internal compartment temperature information that is detected by internal compartment temperature sensor 9 is transmitted to controller 7 (refer to FIG. 18), which is described later, and is used for control in various thermal cooking operations.

[Plane heater unit]

[0040] FIG. 5 is an exploded perspective view of plane heater unit 8. As shown in FIG. 5, plane heater unit 8 has, in order from a bottom in FIG. 5, upper heating compartment plate 10 that forms the ceiling wall of heating compartment 4, plane heater 11 that is closely fitted to an upper surface of upper heating compartment plate 10, pressing tools 12 that are formed of mica and serve as stiffening plates, first heat insulator 13 that blocks upward heat transfer from plane heater 11, and keep plate 14 that presses plate heater 11 against upper heating compartment plate 10 via first heat insulator 13. Plane heater unit 8 is also provided with insulating sheet 15 that electrically insulates, for example, terminal part 24 (refer to FIG. 16) of plane heater 11, heat shield plate 16 that blocks transfer of heat of plane heater unit 8 to the outer cover of main body 1, and second heat insulator 17. Plane heater unit 8 is assembled to have such a stacked structure, and all the components can be replaced during maintenance, so that improved maintainability is achieved. Plane heater unit 8 is also provided with heater temperature sensor 18 that detects, as a heater temperature detecting means, a temperature of a heating area that is heated directly by plane heater 11. The components of plane heater unit 8 are detailed below.

[Upper heating compartment plate]

[0041] FIGS. 6A to 6C illustrate plane-heater-unit upper heating compartment plate 10 that forms the ceiling wall of heating compartment 4 in plane heater unit 8. FIG. 6A is a plan view of upper heating compartment plate 10. FIG. 6B is an end elevational view of upper heating compartment plate 10 of FIG. 6A, taken along line 6B-6B. FIG. 6C is an end elevational view of upper heating compartment plate 10 of FIG. 6A, taken along line 6C-6C.

[0042] Upper heating compartment plate 10 forms the ceiling wall of heating compartment 4, and its central portion other than its outer peripheral border has a rectangular form (10a) when viewed in a plane. This rectangular form has curved surfaces concavely facing the heating compartment (downward) and is heat-generating area 10a to which plane heater 11 is closely fitted. In the present exemplary embodiment, heating compartment 4 has the shape of a rectangular parallelepiped having a long side on its front face side with heat-generating area 10a covering a substantially entire area of the ceiling wall of heating compartment 4. Plane heater 11 is rectangular correspondingly to the shape of heating compartment 4 and is closely fitted to an entire area of heat-generating area 10a having the curved surfaces. As such, the substantially entire area of upper heating compartment plate 10 that forms the ceiling wall of heating compartment 4 is a heat generator that undergoes heating by plane heater 11.

[0043] As shown in the end elevational view of FIG. 6B, a longitudinal section (taken along a left-right line in FIG. 6A) of heat-generating area 10a of upper heating compartment plate 10 is defined by a curve. As shown in the end elevational view of FIG. 6C, a transverse section (taken along an up-down line in FIG. 6A) of heat-generating area 10a of upper heating compartment plate 10 is similarly defined by a curve. Thus, heat-generating area 10a of upper heating compartment plate 10 has the three-dimensional curved surface concavely facing the heating compartment. In the present exemplary embodiment, a curvature of the longitudinal curve of heat-generating area 10a differs from a curvature of the transverse curve of heat-generating area 10a. The longitudinal curvature is greater than the transverse curvature. Heat-generating area 10a is not limited to this and may have a longitudinal curvature that is smaller than its transverse curvature.

[0044] In upper heating compartment plate 10, heat-generating area 10a to which plane heater 11 is closely mounted has a plurality of areas (honeycomb areas) 10b each having the shape of a regular hexagon (honeycomb) as shown in the plan view of FIG. 6A. In upper heating compartment plate 10 of the present exemplary embodiment, boundaries of honeycomb areas 10b are formed of respective grooves that project toward the heating compartment, and honeycomb areas 10b have respective areas that are substantially identical. Upper heating compartment plate 10 having such a structure is formed by press working.

[0045] As described above, heat-generating area 10a of upper heating compartment plate 10 is formed to have the plurality of honeycomb areas 10b. Heat-generating area 10a expands with heat of plane heater 11 or contracts when plane heater 11 is in an off condition with power cut off. However, deformation forces resulting from expansion or contraction in all directions can be absorbed within honeycomb areas 10b. While heat-generating area 10a is heated by closely fitted plane heater 11, heat-generating area 10a is not uniformly heated throughout its entire area by plane heater 11, so that there is non-uniformity in heat generation distribution of heat-generating area 10a. Accordingly, the deformation forces resulting from the expansion or the contraction can be of different magnitudes among the areas of heat-generating area 10a. If the upper heating compartment plate, which is the ceiling wall of heating compartment 4, had a flat shape with no areas that can each absorb deformation force resulting from expansion or contraction, the ceiling wall would undergo localized heating and thus would be deformed and distorted in a non-uniform manner. A clearance would thus be caused between the upper heating compartment plate and the plane heater, so that this structure makes it difficult for heat to be transferred from the plane heater.

[0046] In the thermal cooking device according to the present exemplary embodiment, heat-generating area 10a of upper heating compartment plate 10 is formed with the plurality of areas (honeycomb areas) 10b that are divided by the grooves from one another. As such, the deformation forces resulting from the expansion or the contraction are dispersed among these honeycomb areas and are absorbed. Heat-generating area 10a of the ceiling wall does not undergo significant localized deformation and distortion, and its curved surface concavely facing the heating compartment thus rises smoothly as a whole. As a result, heat-generating area 10a maintains its close contact with plane heater 11 and thus can receive heat from plane heater 11 with higher efficiency and without fail.

[0047] As described above, heat-generating area 10a of upper heating compartment plate 10 is prevented from undergoing localized deformation in the present exemplary embodiment and rises as a whole while maintaining a similar shape as a whole, so that the close contact between plane heater 11 and heat-generating area 10a is maintained without fail.

[0048] While upper heating compartment plate 10 of the present exemplary embodiment is described with heat-generating area 10a being divided into the plurality of honeycomb areas 10b that each have the shape of the regular hexagon (honeycomb), the honeycomb is not necessarily specified for the shape of area 10b. Heat-generating area 10a may be formed of any plurality of areas among which localized deformation forces resulting from expansion or contraction can be dispersed and absorbed. For example, areas each having the shape of a polygon such as a triangle or a quadrangle or areas formed by curved lines can absorb deformation forces resulting from expansion or contraction.

[0049] In the present exemplary embodiment, upper heating compartment plate 10 is provided with, at its substantially central position, keep plate engagement part 10c to which keep plate 14 (described later) is mounted to play vertically. Keep plate 14 is mounted to this keep plate engagement part 10c with stepped screw serving as locking tool 19 that is screwed into keep plate engagement part 10c. Upper heating compartment plate 10 is also provided with a plurality of projecting fasteners 10d to achieve close mounting of plane heater 11. Fasteners 10d are small pieces projecting upward from the upper surface of heat-generating area 10a. Heat-generating area 10a has these bendable plates fixed to its upper surface.

[0050] In the present exemplary embodiment, the steel or stainless steel (SUS) plate that is plated with aluminum is used for upper heating compartment plate 10. Upper heating compartment plate 10 is formed with, for example, a black film member made of, for example, silicon resin at each of its surfaces. With the formation of such a black film member on the plane-heater-end surface, heat from plane heater 11 can be absorbed with high efficiency. In the present exemplary embodiment, upper heating compartment plate 10 is formed with, at its heating-compartment-end surface, the film layer with the self-cleaning function that effects the automatic cleaning by decomposing oil and fat that are scattered during cooking through heating that is performed for the cooking. The method of forming the film layer having the self-cleaning function has been mentioned above and thus is omitted here. In the present exemplary embodiment, the film layer having the self-cleaning function is formed even on each of the side walls as well as on the rear wall of heating compartment 4.

[Plane heater]

[0051] FIG. 7 is an exploded perspective view of plane heater 11 that is closely mounted to heat-generating area 10a of upper heating compartment plate 10. As shown in FIG. 7, heater 25 that is a heat source in plane heater 11 is divided into inner-side heater (inner heater) 20 and outer-side heater (outer heater) 21. FIG. 8 is a plan view of heater 25, which is the heat source formed of inner heater 20 and outer heater 21. With outer heater 21 surrounding inner heater 20, inner heater 20 and outer heater 21 are disposed substantially on the same plane and are drivingly controlled in a separate manner. In the present exemplary embodiment, inner heater 20 is variably controlled in a stepless manner in a range of from

300 W to 900 W, while outer heater 21 undergoes on and off control using 700 W.

[0052] Inner heater 20 and outer heater 21 are each formed by winding of a heater wire around an insulating plate of mica, and with a heater output of 900 W as opposed to 650 W in conventional cases, and thus a heater output per unit area is 1.6 times greater. In the present exemplary embodiment, an (inner-heater) heater output of 3.0 W/cm^2, for example, is possible. It is to be noted that in the present exemplary embodiment, the heater wire used for inner heater 20 is belt-shaped and 0.144 mm in thickness, while the heater wire used for outer heater 21 is belt-shaped and 0.10 mm in thickness. Because the heater wires are densely wound during the formation, upper heating compartment plate 10 can undergo a more uniform temperature rise.

[0053] As shown in FIG. 7, heater 25 that is formed, as the one heat source, of inner heater 20 and outer heater 21 is held from both sides by two plates of mica, namely, upper insulator 22 and lower insulator 23. In this way, plane heater 11 is formed. FIG. 9 is a top plan view of plane heater 11, showing upper insulator 22. FIG. 10 is a rear view of plane heater 11, showing lower insulator 23.

[0054] As shown in FIGS. 9 and 10, upper insulator 22 and lower insulator 23 each have areas where the respective heater wires of inner heater 20 and outer heater 21 are clamped, and these areas are divided by slit 22a, 23a. As such, the areas of each of upper and lower insulators 22 and 23 are respectively heated by the respective heater wires of inner and outer heaters 20 and 21 with heat transfer being blocked between these areas. Slit 22a, 23a serving as the division can prevent the close fitting of upper heating compartment plate 10 from being impaired due to expansion of both inner heater 20 and outer heater 21 that are energized simultaneously. Upper insulator 22 and lower insulator 23 that clamp heater 25 are each formed with openings 22b, 23b through which above-mentioned keep plate engagement part 10c and the plurality of fasteners 10d of upper heating compartment plate 10 are respectively inserted. Plane heater 11 has terminal part 24. Terminal part 24 is provided with terminals that are connected to the respective heater wires of inner heater 20 and outer heater 21.

[0055] FIG. 11 is a perspective view illustrating plane heater 11 mounted to the upper surface of above-mentioned upper heating compartment plate 10. As shown in FIG. 11, plane heater 11 is closely mounted to curved heat-generating area 10a of upper heating compartment plate 10. Fasteners 10d formed on upper heating compartment plate 10 are bent to closely mount plane heater 11 in a predetermined position on heat-generating area 10a. Here fasteners 10d of upper heating compartment plate 10 are respectively passed through openings (22b, 23b), which are formed to vertically pass through plane heater 11, and respective holes in pressing tools 12, which serve as the stiffening plates formed of mica, and then are bent, whereby plane heater 11 is closely mounted to the upper surface of heat-generating area 10a. Keep plate engagement part 10c provided at the central position of upper heating compartment plate 10 is disposed in openings (22b, 23b) that are formed in a center of plane heater 11.

[First heat insulator]

[0056] As shown in FIG. 5, first heat insulator 13 is disposed over plane heater 11. First heat insulator 13 functions to block off heat from an upper surface of plane heater 11 and is formed of, for example, glass wool. First heat insulator 13 is shaped to cover at least the entire area of heat-generating area 10a of upper heating compartment plate 10, has a substantially uniform thickness, and has elasticity (restoring force) at least thicknesswise.

[0057] As shown in above-mentioned FIG. 5, first heat insulator 13 is formed with a plurality of openings. The opening formed in a center of first heat insulator 13 is engagement part opening 13a that receives keep plate engagement part 10c protrusively provided to upper heating compartment plate 10. Included in first heat insulator 13, fastener openings 13b respectively receive fasters 10d that are provided to upper heating compartment plate 10, terminal opening 13c allows passage of the heater wires of plane heater 11, and temperature sensor opening 13d receives probe 18a (refer to FIG. 15) of heater temperature sensor 18 that detects, as the heater temperature detecting means, the temperature of the heating area (described later) that undergoes direct heating by plane heater 11.

[Keep plate]

[0058] FIGS. 12A to 12C illustrate keep plate 14 that is mounted to upper heating compartment plate 10 while covering a top of first heat insulator 13. FIG. 12A is a plan view of keep plate 14. FIG. 12B is an end elevational view of keep plate 14 of FIG. 12A, taken along line 12B-12B. FIG. 12C is an end elevational view of keep plate 14 of FIG. 12A, taken along line 12C-12C.

[0059] As shown in FIGS. 12A to 12C, keep plate 14 that is mounted to upper heating compartment plate 10 is formed with curved-surface area 14a that has curved surfaces similar to the curved surfaces of heat-generating area 10a of upper heating compartment plate 10. Keep plate 14 functions to press plane heater 11 against heat-generating area 10a of upper heating compartment plate 10 via first heat insulator 13, so that plane heater 11 is closely fitted to heat-generating area 10a with no clearance throughout its entire area. Keep plate 14 is formed with pressing parts 14b in positions respectively facing inner heater 20 and outer heater 21 of plane heater 11. Pressing parts 14b formed are continuous projections each projecting toward plane heater 11 and press inner heater 20 and outer heater 21 of plane heater 11 via first heat insulator 13. Because of being formed with pressing parts 14b as described above, keep plate 14 has increased rigidity. In cases where there is a part where close fitting is poor, this part can be provided with pressing part 14b for improvement, whereby upper heating compartment plate 10 can undergo a uniform temperature rise.

[0060] As shown in the end elevational view of FIG. 12B, a longitudinal section (taken along a left-right line in FIG. 12A) of curved-surface area 14a of keep plate 14 is substantially defined by a curve.

Similarly, a transverse section (taken along an up-down line in FIG. 12A) of curved-surface area 14a of keep plate 14 is substantially defined by a curve as shown in the end elevational view of FIG. 12C. Thus, curved-surface area 14a of keep plate 14 has the three-dimensional curved surface concavely facing the heating compartment (downward). In the present exemplary embodiment, a curvature of the longitudinal curve of curved-surface area 14a differs from a curvature of the transverse curve of curved-surface area 14a. The longitudinal curvature is smaller than the transverse curvature. Curved-surface area 14a is not limited to this and may have a longitudinal curvature that is greater than its transverse curvature. As described above, curved-surface area 14a of keep plate 14 has the curved surfaces similar to the curved surfaces of heat-generating area 10a of upper heating compartment plate 10.

[0061] As shown in FIG. 12A, keep plate 14 is formed with, in its center, engagement part mounting hole 14c for allowing passage of threaded part 19c (refer to FIG. 13) of locking tool (stepped screw) 19 that is screwed to keep plate engagement part 10c protrusively provided to upper heating compartment plate 10.

[0062] FIG. 13 is a sectional view describing a method of screwing stepped screw 19, which is the locking tool, to keep plate engagement part 10c of upper heating compartment plate 10 so that keep plate 14 is mounted to upper heating compartment plate 10 to play vertically. In FIG. 13, part (a) illustrates stepped screw 19 that is in the middle of being screwed to keep plate engagement part 10c, while part (b) illustrates an assembled condition with stepped screw 19 screwed to keep plate engagement part 10c. As shown in FIG. 13, stepped screw 19 is formed of head 19a, cylinder 19b, and threaded part 19c with cylinder 19b having a larger diameter than threaded part 19c.

[0063] As shown in part (a) of FIG. 13, head 19a of stepped screw 19 abuts keep plate 14 when stepped screw 19 is in the middle of being screwed to keep plate engagement part 10c. In the structure of the present exemplary embodiment, after head 19a of stepped screw 19 abuts keep plate 14 as shown in part (a) of FIG. 13, screwing is performed by a predetermined pitch, whereby cylinder 19b of stepped screw 19 abuts keep plate engagement part 10c of upper heating compartment plate 10. In this way, the screwing of stepped screw 19 to keep plate engagement part 10c is completed, and the assembling is completed.

[0064] FIG. 14 illustrates heat-generating area 10a that has expanded and risen when heat-generating area 10a of upper heating compartment plate 10 has been heated to a high temperature by plane heater 11 during use of the thermal cooking device. Even when heat-generating area 10a rises due to its expansion, cylinder 19b of stepped screw 19 is vertically slidable in engagement part mounting hole 14c of keep plate 14 as shown in FIG. 14. For this reason, keep plate 14 does not rise in a manner similar to heat-generating area 10a that rises due to its expansion, and plane heater 11 is always held pressed against heat-generating area 10a under a predetermined pressure or more by keep plate 14. Because plane heater 11 is always pressed against heat-generating area 10a by keep plate 14 as described above, plane heater 11 is held closely fitted to heat-generating area 10a with no clearance during the cooking operation of the thermal cooking device according to the present exemplary embodiment.

[0065] As shown in the plan view of keep plate 14 of FIG. 12A, keep plate 14 is provided with temperature sensor mounting part 14d and terminal mounting part 14e. Temperature sensor mounting part 14d is a part where heater temperature sensor 18 such as a thermistor is mounted to detect the temperature of the area that is heated directly by heat from plane heater 11. Terminal mounting part 14e is where terminal part 24 having the terminals for inner heater 20 and outer heater 21 of plane heater 11 is mounted. The terminals of terminal part 24 are connected to a power supply unit that is drivingly controlled by controller 7 of the thermal cooking device.

[0066] FIG. 15 is an enlarged sectional view illustrating heater temperature sensor (thermistor) 18 mounted in temperature sensor mounting part 14d of keep plate 14. It is to be noted that an area indicated by reference mark XV in above-mentioned FIG. 4 is shown enlarged in the sectional view of FIG. 15. As shown in FIG. 15, probe 18a of heater temperature sensor 18 is disposed in temperature sensor opening 13d formed in first heat insulator 13. Temperature sensor opening 13d defines the heating area (heating space) that undergoes direct heating by plane heater 11. Accordingly, probe 18a of heater temperature sensor 18 is disposed in this heating area (heating space), which is heated directly by plane heater 11. In the present exemplary embodiment, the heating area (heating space) is formed right above inner heater 20 of plane heater 11 to be heated directly by inner heater 20. With heater temperature sensor 18 detecting the temperature of the heating area that is heated directly by inner heater 20, based on this heater temperature information and the internal compartment temperature information from internal compartment temperature sensor 9 that detects the internal temperature of heating compartment 4, controller 7 drivingly controls the heat source of plane heater 11 and heat sources of the other various thermal cooking means that are used in the thermal cooking device.

[0067] FIG. 16 is a perspective view of plane heater

unit 8 with above-mentioned upper heating compartment plate 10 being mounted with plane heater 11, first heat insulator 13, keep plate 14, and others.
As shown in FIG. 16, keep plate 14 of plane heater unit 8 is mounted over heat-generating area 10a of upper heating compartment plate 10.

[0068] FIGS. 17A to 17C illustrate plane heater unit 8. FIGS. 17A is a plan view of plane heater unit 8. FIG. 17B is a sectional view of plane heater unit 8 of FIG. 17A, taken along line 17B-17B. FIG. 17C is a sectional view of plane heater unit 8 of FIG. 17A, taken along line 17C-17C.

[0069] As shown in FIGS. 17A to 17C, plane heater unit 8 is a substantially integral structure, forming the ceiling wall of heating compartment 4. As shown in the sectional view of FIG. 17B, a longitudinal section (taken along a left-right line in FIG. 17A) of plane heater unit 8 is defined by a curved surface having a substantially uniform thickness (vertical length). As shown in the sectional view of FIG. 17C, a transverse section (taken along an up-down line in FIG. 17A) of plane heater unit 8 is similarly defined by a curved surface having a substantially uniform thickness (vertical length). Thus, plane heater unit 8 as a whole has the three-dimensional curved surface concavely facing the heating compartment (downward). It is to be noted that a surrounded area indicated by reference mark A in the sectional view of FIG. 17B shows where stepped screw 19, which is the locking tool shown in above-mentioned FIGS. 13 and 14, is screwed.

[Heating control]

[0070] In the thermal cooking device according to the present exemplary embodiment, the microwave heating unit is provided as the thermal cooking means other than plane heater unit 8 having the above structure. This microwave heating unit includes a magnetron that makes microwaves, and radiates the microwaves made by the magnetron from its antenna via a wave guide. The antenna that radiates the microwaves into heating compartment 4 is disposed below the bottom wall of heating compartment 4 and radiates the microwaves in the form of, for example, circularly polarized waves from below heating compartment 4 into heating compartment 4. The antenna is capable of radiating microwaves having directivity and enables uniform heating of the interior of heating compartment 4 by being rotated.

[0071] The other thermal cooking means of the thermal cooking device according to the present exemplary embodiment include the steam heating unit that intensively ejects water vapor into the heating compartment for thermal cooking and the hot-air circulation unit that heats or cooks food by circulating hot air in heating compartment 4. The steam heating unit has the water tank inside main body 1 and intensively ejects into heating compartment 4 water vapor that is generated by heating water to a high temperature by means of the steam heaters of the boiler. The hot-air circulation unit sucks air from heating compartment 4, heats the air by means of a rear heater provided behind heating compartment 4, and supplies the heated air to the interior of heating compartment 4.

[0072] As described above, plane heater unit 8, the microwave heating unit, the steam heating unit, and the hot-air circulation unit are provided as the thermal cooking means in the thermal cooking device of the present exemplary embodiment. According to the cooking content, the thermal cooking means is selected. Depending on cases, the thermal cooking means are drivingly controlled simultaneously or in combination. It is to be noted that heating control using plane heater unit 8 is mainly described in the present exemplary embodiment.

[0073] As shown in above-mentioned FIG. 15, probe 18a of heater temperature sensor 18 is received by temperature sensor opening 13d formed in first heat insulator 13 and thus is disposed in the heating area (heating space) that undergoes direct heating by inner heater 20 of plane heater 11. Heater temperature sensor 18 detects the temperature of the space heated directly by inner heater 20 and transmits the detected temperature as the heater temperature information to controller 7 (refer to FIG. 18). Based on the heater temperature information as well as the internal compartment temperature information from internal compartment temperature sensor 9 that detects the internal temperature of heating compartment 4, controller 7 controls, for example, the heat source and a driving source in the thermal cooking operation according to, for example, the cooking content set by the user.

[0074] In the present exemplary embodiment, heater temperature sensor 18 detects the temperature of the heating area (heating space) that undergoes direct heating by inner heater 20, so that in the thermal cooking operation using inner heater 20, controller 7 can perform temperature control based on the highly accurate heater temperature information from heater temperature sensor 18. As described later, a rapid heating operation is carried out using inner heater 20 with a greater heater output in the present exemplary embodiment to cause a rapid temperature rise in heating compartment 4, so that the heater temperature information is effective in this rapid heating operation.

[0075] In a conventional thermal cooking device, as described in [SUMMARY OF THE INVENTION], on and off control of a plane heater based on a detected internal compartment temperature is performed such that an interior of a heating compartment reaches a preset temperature. As such, the plane heater is once turned off far ahead of a time when the internal compartment temperature reaches the preset temperature in the conventional thermal cooking device, and an on and off operation of the plane heater is repeated thereafter to gradually bring the internal compartment temperature closer to the preset temperature. It is thus difficult for the internal compartment temperature to reach the preset temperature with high accuracy through the use of the plane heater, and a length of time is required until the preset temperature is reached.

[0076] In the thermal cooking device according to the present exemplary embodiment, controller 7 performs the temperature control in the thermal cooking operation based on the heater temperature information from heater temperature sensor 18 and the internal compartment temperature information. Particularly in the rapid heating operation where a rapid temperature rise is caused in heating compartment 4 so that a preset temperature is reached within a short period of time, a control operation is carried out based on the heater temperature information indicative of the temperature of the heating area heated by inner heater 20. Accordingly, controller 7 can cause the heating area to be heated rapidly to the preset temperature by means of inner heater 20 and thus can cause the internal temperature of heating compartment 4 to rise rapidly. As described later, current that is input to inner heater 20 can be controlled to a desired value in the present exemplary embodiment, so that the heater output of inner heater 20 can be set at a desired value. As such, controller 7 can maintain the internal compartment temperature at the preset temperature with high accuracy by controlling the current that is input to inner heater 20 based on the internal compartment temperature information and the heater temperature information after the internal compartment temperature has reached the preset temperature. Consequently, the thermal cooking device according to the present exemplary embodiment can significantly shorten a length of time until the internal compartment temperature reaches the preset temperature and can maintain, with high accuracy, the internal compartment temperature at the preset temperature for a predetermined period of time.

[Thermal cooking operations]

[0077] FIG. 18 shows a part of a circuit diagram for control of the thermal cooking means in the thermal cooking device according to the present exemplary embodiment. The heat sources of the thermal cooking means in the thermal cooking device of the present exemplary embodiment include inner heater 20 and outer heater 21 of plane heater unit 8, steam heaters 26 of the steam heating unit, rear heater 27 of the hot-air circulation unit, and magnetron 28 of the microwave heating unit (refer to FIG. 18). The hot-air circulation unit uses circulation fan motor 29.

[0078] As shown in the circuit diagram of FIG. 18, inner heater 20, outer heater 21, steam heaters 26, rear heater 27, and circulation fan motor 29 are respectively connected to corresponding switching elements to each undergo on and off control. Magnetron 28 is a microwave generating means of the microwave heating unit and is connected to an inverter circuit that serves as the driving power source. In the present exemplary embodiment, triode for alternating current (TRIAC) 30 is used as the switching element in driving control of inner heater 20, so that the current that is input to inner heater 20 can be controlled to a desired value. For outer heater 21, relay 31 is used as the switching element to simply switch on and off outer heater 21. While the present exemplary embodiment is described with relay 31 being used as the switching element that simply switches on and off outer heater 21, a TRIAC may be used as the switching element for outer heater 21 as in the case of inner heater 20 so that input power can be controlled variably in a stepless manner.

[0079] Rated power is predetermined for the thermal cooking device, so that power greater than the rated power cannot be consumed. The thermal cooking device according to the present exemplary embodiment is structurally capable of thermal cooking using the plurality of thermal cooking means, and the power that is consumed by the heat sources to be activated is always controlled to not more than the rated power by controller 7. The control of plane heater unit 8 in particular is characteristic in the thermal cooking device of the present exemplary embodiment.

[0080] Heater 25 of plane heater unit 8 is the one heat source formed of inner heater 20 and outer heater 21 with respective maximum heater outputs of inner heater 20 and outer heater 21 being, for example, 900 W and 700 W, in the present exemplary embodiment. As such, a total of the respective maximum heater outputs of inner heater 20 and outer heater 21 exceeds general-home rated power (1500 W = 15 A (rated current) $\times$ 100 V). As shown in FIG. 18, inner heater 20 is drivingly controlled by means of TRIAC 30 that serves as the switching element in the thermal cooking device according to the present exemplary embodiment. Accordingly, inner heater 20 can be driven by a control signal that is input to TRIAC 30 such that its heater output can be varied in the stepless manner in the range of from 300 W to 900 W.

[0081] Specific examples are hereinafter used to describe the thermal cooking operations using the thermal cooking means of the thermal cooking device according to the present exemplary embodiment.

[0082] In cases where thermal cooking is carried out using only plane heater unit 8 with the substantially entire area of the ceiling wall of heating compartment 4 being the heat generator, for example, inner heater 20 of plane heater 11 is drivingly controlled such that its heater output is 700 W, while outer heater 21 is in an on position with its heater output being 700 W. In this way, heating compartment 4 can be heated by plane heater 11 having a total heater output of 1400 W.

[0083] In cases where thermal cooking is carried out in heating compartment 4 by use of the ceiling wall surface of plane heater unit 8 and microwaves of the microwave heating unit from below the bottom wall, for example, inner heater 20 of plane heater 11 is set to the maximum heater output of 900 W while outer heater 21 is in an off condition (0 W). Heating compartment 4 is thus heated from above by plane heater 11 having a total heater output of 900 W. Meanwhile, the microwave heating unit used as the other thermal cooking means can thermally cook food placed on heat-generating pan 6 by heating heat-generating pan 6, which is accommodated by heating compartment 4, with those that include magnetron 28 consuming, for example, 450 W of power.

[0084] In the other example, food placed on heat-generating pan 6 can be thermally cooked with outer heater 21 being in the off condition (0 W), with the heater output of inner heater 20 being 430 W, and with those that include magnetron 28 in the microwave heating unit consuming 550 W of power. As described above, even when plane heater unit 8 and the microwave heating unit are used for thermal cooking, a desired cooking operation can be carried out with consumption of power that is not more than the general-home rated power (1500 W = 15 A (rated current) $\times$ 100 V).

[0085] The use of plane heater unit 8 and the microwave heating unit in the thermal cooking device of the present exemplary embodiment enables intensive heating of a central portion of heating compartment 4. With the heater output of 900 W in plane heater 11 as opposed to 650 W in the conventional cases, the heater output per unit area is 1.6 times greater. Inner heater 20 in particular has the higher heater output than outer heater 21. As such, in the structure of the present exemplary embodiment, a central portion of the ceiling wall surface of heating compartment 4 can be heated rapidly by inner heater 20 having the higher heater output and thus becomes a heat generator. This heat generator can radiate heat intensively toward the central portion of heating compartment 4. Moreover, because the heater wire is densely wound during the formation, upper heating compartment plate 10 can undergo a more uniform temperature rise.

[0086] Meanwhile, the antenna of the microwave heating unit can radiate microwaves (circularly polarized waves) intensively toward the central portion of heating compartment 4 from below heating compartment 4 in the structure of the present exemplary embodiment. Heating compartment 4 accommodates heat-generating pan 6 on which food to be cooked is placed. The heat generator that absorbs the microwaves to generate heat is embedded at mounting surface 33 of heat-generating pan 6. Consequently, the food on the mounting surface of heat-generating pan 6 undergoes heating that is effected from below by the microwave heating unit via heat-generating pan 6 heated by the heat generator while being heated intensively by receiving the upper heat that is radiated by the ceiling wall's central portion heated by plane heater unit 8. This means that the thermal cooking device according to the present exemplary embodiment is structurally capable of rapidly heating the food on heat-generating pan 6, which is accommodated by heating compartment 4, to a high temperature from above and below the food.

[0087] FIG. 19 is a perspective view of heat-generating pan 6 that is used in the thermal cooking device according to the present exemplary embodiment. FIG. 20 is a plan view of heat-generating pan 6 shown in FIG. 19. As shown in FIGS. 19 and 20, when viewed in a plane, heat-generating pan 6 is rectangular with its outer border 34 having the shape of an outwardly spreading flange. A central portion surrounded by outer border 34 is recessed with its bottom being mounting surface 33. Mounting surface 33 is shaped to have irregularities. The irregularities of mounting surface 33 are such that valleys and ridges are alternately formed, running obliquely to a left-right line of mounting surface 33 (to a left-right line of the thermal cooking device). In the present exemplary embodiment, the obliquely running valleys and ridges each extend at an angle of about 45 degrees from the left-right line.

[0088] A central portion of mounting surface 33 of heat-generating pan 6 is provided with area boundary marks 32 to have its rectangular shape defined. Rapid heating area B is located internal to area boundary marks 32 and designates an area where rapid thermal cooking of a cooking object is intensively carried out using inner heater 20 of above-mentioned plane heater unit 8 and microwave heating that is effected by the microwave heating unit. As such, rapid thermal cooking can be carried out when the user places food to be cooked in rapid heating area B located internal to area boundary marks 32 of heat-generating pan 6. It is to be noted that area boundary marks 32 may each, for example, have the shape of a projection or a recess or be printed to be identifiable visually and tactually with ease.

[0089] As described above, the thermal cooking device according to the present exemplary embodiment is structurally capable of rapidly raising the internal compartment temperature and maintaining the internal compartment temperature (the temperature of the upper heating compartment plate) at a constant temperature when performing thermal cooking using at least the plane heater as the thermal cooking means.

[0090] The thermal cooking device according to the present exemplary embodiment enables the internal compartment temperature (the temperature of the upper heating compartment plate) to reach a preset temperature with high accuracy and can shorten a length of time until the internal compartment temperature reaches the preset temperature, thus being structurally capable of shortening a length of cooking time.

[0091] Although the rated power is specified for the thermal cooking device of the present exemplary embodiment, particularly the thermal cooking device intended for general home use, the plurality of power units that consume the total amount of power exceeding the rated power can be used to rapidly start up the interior of the heating compartment with desired high heating power for rapid thermal cooking.

INDUSTRIAL APPLICABILITY

[0092] A thermal cooking device of the present disclosure is structurally capable of rapidly raising an internal compartment temperature to a desired temperature to achieve a shortened length of cooking time and thus is a cooking device having a high market value.

REFERENCE MARKS IN THE DRAWINGS

[0093]

1	main body
2	door
3	handle
4	heating compartment
5	setting part
6	heat-generating pan
7	controller
8	plane heater unit
9	internal compartment temperature sensor
10	upper heating compartment plate (ceiling wall)
10a	heat-generating area
10b	honeycomb area
10c	keep plate engagement part
10d	fastener
11	plane heater
12	pressing tool
13	first heat insulator
14	keep plate
15	insulating sheet
16	heat shield plate
17	second heat insulator
18	heater temperature sensor (thermistor)
18a	probe
19	locking tool (stepped screw)
20	inner heater
21	outer heater
22	upper insulator
23	lower insulator
24	terminal part
25	heater
26	steam heater
27	rear heater
28	magnetron
29	circulation fan motor
30	TRIAC
31	relay
32	area boundary mark
33	mounting surface
34	outer border

Claims

1. A thermal cooking device comprising:

a heating compartment in which a cooking object is heated;

a plane heater provided above a ceiling wall of the heating compartment, the plane heater being one heat source formed of an inner heater disposed right above a central portion of the ceiling wall, and an outer heater surrounding the inner heater; and

a controller that controls the inner heater and the outer heater of the plane heater,

wherein the ceiling wall of the heating compartment has a three-dimensional curved surface concavely facing the heating compartment, and the plane heater is fixed to make close contact with the ceiling wall throughout an entire area of the plane heater.

2. The thermal cooking device according to claim 1, wherein the three-dimensional curved surface of a ceiling wall surface of the heating compartment is rectangular when viewed in a plane and has a longitudinal curvature and a transverse curvature that are different from each other.

3. The thermal cooking device according to claim 1, wherein the ceiling wall of the heating compartment includes a plurality of areas that each absorb deformation force resulting from expansion or contraction that is caused by heat of the plane heater.

4. The thermal cooking device according to claim 1, wherein

the ceiling wall of the heating compartment includes a plurality of areas that each absorb deformation force resulting from expansion or contraction that is caused by heat of the plane heater, and

the plurality of areas are identical in shape.

5. The thermal cooking device according to claim 1, wherein the ceiling wall of the heating compartment includes a plurality of polygonal areas that each absorb deformation force resulting from expansion or contraction that is caused by heat of the plane heater.

6. The thermal cooking device according to claim 1, wherein the ceiling wall of the heating compartment includes a plurality of honeycomb-shaped areas that each absorb deformation force resulting from expansion or contraction that is caused by heat of the plane heater.

7. The thermal cooking device according to claim 1, wherein the plane heater is held, via a heat insulator, by a keep plate that is mounted to the ceiling wall to have a movable range and has a three-dimensional curved surface.

8. The thermal cooking device according to claim 7, wherein

the keep plate is formed with, in areas respectively facing the inner heater and the outer heater, pressing parts that project toward the inner heater and the outer heater, and

the pressing parts press the inner heater and the outer heater via the heat insulator.

9. The thermal cooking device according to claim 1, wherein
a total of respective maximum heater outputs of the inner heater and the outer heater exceeds rated power of the thermal cooking device, and
the controller controls power that is input to the inner heater to prevent a total of respective heater outputs of the inner heater and the outer heater from exceeding the rated power of the thermal cooking device.

10. The thermal cooking device according to claim 1, further comprising a heater temperature sensor that detects a temperature of an area that undergoes direct heating by the inner heater,
wherein based on heater temperature information detected by the heater temperature sensor, the controller performs control that starts up the inner heater to cause the inner heater to reach a temperature that is preset for the heating compartment.

11. The thermal cooking device according to claim 1, wherein at least a plane-heater-end surface of the ceiling wall of the heating compartment has a black silicon film.

12. The thermal cooking device according to claim 1, wherein at least the ceiling wall of the heating compartment has a self-cleaning film at a heating-compartment-end surface of the ceiling wall.

FIG. 1

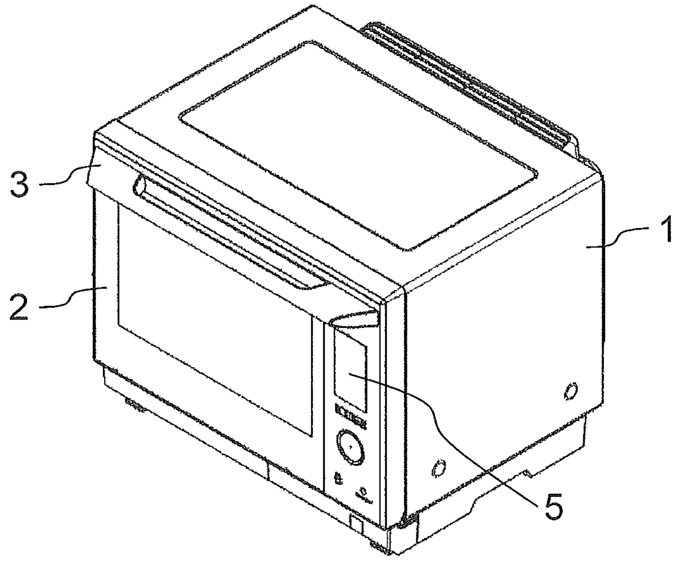


FIG. 2

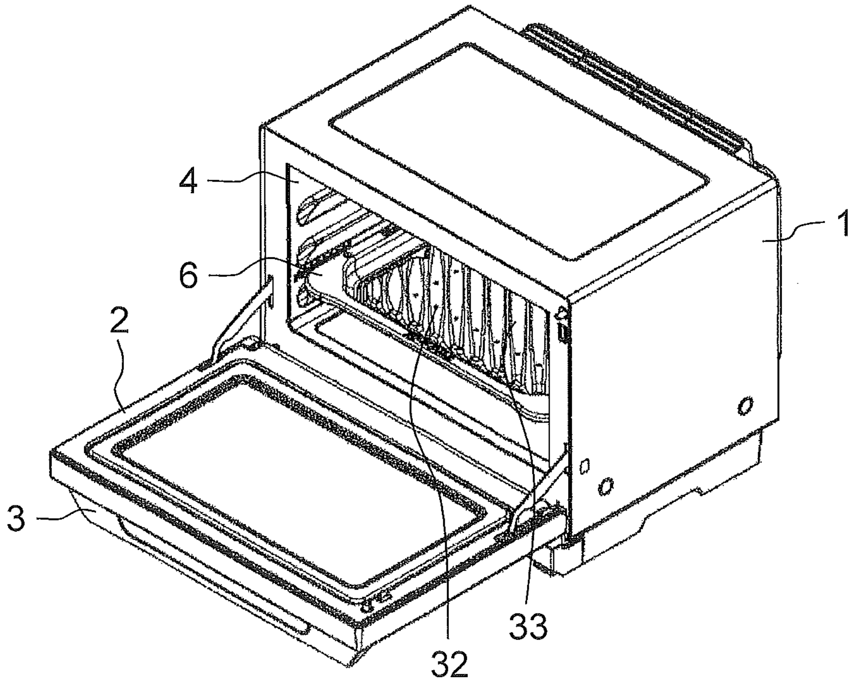


FIG. 3

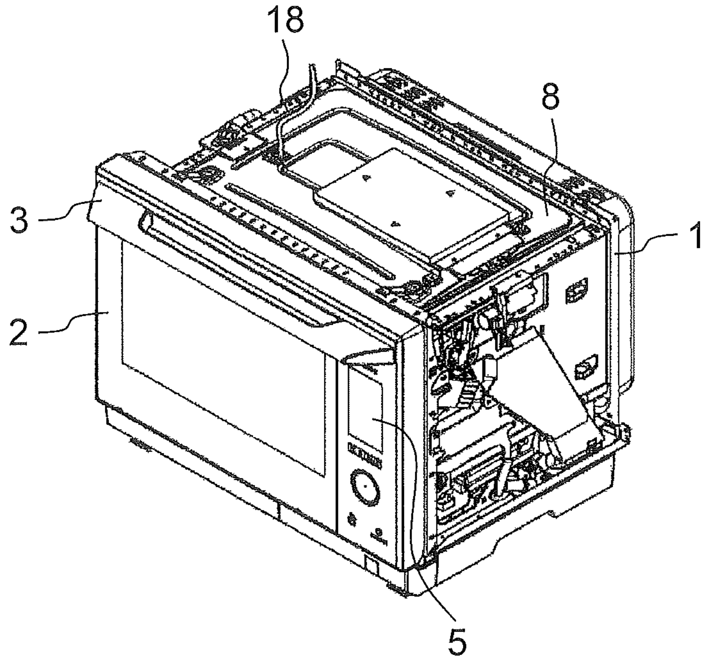


FIG. 4

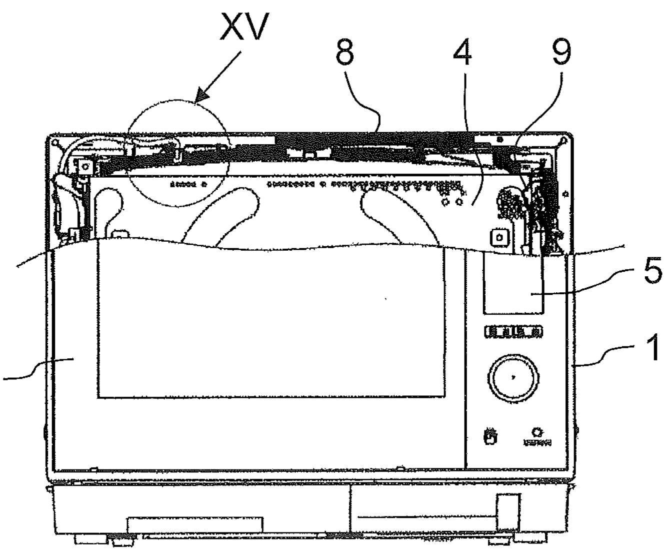
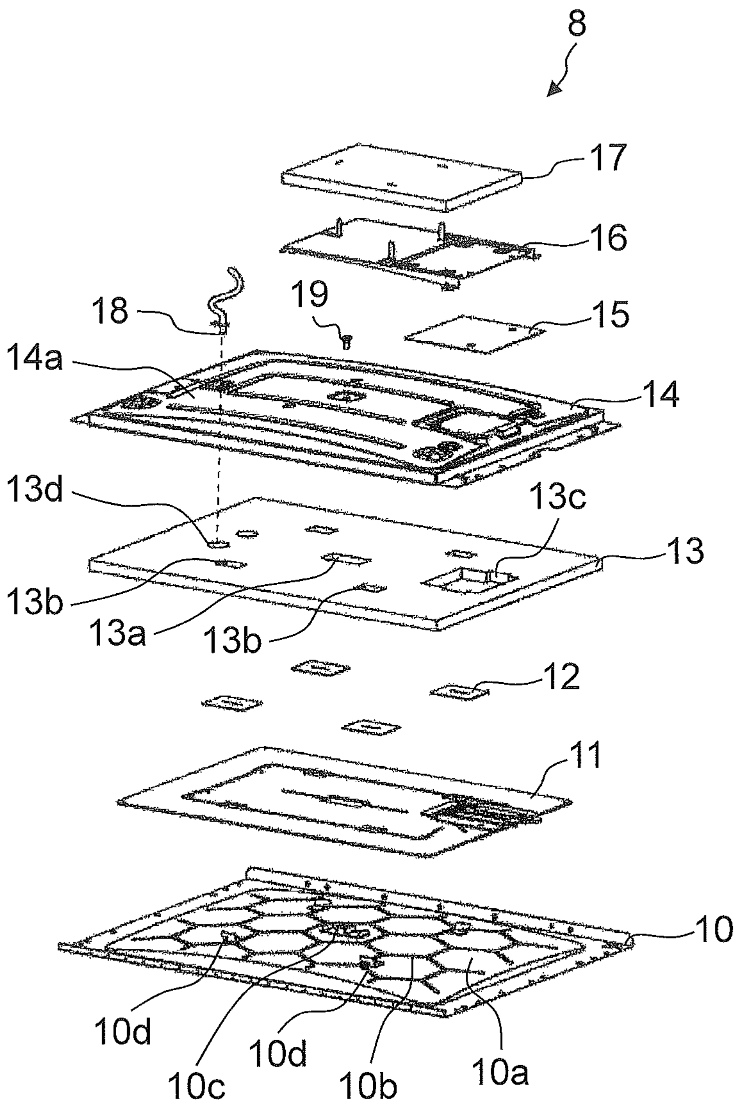


FIG. 5


8
17
16
18
19
15
14a
14
13d
13c
13
13b
13a
13b
12
11
10
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10c
10d
10b
10a

FIG. 6A

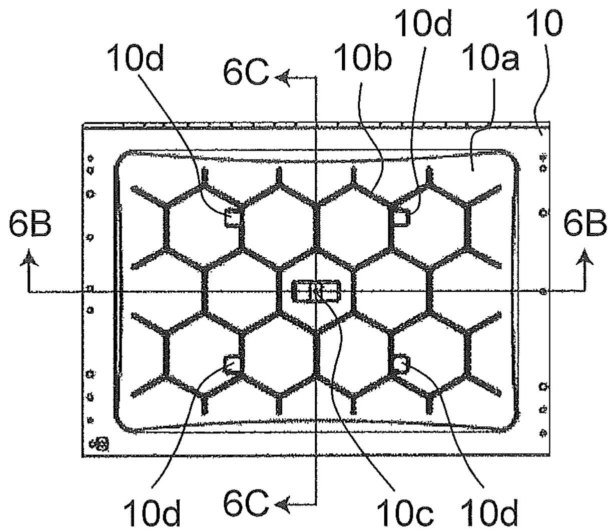


FIG. 6C

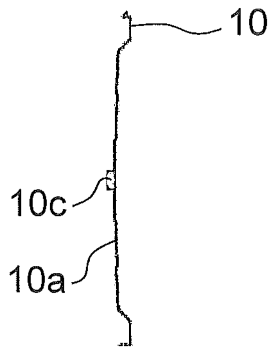


FIG. 6B

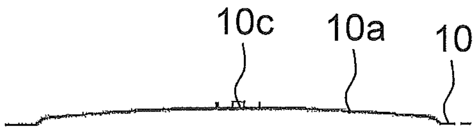


FIG. 7

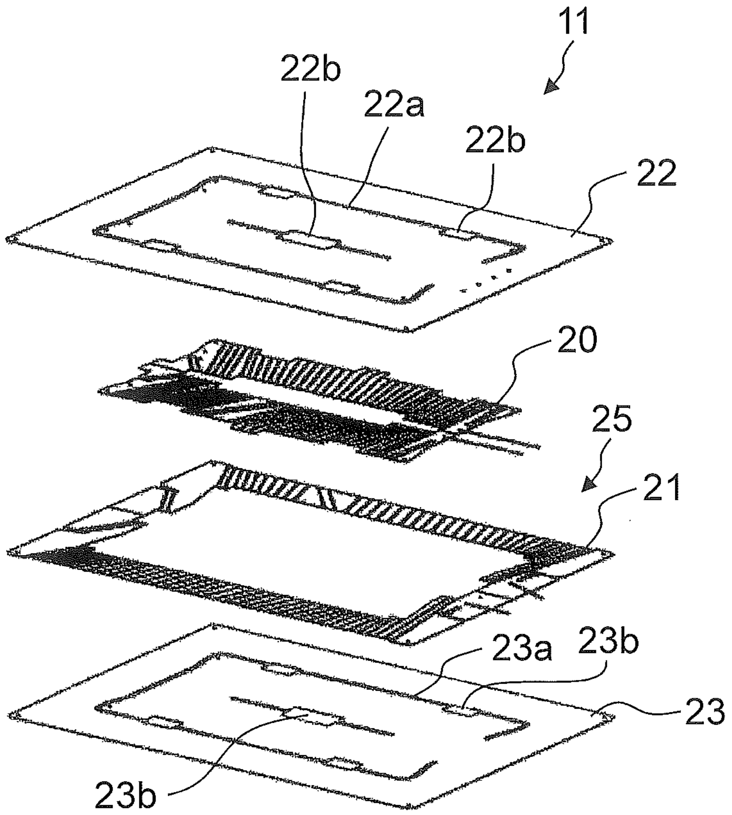


FIG. 8

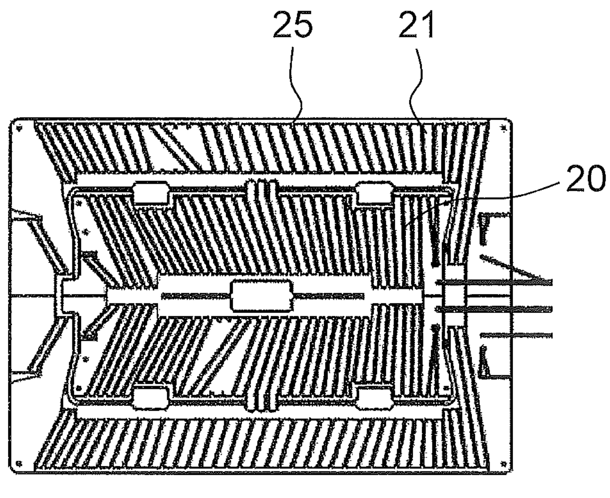


FIG. 9

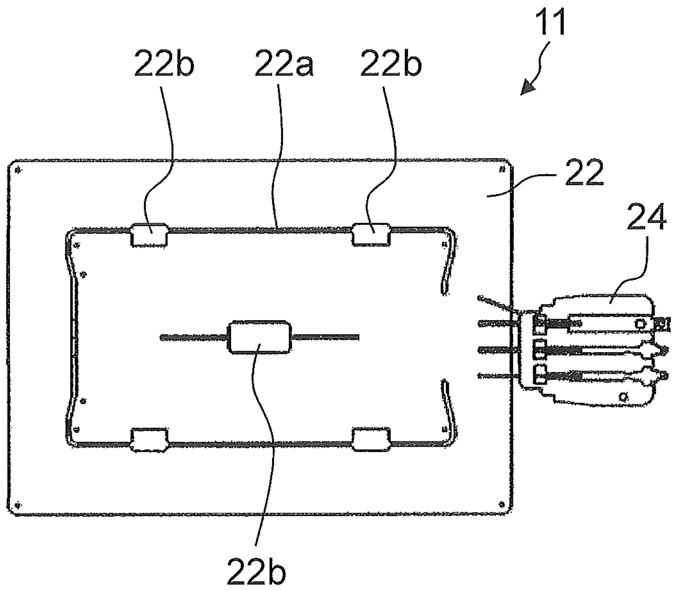


FIG. 10

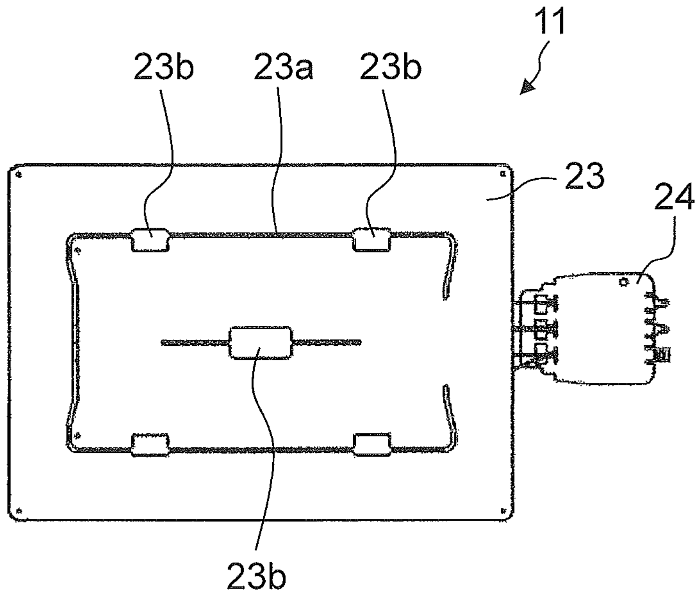


FIG. 11

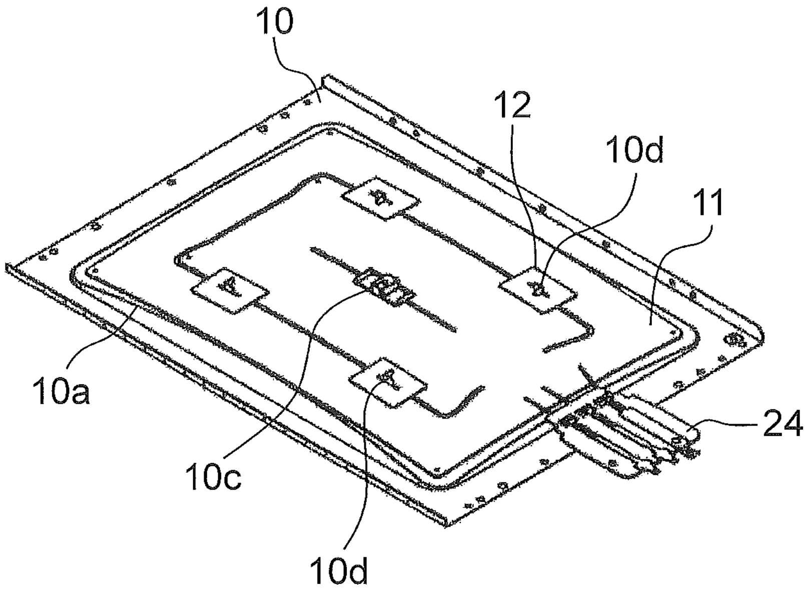


FIG. 12A

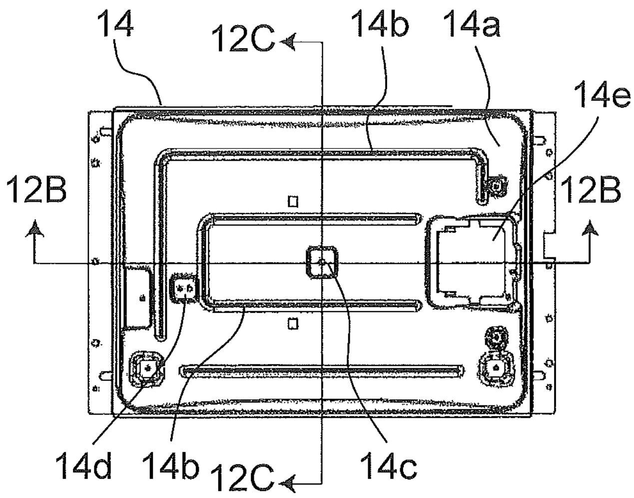


FIG. 12C

FIG. 12B

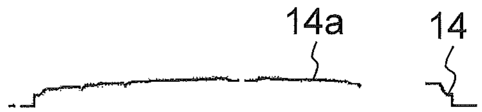


FIG. 13

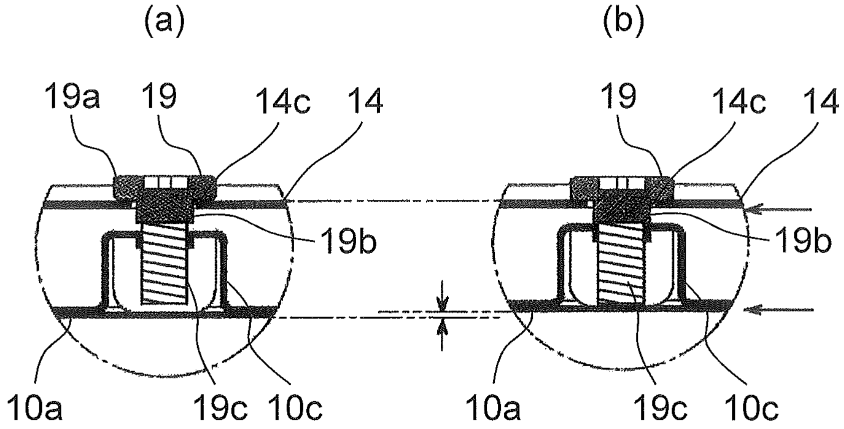


FIG. 14

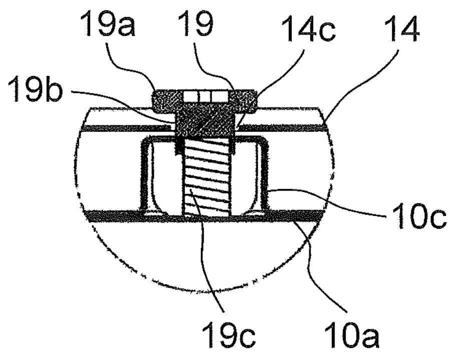


FIG. 15

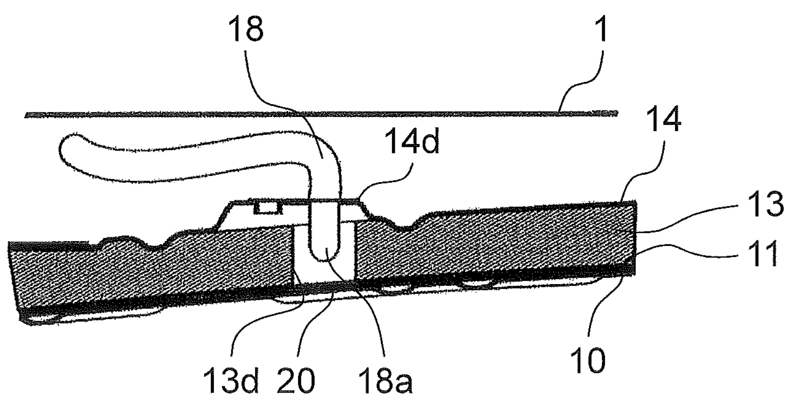


FIG. 16

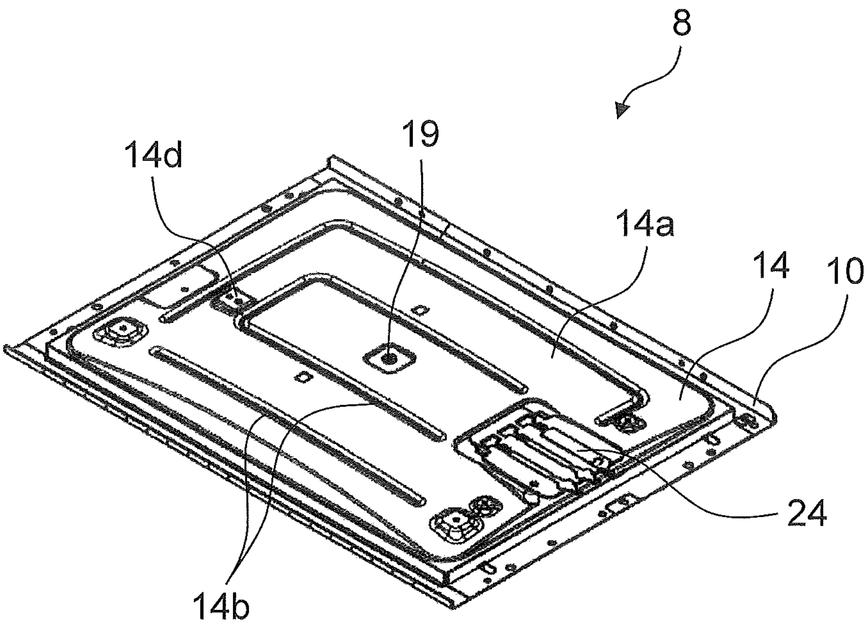


FIG. 17A

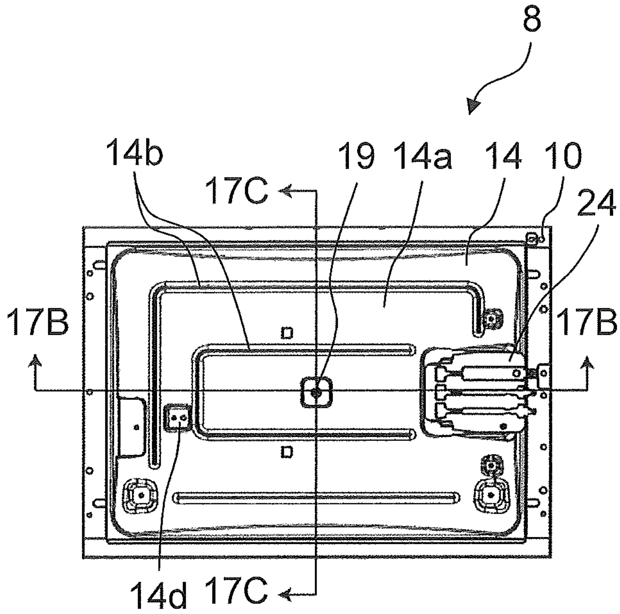


FIG. 17C

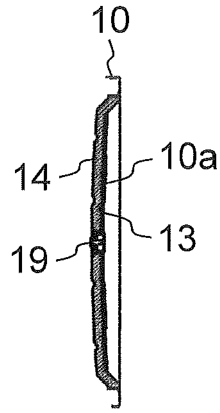


FIG. 17B

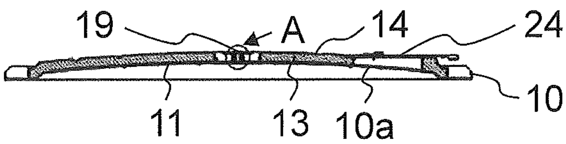


FIG. 18

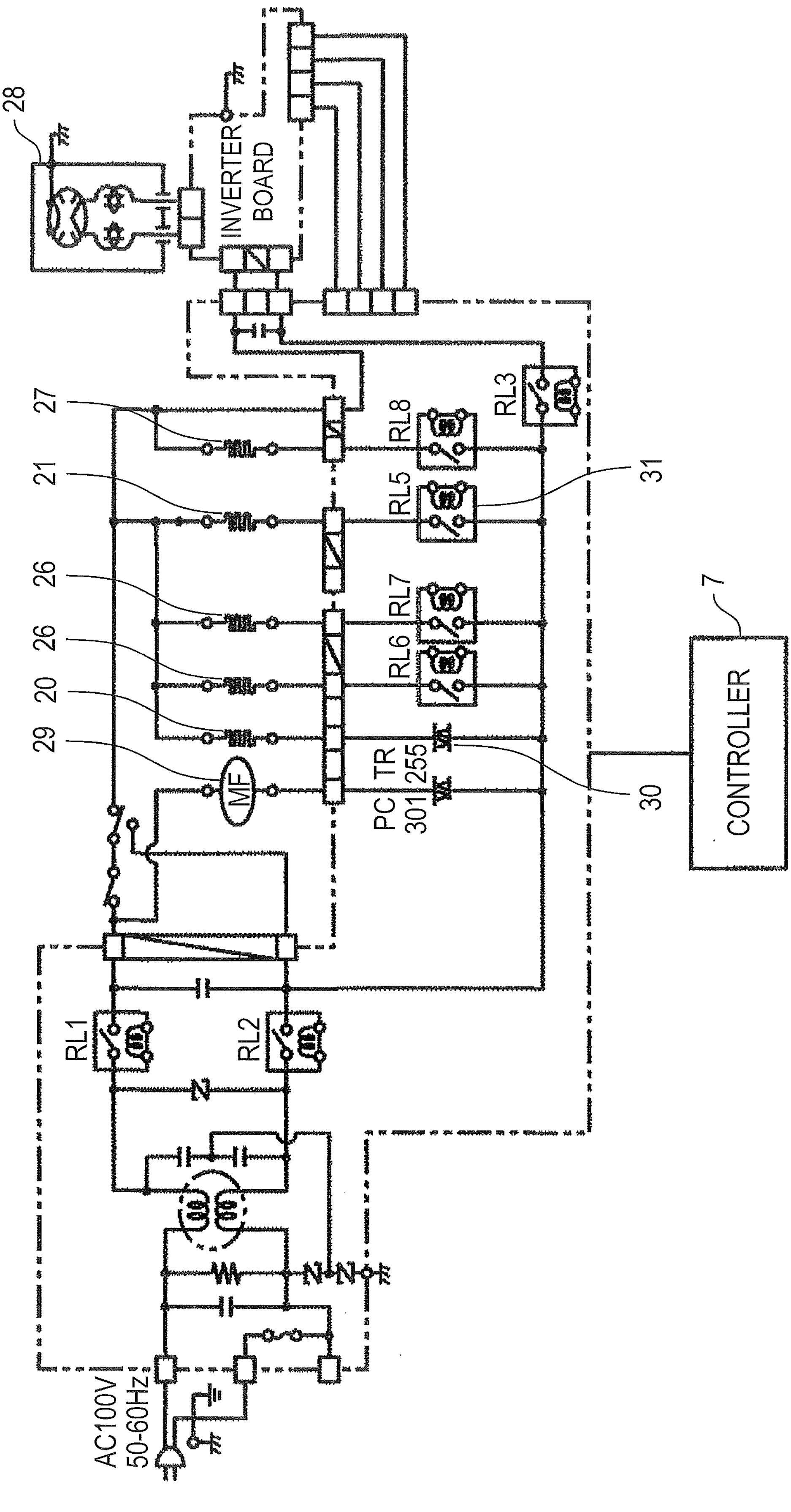

28
INVERTER BOARD
27
21
26
26
20
29
MF
RL8
RL5
RL7
RL6
RL3
31
TR 255
PC 301
30
7
CONTROLLER
RL1
RL2
AC100V 50-60Hz

FIG. 19

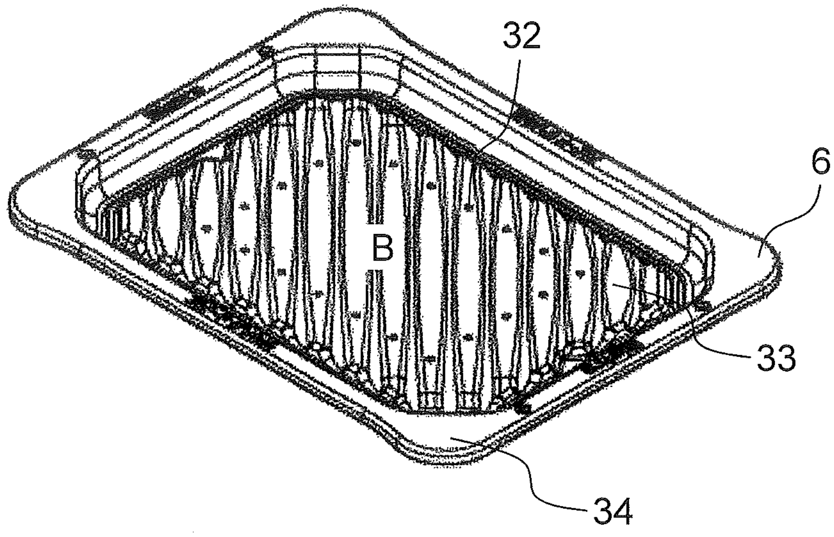
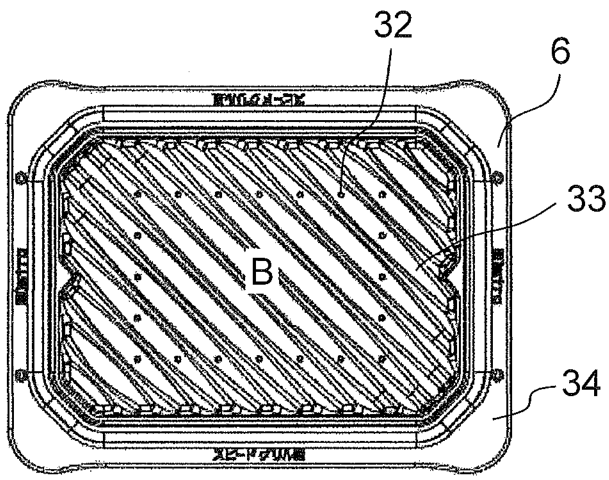


FIG. 20



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2017/001643

A. CLASSIFICATION OF SUBJECT MATTER
F24C7/06(2006.01)i, *F24C7/02*(2006.01)i, *F24C7/04*(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)
F24C7/06, F24C7/02, F24C7/04

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	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 62-299628 A (Matsushita Electric Industrial Co., Ltd.), 26 December 1987 (26.12.1987), claims; page 2, upper right column, line 8 to lower left column, line 15; fig. 1 to 5 (Family: none)	1-12
Y	JP 3-103206 A (Sanyo Electric Co., Ltd.), 30 April 1991 (30.04.1991), page 2, lower right column, lines 11 to 16; page 3, lower right column, line 1 to page 4, upper right column, line 12; all drawings (Family: none)	1-12

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

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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
29 March 2017 (29.03.17)	11 April 2017 (11.04.17)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/001643

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 62-010517 A (Matsushita Electric Industrial Co., Ltd.), 19 January 1987 (19.01.1987), page 2, upper right column, line 18 to lower right column, line 6; fig. 3 & US 4675507 A column 3, line 51 to column 4, line 4 & EP 198500 A2	3-6
Y	JP 3-050421 A (Sanyo Electric Co., Ltd.), 05 March 1991 (05.03.1991), fig. 4 (Family: none)	7,8
Y	JP 2011-098139 A (Panasonic Corp.), 19 May 2011 (19.05.2011), paragraph [0060] (Family: none)	11
Y	JP 63-225494 A (Matsushita Electric Industrial Co., Ltd.), 20 September 1988 (20.09.1988), claim 3 (Family: none)	12

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H03103206 B **[0004]**
- JP 2010054124 A **[0004]**