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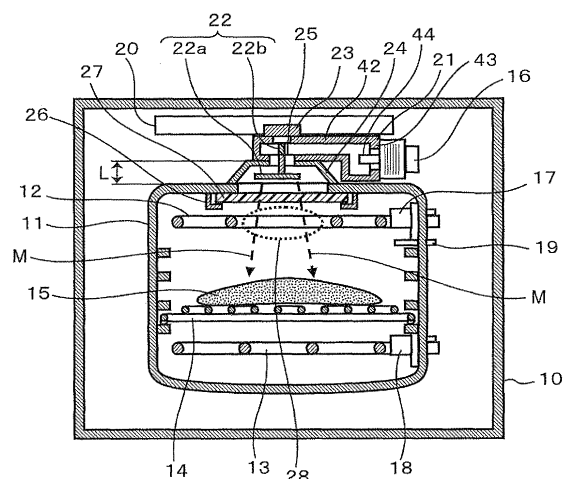
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(54) **MICROWAVE HEATING DEVICE**

(57) According to the present invention, in order to provide a small-sized microwave heating device having higher heating efficiency and, further, having a compacted microwave feeding structure placed on an upper side of the heating chamber, a waveguide for propagating microwaves from a microwave generating part is structured to include a horizontal propagation path and a vertical propagation path which are orthogonal to each other, such that the microwave generating part is horizontally coupled to the vertical propagation path, and microwaves from the microwave generating part are propagated to a feeding part through the vertical propagation path and the horizontal propagation path, wherein a horizontal propagation distance in the horizontal propagation path is longer than 1/2 the wavelength of microwaves which propagate through the waveguide.

Fig. 1



Description**Technical Field**

5 **[0001]** The present invention relates to microwave heating devices for inductively heating objects to be heated through radiation of microwaves and, more particularly, relates to heating cookers for cooking food as objects to be heated through induction heating.

Background Art

10 **[0002]** Among microwave heating devices, heating cookers using microwaves, which are represented by microwave ovens, have basic structures including a heating chamber sealed in such a way as to prevent leakages of microwaves to the outside, a magnetron for generating microwaves, and a waveguide for propagating microwaves generated from the magnetron to the heating chamber.

15 **[0003]** Such heating cookers have employed various structures according to the system suitable for the aim, as components other than the heating chamber, the magnetron and the waveguide which have been described above. For example, there have been lateral feeding systems, downward feeding systems, upward feeding systems and upward-and-downward feeding systems, depending on the direction in which microwaves should be incident to the heating chamber. According to these respective feeding systems, there have been provided different structures.

20 **[0004]** In cases of lateral feeding systems adapted to cause microwaves to be incident to a side surface of a heating chamber, there is a need for rotating food itself as an object to be heated, within the heating chamber, in order to prevent ununiformity of the microwave distribution. Such lateral feeding systems have employed so-called turn table systems. On the other hand, in cases of downward feeding systems adapted to cause microwaves to be incident to the bottom surface of the heating chamber, upward feeding systems adapted to cause microwaves to be incident to the ceiling surface of the heating chamber, and upward-and-downward feeding systems adapted to cause microwaves to be incident to both the bottom surface and the ceiling surface of the heating chamber, and the like, an antenna as a feeding part provided in the portion which couples the waveguide and the heating chamber is rotated to stir and radiate microwaves, without moving food as an object to be heated. So-called rotational antenna systems for rotating an antenna as described above have been employed with downward feeding systems, upward feeding systems and upward-and-downward feeding systems.

25 **[0005]** Which feeding system should be employed in a microwave oven is determined, in consideration of not only functions of the microwave oven but also other functions, such as oven functions, grill functions, steam functions and the like. In cases of employing functions of a microwave oven in combination with other functions, it is necessary to provide heaters, a water tank, a steam generating mechanism and the like, for example, in addition to a microwave feeding structure. Therefore, the respective components should be efficiently placed within the apparatus (refer to Patent Literature 1, for example).

30 **[0006]** Further, in cases of employing, for example, an oven, a grill and a superheated steam, which is water vapor at a temperature higher than 100 degrees, in a heating cooker, a plate made of a conductor having higher heat resistance may be used, as the material of the plate for placing food as objects to be heated thereon, since the inside of the heating chamber can be raised to higher temperatures. In cases of employing such a plate made of a conductor, the plate made of the conductor reflects microwaves, which changes the microwave distribution within the heating chamber from those in cases of employing plates made of dielectric members such as glasses, ceramics and the like which pass microwaves therethrough.

35 **[0007]** Also, instead of plates made of conductors, grids made of conductors may be employed, in some cases. In cases of employing a grid made of a conductor, when its meshes have a size larger to some extent than the wavelength, microwaves may pass therethrough. Therefore, the microwave distribution within the heating chamber may be also changed depending on the shape of the meshes.

40 **[0008]** Further, recently, there have been increasingly needs for cooking using functions of a microwave oven in combination with other functions. For example, in cases of roasting larger food or in cases of roasting frozen food, and the like, the food can be heated only at its surface by heating using heaters and, thus, the food can not be cooked in its interior. Toaster ovens including only heaters as heating sources correspond to such cookers using only heaters. In order to heat food in its interior only with heaters, using a toaster oven, it is possible to employ only a method which includes a step of gradually heating the food through heat conduction for a long time period at a lower temperature, with reduced heating power (output), in order to prevent the food surfaces from being scorched.

45 **[0009]** On the other hand, by heating an object to be heated using a microwave oven for induction heating, it is possible to heat the food in its interior, since the food as the object to be heated is a dielectric member and, thus, microwaves can penetrate up to the interior of the food. By employing a microwave oven as described above, it is possible to cook food in its interior in a shorter time period. Accordingly, by employing functions of a microwave oven for heating the

interior of food in combination with functions of heaters for roasting the surfaces of food, it is possible to deliciously roast larger food and frozen food in shorter time periods.

Citation List

Patent Literatures

[0010] Patent Literature 1: Unexamined Japanese Patent Publication No. 58-181289

Summary of Invention

Technical Problem

[0011] However, in order to allow a microwave feeding structure and another structure (for example, a heater structure) to coexist in a conventional heating cooker, there is the problem that microwaves from the antenna as the feeding part can heat the heaters, thereby degrading the efficiency of heating food. Further, in order to prevent the microwave feeding structure from overlapping with the structure for supplying electric power to the heaters, there is the problem that the heating cooker is required to have a larger apparatus size for placing them inside the apparatus. As described above, in cases of causing a microwave feeding structure and a heater electric-power supplying structure to coexist in a conventional heating cooker, there has been the problem of difficulty in attaining both improvement of the heating efficiency and the size reduction of the apparatus.

[0012] Fig. 10 is a front cross-sectional view illustrating a schematic structure of a heating cooker having a conventional microwave feeding structure provided on the upper side of a heating chamber, in cases where a heater electric-power supply structure including heaters is further provided therein. The heating cooker illustrated in Fig. 10 is provided with a heating chamber 101 for inductively heating food as an object to be heated, inside a cabinet 100 which forms the external appearance of the heating cooker. Heaters 102 are provided at upper and lower positions within the heating chamber 101. Further, above the upper heater 102 and, further, above the heating chamber 101, there is placed the microwave feeding structure constituted by a magnetron 103, a waveguide 104, a rotational antenna 105, a motor 106, and the like. The conventional heating cooker having such a structure is structured such that heat generated from the heating chamber 101 is conducted to the magnetron 103 through the waveguide 104, which tends to heat the magnetron. As a result thereof, the conventional heating cooker has induced temperature rises in the magnetron 103, thereby inducing the problem of degradation of the microwave heating efficiency of the magnetron 103. Further, in the conventional heating cooker, some microwaves are radiated within the heating chamber 101 from the rotational antenna 105 to heat the upper heater 102, thereby inducing the problem of degradation of the microwave heating efficiency. Further, since the microwave feeding structure is placed in the space above the heating chamber 101, there has been a need for a significantly-larger space above the heating chamber 101, thereby inducing the problem that the cabinet 100 is required to have a larger size.

[0013] It is an object of the present invention to provide a microwave heating device with higher heating efficiency which is capable of suppressing temperature rises in a magnetron due to heat from a heating chamber and, also, to provide a small-sized microwave heating device having a compacted microwave feeding structure placed on the upper side of the heating chamber.

Solution to Problem

[0014] A microwave heating device in a first aspect of the present invention includes:

a heating chamber for housing an object to be heated and for radiating a microwave toward the object to be heated for performing high-frequency heating on the object to be heated;

a microwave generating part adapted to generate a microwave for performing high-frequency heating on the object to be heated within the heating chamber;

a waveguide having a horizontal propagation path and a vertical propagation path orthogonal to each other such that the microwave generating part is horizontally coupled to the vertical propagation path, for propagating a microwave from the microwave generating part through the horizontal propagation path;

a feeding part which is coupled to the horizontal propagation path and includes an antenna part for radiating, within the heating chamber, the microwave propagated through the waveguide; and

an antenna room which is provided in a ceiling surface of the heating chamber, further is adapted to reflect the microwave radiated in a horizontal direction from the antenna part, and is opened at its lower end portion such that the microwave from the antenna part is radiated within the heating chamber;

wherein the waveguide is structured such that a horizontal propagation distance in the horizontal propagation path is longer than $1/2$ the wavelength of the microwave which propagates through the waveguide.

[0015] With the microwave heating device having the structure in the first aspect of the present invention, since the horizontal propagation distance to the feeding port from the folding position in the waveguide is longer than $1/2$ the wavelength of the microwave which propagates through the waveguide, it is possible to stabilize the coupling of the propagation between the microwave generating part and the feeding part, which enables maintaining heating with higher efficiency, even in cases of changes of operating conditions, such as load changes. Further, with the microwave heating device in the first aspect of the present invention, the waveguide having the longer horizontal propagation path can suppress heat conduction from the heating chamber to the magnetron. Further, with the microwave heating device in the first aspect of the present invention, since the microwave generating part, such as a magnetron, is horizontally coupled, in a lateral orientation, to the vertical propagation path of the waveguide, it is possible to compact the entire apparatus in heightwise size.

[0016] In a second aspect of the present invention, the microwave heating device in the first aspect further includes a radiant heating part for heating the object to be heated through radiant heat from above the object to be heated, the radiant heating part being provided within the heating chamber, wherein the radiant heating part is placed in an area which is not beneath the antenna room. With the microwave heating device having the structure in the second aspect of the present invention, it is possible to prevent the microwave radiated from the feeding part from directly heating the radiant heating part, which prevents occurrences of heating losses, thereby improving the heating efficiency.

[0017] In a third aspect of the present invention, the microwave heating device in the first or second aspect further includes a convection heating part adapted to circulate a hot air flow within the heating chamber, for heating the object to be heated. With the microwave heating device having the structure in the third aspect of the present invention, it is possible to suppress heat conduction from the heating chamber to the magnetron and, further, it is possible to prevent occurrences of heating losses, thereby enabling heating processing through hot air flows within the heating chamber with higher efficiency.

[0018] In a fourth aspect of the present invention, in the microwave heating device in any of the first to third aspects, the antenna part in the feeding part is adapted to rotate within the antenna room for stirring and radiating a microwave within the heating chamber. With the microwave heating device having the structure in the fourth aspect of the present invention, it is possible to uniformly radiate microwaves within the entire heating chamber.

[0019] In a fifth aspect of the present invention, in the microwave heating device in any of the first to fourth aspects, the waveguide is adapted such that the vertical propagation path is extended downwardly with respect to the horizontal propagation path, and a feeding port in the horizontal propagation path is coupled to an opening in an upper end portion of the antenna room which is formed to protrude upwardly from the ceiling surface of the heating chamber. With the microwave heating device having the structure in the fifth aspect of the present invention, it is possible to eliminate wasted spaces within the microwave feeding structure, thereby compacting it, since the antenna room protruding from the heating chamber is offset by the heightwise size of the waveguide in the upward and downward direction. Further, with the microwave heating device in the fifth aspect of the present invention, since the waveguide is coupled to the heating chamber with the antenna room interposed therebetween, it is possible to eliminate portions of the waveguide and the heating chamber which come in contact with each other and, further, it is possible to reduce heat conducted from the heating chamber to the microwave generating part, which can improve the heating efficiency of the microwave generating part.

[0020] In a sixth aspect of the present invention, in the microwave heating device in any of the first to fourth aspects, the waveguide is adapted such that the vertical propagation path is extended upwardly with respect to the horizontal propagation path, and a feeding port in the horizontal propagation path is coupled to an opening in an upper end portion of the antenna room which is formed to protrude upwardly from the ceiling surface of the heating chamber, and such that the microwave from the microwave generating part coupled horizontally to the vertical propagation path is radiated within the heating chamber from the feeding part through the horizontal propagation path. With the microwave heating device having the structure in the sixth aspect of the present invention, it is possible to compactly form the microwave feeding structure.

[0021] In a seventh aspect of the present invention, in the microwave heating device in any of the first to fourth aspects, a heat insulation part is provided in a space between the waveguide and the heating chamber, outside the antenna room. With the microwave heating device having the structure in the seventh aspect of the present invention, it is possible to largely reduce the amount of heat conducted to the microwave generating part from the heating chamber through the waveguide during heating at higher temperatures, which can improve the output efficiency of the microwave generating part.

[0022] In an eighth aspect of the present invention, in the microwave heating device in any of the first to fourth aspects, the antenna room includes a shield wall protruding downwardly from the ceiling surface of the heating chamber, and the radiant heating part is placed around the outer peripheral portion of the shield wall. With the microwave heating device

having the structure in the eighth aspect of the present invention, it is possible to prevent microwaves from the feeding part from directly heating the radiant heating part, which can reduce losses thereof in the radiant heating part, thereby enabling heating the object to be heated with higher efficiency. Further, it is possible to make the entire apparatus have a smaller heightwise size, thereby making it have a compact structure.

[0023] In a ninth aspect of the present invention, in the microwave heating device in any of the first to fourth aspects, the waveguide is provided with through holes having a diameter which prevents the microwave from being leaked through the through holes, in its surfaces facing each other, such that a cooling air flow created by a cooling fan passes through the through holes. With the microwave heating device having the structure in the ninth aspect of the present invention, it is possible to cool the waveguide, thereby reducing heat conducted from the heating chamber to the microwave generating part through the waveguide.

[0024] In a tenth aspect of the present invention, in the microwave heating device in any of the first to fourth aspects, the waveguide is provided with a ventilation area having a plurality of through holes having a diameter which prevents the microwave from being leaked through the through holes. With the microwave heating device having the structure in the tenth aspect of the present invention, it is possible to increase the heat transfer resistance in the wall surfaces of the waveguide and, further, it is possible to cause cooling air to flow through the through holes in the ventilation area for cooling the waveguide, thereby reducing heat conducted from the heating chamber to the microwave generating part through the waveguide. This realizes a structure which increases the microwave heating efficiency of the microwave generating part.

[0025] In an eleventh aspect of the present invention, in the microwave heating device in any of the first to fourth aspects, the waveguide is adapted such that the vertical propagation path is extended downwardly with respect to the horizontal propagation path, and a feeding port in the horizontal propagation path is coupled to an opening in an upper end portion of the antenna room which is formed to protrude upwardly from the ceiling surface of the heating chamber, and such that the microwave generating part is placed in a space between the antenna room and the vertical propagation path. With the microwave heating device having the structure in the eleventh aspect of the present invention, it is possible to effectively utilize the space above the heating chamber, which can eliminate wasted spaces, thereby compacting the heating cooker, since the microwave generating part is placed in a space which exists under the horizontal propagation path, which is sandwiched between the antenna room and the vertical propagation path in the waveguide, in the direction of the extension of the horizontal propagation path in the waveguide.

[0026] In a twelfth aspect of the present invention, in the microwave heating device in any of the first to fourth aspects, the waveguide is adapted such that a vertical propagation distance in the vertical propagation path is shorter than $1/4$ the wavelength of the microwave which propagates through the waveguide. With the microwave heating device having the structure in the twelfth aspect of the present invention, it is possible to prevent occurrences of electric fields in the opposite direction within the vertical propagation path, which can prevent occurrences of complicated reflections within the propagation path in the waveguide, thereby increasing the propagation efficiency.

Advantageous Effects of Invention

[0027] With the present invention, it is possible to increase the heating efficiency and, further, it is possible to compact the microwave feeding structure placed on the upper side of the heating chamber, which can provide a small-sized microwave heating device with a reduced apparatus size.

Brief Description of Drawings

[0028]

Fig. 1 is a front cross-sectional view illustrating the internal structure of a main part of a heating cooker according to a first embodiment of the present invention.

Fig. 2 is a perspective view illustrating a waveguide and an antenna room in the heating cooker according to the first embodiment of the present invention.

Fig. 3 is a front cross-sectional view illustrating the internal structure of a main part of a heating cooker according to a second embodiment of the present invention.

Fig. 4 is a side cross-sectional view of the main part of the heating cooker according to the second embodiment of the present invention.

Fig. 5 is a rear view illustrating a feeding part, a heating part and the like, which are provided on a ceiling surface of a heating chamber in the heating cooker according to the second embodiment of the present invention.

Fig. 6 is a front cross-sectional view illustrating a microwave feeding structure in a heating cooker according to a third embodiment of the present invention.

Fig. 7 is a front cross-sectional view illustrating a microwave feeding structure in a heating cooker according to a

fourth embodiment of the present invention.

Fig. 8 is a front cross-sectional view illustrating a microwave feeding structure in a heating cooker according to a fifth embodiment of the present invention.

Fig. 9 is a front cross-sectional view illustrating a microwave feeding structure in a heating cooker according to a sixth embodiment of the present invention.

Fig. 10 is a front cross-sectional view illustrating a schematic structure of a common microwave feeding structure in a heating cooker.

Description of Embodiments

[0029] Hereinafter, with reference to the accompanying drawings, there will be described preferred embodiments of a microwave heating device according to the present invention. Further, in the following embodiments, the microwave heating device will be described with respect to a heating cooker. However, the heating cooker is merely illustrative, and the microwave heating device according to the present invention is not limited to heating cookers and is intended to include heating apparatuses utilizing induction heating as high-frequency heating, and heating apparatuses such as garbage disposers, semiconductor fabrication apparatuses, and the like. Accordingly, the present invention is not limited to the concrete structures in the following embodiments and is intended to include structures based on equivalent technical concepts.

(First Embodiment)

[0030] A heating cooker, among microwave heating devices, will be described, as a first embodiment of the present invention. Further, in the following respective embodiments, there will be described a microwave oven including at least one heater as a heating part, as an example of a heating cooker.

[0031] Fig. 1 is a front cross-sectional view illustrating the internal structure of a main part of the heating cooker as the microwave heating device according to the first embodiment of the present invention. The heating cooker illustrated in Fig. 1 is provided with a heating chamber 11 for performing induction heating (higher-frequency heating) on food 15 as an object to be heated, within a cabinet 10 which forms the external appearance of the heating cooker. Namely, within the heating chamber 11, the food 15 as an object to be heated is housed, and microwaves are radiated toward the food 15 for performing high-frequency heating thereon. Within the heating chamber 11 having surfaces formed from steel plates coated with an enamel, there are provided two heaters 12 and 13 as radiant heating parts for raising the inside of the heating chamber to a higher temperature. One heater 12 is placed near the ceiling surface (in the upper side) of the heating chamber 11, while the other heater 13 is placed near the bottom surface (in the lower side) of the heating chamber 11. Inside the heating chamber 11, there is detachably provided a roasting grid 14 formed from stainless-steel rod members which are longitudinally and laterally coupled and welded to one another. The roasting grid 14 can be mounted at desired positions in a plurality of stages in the heating chamber 11. The food 15 as the object to be heated, which is placed on the roasting grid 14, is sandwiched between the upper heater 12 and the lower heater 13 and is radiatively heated thereby in upper and lower directions. The corners of the bonding portions between the respective wall surfaces forming the heating chamber 11 are formed to have curved surfaces. Further, the bottom surface of the heating chamber 11 is formed to have a curved-surface shape having a larger radius of curvature, in its entirety.

[0032] Further, the heating cooker according to the first embodiment will be described with respect to an example where the wall surfaces are formed from enamel-coated steel plates, but they can be also formed from steel plates provided with other thermal-resistant coating. Also, the material of the wall surfaces can be PCM (Pre-coated metal) steel plates. While, in the first embodiment, the roasting grid 14 is formed from stainless-steel rod members coupled to one another, it can be also formed from plated steel members and the like.

[0033] As illustrated in Fig. 1, an antenna room 24 is provided around the center of the ceiling surface of the heating chamber 11. Inside the antenna room 24, a feeding part 22 which forms a rotational antenna is placed, as radio-wave stirring means. The antenna room 24 is made of a material which reflects microwaves radiated from the feeding part 22 and has a shield structure for preventing leakages of microwaves to the outside of the antenna room 24. The feeding part 22 forming the rotational antenna is provided in such a way as to protrude through a feeding port 25 formed in a waveguide 21. The waveguide 21 is adapted to propagate, to the feeding part 22, microwaves from a magnetron 16 as a microwave creating part. The magnetron 16 creates microwaves for performing high-frequency heating on the food 15 as the object to be heated, within the heating chamber 11. The microwaves propagated to the feeding part 22 are radiated within the heating chamber 11. The magnetron 16 is placed on the right end portion (see Fig. 1) of the waveguide 21 placed on the upper side of the heating chamber 11, and a magnetron output part 44, which forms an oscillation antenna of the magnetron 16, is inserted, in a lateral orientation, into the waveguide 21.

[0034] The heating cooker having the structure according to the first embodiment includes an induction heating part which uses microwaves, as single heating means, and, further, includes a radiant heating part which uses radiation from

the upper and lower heaters 12 and 13, as another heating means. As described above, the heating cooker according to the first embodiment is adapted to perform desired heating cooking on the food 15 as the object to be heated within the heating chamber 11, by employing both the induction heating part and the radiant heating part. Further, the first embodiment will be described with respect to a structure including the induction heating part which uses microwaves as single heating means and, further, including the radiant heating part using the upper and lower heaters 12 and 13 as another heating means. However, instead of the radiant heating part, it is also possible to provide a convection heating part adapted to circulate hot air flows within the heating chamber for performing heating cooking. Such a convection heating part is structured to heat air within the heating chamber to a higher temperature and to circulate it, with a circulation fan and a circulation heater which are provided near the back surface of the heating chamber. As a matter of course, it is also possible to provide the three heating means, which are the induction heating part, the radiant heating part and the convection heating part, in order to perform heating cooking.

[0035] In the first embodiment, the upper and lower heaters 12 and 13 as the radiant heating part are formed from electrically-heated wires and a filler material which are enclosed in metal pipes. Within the heating chamber 11, an upper-heater thermocouple 17 is provided in contact with the surface of the upper heater 12. The upper-heater thermocouple 17 is covered with a metal pipe, in order to prevent it from being influenced by microwaves radiated from the feeding part 22 and, further, the upper-heater thermocouple 17 functions as means for detecting the temperature of the upper heater 12. Further, within the heating chamber 11, a lower-heater thermocouple 18 is provided in contact with the surface of the lower heater 13, wherein the lower-heating thermocouple 18 has the same structure as that of the upper-heater thermocouple 17. The lower-heater thermocouple 18 functions as means for detecting the temperature of the lower heater 13. A thermistor 19 is fixed to a wall surface of the heating chamber 11, as means for detecting the temperature within the heating chamber. The upper-heater thermocouple 17, the lower-heater thermocouple 18 and the thermistor 19 are electrically connected to a control part 20 as control means. The control part 20 is adapted to control the amounts of electricity supplied to the upper heater 12 and the lower heater 13, based on respective detection signals from the upper-heater thermocouple 17, the lower-heater thermocouple 18 and the thermistor 19. As described above, in the heating cooker according to the first embodiment, the amount of heating for the heating chamber 11 is accurately controlled to be increased and decreased, in such a way as to realize a set temperature.

[0036] Within the heating chamber 11, the upper heater 12 in the radiant heating part, which is adapted to heat the food 15 as the object to be heated, through radiant heat from thereabove, is placed in an area which is not beneath the antenna room 24. Namely, the food 15 as the object to be heated is directly irradiated with microwaves radiated from the feeding part 22 as the rotational antenna within the antenna room 24, while the upper heater 12 is not directly irradiated therewith.

[0037] The waveguide 21 provided on the upper side of the heating chamber 11 is constituted by a horizontal part 42 extended in the horizontal direction, and a vertical part 43 extended in the vertical direction. Namely, the waveguide 21 includes an internal passage (propagation path) having an orthogonally-folded L-shape which is constituted by a horizontal propagation path (42) formed by the horizontal part 42, and a vertical propagation path (43) formed by the vertical part 43. The magnetron output part 44 as the oscillation antenna is inserted in the horizontal direction into the vertical part 43 of the waveguide 21, so that the magnetron 16 as the microwave creating part is coupled thereto. Accordingly, the magnetron 16 is coupled in a lateral orientation (coupled horizontally) to the waveguide 21, so that its heightwise size in the vertical direction is smaller than that in a case where the magnetron 16 is coupled longitudinally (coupled vertically, see Fig. 10) to the waveguide 21.

[0038] In the feeding port 25 formed in the horizontal part 42 (the horizontal propagation path) in the waveguide 21 having the L-shaped internal passage (the propagation path) as described above, the feeding part 22 as the rotational antenna is provided. The feeding part 22 is constituted by an antenna part 22a and a shaft part 22b. The shaft part 22b in the feeding part 22 is coupled to a motor 23. By driving the motor 23, the shaft part 22b is rotated, thereby rotating the antenna part 22a. The feeding part 22 is coupled to the horizontal propagation path (42) in the waveguide 21, so that microwaves propagated through the waveguide 21 are radiated within the heating chamber 11 through the antenna part 22a in the feeding part 22.

[0039] Substantially at the center of the ceiling surface of the heating chamber 11, there is provided the dome-shaped antenna room 24 which houses the antenna part 22a adapted to rotate. The antenna room 24 is shaped to extend in a circular shape at its lower end portion and, thus, has a circular truncated cone shape. The antenna room 24 is formed to have such a circular truncated cone shape, by outwardly protruding the ceiling surface of the heating chamber 11 through drawing processing. The feeding port 25 formed in the lower surface of the horizontal part 42 of the waveguide 21 is coupled to an opening formed in the upper end portion of the antenna room 24, which secures a feeding port with a predetermined diameter, around the portions of the waveguide 21 and the feeding part 22 which are coupled to each other. As described above, the antenna room 24 is provided in the ceiling surface of the heating chamber 11 and, further, is structured to reflect microwaves radiated horizontally from the antenna part 22a. Further, the antenna room 24 is opened at its lower end portion, such that microwaves from the antenna part 22a are radiated within the heating chamber.

[0040] Fig. 2 is a perspective view illustrating the waveguide 21 and the antenna room 24 in the heating cooker

according to the first embodiment. As illustrated in Fig. 2, the waveguide 21 includes the horizontal part 42 forming the horizontal propagation path, and the vertical part 43 forming the vertical propagation path, wherein the internal passage forming the propagation path has a folded shape which is folded orthogonally in an L shape. Namely, the direction in which the horizontal propagation path (42) extends (the horizontal direction) is orthogonal to the direction in which the vertical propagation path (43) extends (the vertical direction). As described above, the waveguide 21 includes the horizontal propagation path (42) and the vertical propagation path (43) which are orthogonal to each other, wherein the magnetron 16 as the microwave creating part is horizontally coupled to the vertical propagation path (43), so that microwaves from the magnetron 16 are propagated through the horizontal propagation path (42).

[0041] In the first embodiment, assuming that the horizontal propagation distance to the center of the feeding port 25 from the folding position C (see Fig. 2) at the portion at which the horizontal part 42 and the vertical part 43 are coupled to each other is H (see Fig. 2), the distance H is set to be about 135 mm in the first embodiment. Further, the horizontal propagation distance H refers to the horizontal distance from the folding position C to the center of the feeding port 25 in the propagation path in the waveguide 21, along the direction in which the horizontal propagation path extends (the rightward and leftward direction in Fig. 1).

[0042] The width a of the internal passage, which is the propagation path in the waveguide 21, is about 80 mm, and the height b of the internal passage in the horizontal part 42 in the waveguide 21 is about 16 mm. Further, the width a of the internal passage and the height b of the internal passage in the horizontal part 42 indicate the lengths of the propagation path in the inner-surface side of the waveguide 21.

[0043] As described above, the magnetron 16 is secured to the vertical part 43 of the waveguide 21, by being horizontally coupled thereto in a lateral orientation. Namely, the magnetron output part 44 as the oscillation antenna in the magnetron 16 is inserted and mounted, in a lateral orientation, in an opening part 21a formed in the side surface wall (the right side surface wall) of the vertical part 43 in the waveguide 21. Assuming that the vertical propagation distance (the length in the vertical direction) from the folding position C to the center of the magnetron output part 44 in the magnetron 16 is V (see Fig. 2), the vertical propagation distance V is set to be about 15 mm in the first embodiment.

[0044] The heating cooker according to the first embodiment employs, as the magnetron 16, one having an oscillation frequency of about 2450 MHz. Therefore, assuming that the in-tube wavelength within the waveguide 21 is λ_g , λ_g is about 190 mm, and the length of half the wavelength ($\lambda_g/2$) is about 95 mm ($\lambda_g/2 = 95$ mm). Accordingly, in the heating cooker according to the first embodiment, the waveguide 21 is structured such that the horizontal propagation distance H (about 135 mm), which is substantially the length of the propagation path in the horizontal part 42, is larger than half the wavelength ($\lambda_g/2$) ($H > \lambda_g/2$). Further, the vertical propagation distance V (about 15 mm), which is substantially the length of the propagation path in the vertical part 43, is smaller than 1/4 the wavelength ($\lambda_g/4$), i.e., ($V < \lambda_g/4$).

[0045] The antenna part 22a in the feeding part 22, which is adapted to stir and radiate microwaves propagated through the waveguide 21, is made of a metal and has a substantially-disk shape with a thickness of 1 mm and a diameter of about $\phi 62$. The shaft part 22b adapted to transmit the rotation of the motor 23 to the antenna part 22a is coupled to the antenna part 22a at a position decentered by about 12 mm from the disk center. The shaft part 22b includes a portion made of a fluorocarbon resin which is closer to the motor 23 and, further, includes a portion made of a metal which is closer to the antenna part 22a. The metal portion of the shaft part 22b is inserted in the waveguide 21 by about 11 mm and, further, is protruded by about 15 mm into the antenna room 24 through the feeding port 25 in the waveguide 21. Further, it is ensured that the gap between the feeding port 25 and the metal portion of the shaft part 22b has a length equal to or more than 5 mm.

[0046] As illustrated in Fig. 1, a cover 27 is provided on the ceiling surface of the heating chamber 11, over the opening part at the lower end of the antenna room 24. The cover 27, which is made of mica, is provided, in order to prevent contaminations and the like which have scattered from the food within the heating chamber 11 from being adhered to the antenna part 22a of the feeding part 22, and the like. The cover 27 is detachably mounted on an insulation hook 26 provided on the ceiling surface of the heating chamber 11. Further, although there has been described an example where the cover 27 is made of mica, which is a low dielectric-loss material, the material thereof is not limited to mica, and it is also possible to employ ceramics, glasses or other materials, which can offer the same effects.

[0047] The upper heater 12 provided at an upper portion within the heating chamber 11 is placed so as not be beneath the opening part at the lower end of the antenna room 24, in order that the upper heater 12 is not directly heated by microwaves from the feeding part 22. Thus, the upper heater 12 is placed in such a way as to evade the opening part in the antenna room 24, thereby forming a vacant part 28 at the center portion of the upper heater 12. Accordingly, microwaves M (see Fig. 1) radiated directly toward the food 15 from the feeding part 22 are not obstructed by the upper heater 12. As described above, the heating cooker according to the first embodiment is adapted to prevent the upper heater 12 from being directly heated by microwaves radiated from the feeding part 22, which prevents occurrences of losses, thereby improving the heating efficiency.

[0048] In the heating cooker according to the first embodiment, the waveguide 21 is orthogonally folded to have an L shape, and the magnetron 16 is coupled, in a lateral orientation, to the waveguide 21. Namely, the magnetron output part 44 in the magnetron 16 is mounted to the vertical wall surface of the waveguide 21, such that its protruded portion

is orthogonal thereto. This reduces the space within which there is placed the waveguide 21 to which the magnetron 16 is coupled, in vertical size (the height) in the upward and downward direction. For example, in comparison with the height of the space within which there is placed the waveguide 104 to which the magnetron 103 is vertically coupled in the structure illustrated in Fig. 10, the space within which there is placed the waveguide 21 to which the magnetron 16 is coupled according to the first embodiment has a reduced height. Further, since the magnetron 16 is coupled, in a lateral orientation, to the waveguide 21, there is leeway in the space above the magnetron 16, which enables placing other structural members.

[0049] Accordingly, in the heating cooker according to the first embodiment, it is possible to compactly form the microwave feeding structure constituted by the magnetron 16, the waveguide 21, the antenna room 24 and the like. In the heating cooker according to the first embodiment, the horizontal part 42 of the waveguide 21 is coupled to the opening in the protruding end portion of the antenna room 24 protruded upwardly from the ceiling surface of the heating chamber 11, and the lower end portion of the vertical part 43 of the waveguide 21 is placed on the ceiling surface of the heating chamber 11. Accordingly, in the first embodiment, the length of the heightwise size K (see Fig. 2) of the vertical part 43 in the waveguide 21 is set so as to cancel the protruding size L (see Fig. 1) of the antenna room 24. Namely, the protruding size K of the vertical part 43 and the heightwise size L of the antenna room 24 are set to have substantially the same length. Since the antenna room 24 is placed within the heightwise size of the waveguide 21 having the L shape, as described above, the protruding size L of the antenna room 24 is cancelled by the heightwise size K of the waveguide 21 in the upward and downward direction. Further, since the magnetron 16 which is laterally oriented is placed within the heightwise size of the waveguide 21, the antenna room 24 and the magnetron 16 are placed substantially within the heightwise size of the waveguide 21.

[0050] As described above, with the heating cooker according to the first embodiment, it is possible to eliminate wasted spaces in the microwave feeding structure, thereby attaining compaction thereof. Further, in the heating cooker according to the first embodiment, as illustrated in Fig. 1, the vertical part 43 of the waveguide 21 is provided proximally to the bottom edge (the lower end portion) of the antenna room 24, which enables compaction of the microwave feeding structure without increasing the size of the microwave feeding structure in the leftward and rightward direction (the direction of the extension of the horizontal part 42), even through the magnetron 16 is placed in a lateral orientation.

[0051] In the heating cooker according to the first embodiment, the antenna room 24 is formed in the ceiling surface of the heating chamber 11, and the waveguide 21 is coupled to the upper end portion of the antenna room 24. Therefore, the waveguide 21 is coupled to the heating chamber 11 with the antenna room 24 interposed between the waveguide 21 and the heating chamber 11. This allows the waveguide 21 and the antenna room 24 to come in contact with each other over a smaller area than that in cases where the waveguide is directly in contact with the ceiling surface of the heating chamber. Further, a space is formed between the waveguide 21 and the heating chamber 11, which prevents direct heat conduction to the waveguide 21 from the ceiling surface of the heating chamber 11 during heating at higher temperatures. Further, a significantly-reduced amount of heat is conducted from the heating chamber 11 to the magnetron 16 through the antenna room 24 and the waveguide 21.

[0052] In the heating cooker according to the first embodiment, by setting the horizontal propagation path H (see Fig. 2) in the horizontal part 42 of the waveguide 21 to be larger, it is possible to further reduce the amount of heat conducted from the heating chamber 11 to the magnetron 16 through the antenna room 24 and the waveguide 21. This can further improve the output efficiency of the magnetron 16, since the magnetron 16 exhibits higher efficiency at lower temperatures in general.

[0053] Further, in the structure according to the first embodiment, the horizontal propagation distance H in the horizontal part 42 of the waveguide 21 is set to be larger than half the wavelength ($\lambda/2$), which can stabilize the state of coupling between the magnetron 16 and the feeding part 22, thereby realizing a structure capable of maintaining higher efficiency, even in cases of changes of operating states, such as load changes.

[0054] Further, in the heating cooker according to the first embodiment, by setting the vertical propagation distance V to the folding position C from the center of the magnetron output part 44 in the waveguide 21 to be shorter than $1/4$ the wavelength ($\lambda/4$), it is possible to improve the propagation efficiency. Further, by setting the vertical propagation distance V to be equal to or less than $1/4$ the wavelength corresponding to the oscillation frequency, it is possible to prevent occurrences of electric fields in the opposite direction within the area from the magnetron output part 44 to the folding portion including the folding position C, which can prevent occurrences of complicated reflections within the propagation path in the waveguide 21. As a result thereof, the heating cooker according to the first embodiment has higher oscillation efficiency and, thus, forms an apparatus with higher heating efficiency.

[0055] Further, the heating cooker according to the first embodiment has been described as having a structure employing the induction heating part which uses microwaves as single heating means and, further, employing the radiant heating part which uses radiation through the upper and lower heaters 12 and 13 as another heating means, in combination with each other. However, the present invention is not limited to this structure, and it is also possible to provide a convection heating part adapted to circulate hot air flows within the heating chamber for performing heating cooking, as another heating means. Also, it is possible to provide both the radiant heating part and the convection heating part, in

addition to the induction heating part employing the magnetron. The microwave heating device having the structure according to the present invention is capable of improving the heating efficiency, even with other heating means, since it is possible to largely reduce the amount of heat conducted from the heating chamber 11 to the magnetron 16 through the antenna room 24 and the waveguide 21, in the structure of the induction heating part.

(Second Embodiment)

[0056] Hereinafter, a heating cooker according to a second embodiment of the present invention will be described. The heating cooker according to the second embodiment is different from the heating cooker according to the first embodiment, in terms of the structure for supplying microwaves to a heating chamber.

[0057] The heating cooker according to the second embodiment will be described, hereinafter, by designating components having the same functions and structures as those of the components of the heating cooker according to the first embodiment by the same reference characters, and by substituting the description about the first embodiment for detailed descriptions thereof. Fig. 3 is a front cross-sectional view illustrating the internal structure of a main part of the heating cooker according to the second embodiment. Fig. 4 is a side cross-sectional view of the heating cooker illustrated in Fig. 3.

[0058] As illustrated in Fig. 3 and Fig. 4, in the heating cooker according to the second embodiment, a waveguide 46 for propagating microwaves from a magnetron 16 is structured to include a horizontal part 47 and a vertical part 48 and, thus, is folded in an L shape, similarly to the waveguide 21 according to the first embodiment. Namely, the waveguide 46 includes an internal passage constituted by a horizontal propagation path and a vertical propagation path which are orthogonal to each other. In the waveguide 46 according to the second embodiment, the vertical part 48 which forms the vertical propagation path is extended so as to protrude upwardly from the horizontal part 47 which forms the horizontal propagation path. The magnetron 16 is coupled in a lateral orientation (horizontally coupled) to the waveguide 46, such that a magnetron output part 44 is horizontally inserted in the waveguide 46. Namely, the magnetron output part 44 is provided such that its protruding portion is orthogonal to the vertical side surface of the vertical part 48 of the waveguide 46. Accordingly, in the state where the magnetron 16 is coupled to the waveguide 46, the heightwise size in the vertical direction, which is the upward and downward direction, is made smaller, similarly to in the structure according to the first embodiment. In the waveguide 46 according to the second embodiment, the horizontal propagation distance H in the horizontal part 47 is about 135 mm and, thus, is set to be longer than half the wavelength ($\lambda_g/2$), i.e., ($H > \lambda_g/2$), similarly to in the waveguide 21 according to the first embodiment. Further, the vertical propagation distance V in the vertical part 48 is about 15 mm and, thus, is set to be shorter than $1/4$ the wavelength ($\lambda_g/4$), i.e., ($V < \lambda_g/4$). Further, in the second embodiment, similarly, the magnetron 16 used therein has an oscillation frequency of about 2450 MHz and, therefore, the in-tube wavelength λ_g within the waveguide 46 is about 190 mm, and the length of half the wavelength is 95 mm ($\lambda_g/2 = 95$ mm).

[0059] A feeding part 22 including an antenna part 22a and a shaft part 22b is coupled to the horizontal part 47 of the waveguide 46 having the L-shaped internal passage (the propagation path) as described above. Substantially at the center of the ceiling surface of the heating chamber 11, there is formed an antenna room 49 for housing the antenna part 22a. The antenna room 49 is shaped to extend in a circular shape at its lower end portion and, thus, has a circular truncated cone shape. The antenna room 49 is formed, by applying drawing processing to the ceiling surface of the heating chamber 11. Further, in the second embodiment, there is provided no cover which covers the lower end portion of the antenna room 49, which prevents occurrences of slight dielectric losses in such a cover, thereby realizing a structure capable of further improving the heating efficiency.

[0060] As illustrated in Fig. 3, the antenna room 49 is protruded into the heating chamber 11, at its bottom portion at the lower end portion, to form a shield wall protruding downwardly from the ceiling surface of the heating chamber. On the other hand, the antenna room 49 is protruded upwardly, at its upper end portion, from the ceiling surface of the heating chamber 11. A feeding port 25 formed in the horizontal part 47 of the waveguide 46 is coupled to an opening formed in the upper end portion of the antenna room 49. Therefore, the waveguide 46 is coupled to the heating chamber 11 with the antenna room 49 interposed therebetween. This allows the waveguide 46 and the antenna room 49 to come in contact with each other over a smaller area than that in cases where the waveguide is directly in contact with the ceiling surface of the heating chamber. Further, on the upper surface in the ceiling surface of the heating chamber 11, a heat insulation part 50 made of a heat insulation material is provided in such a way as to surround the periphery of the antenna room 49. Since the heat insulation part 50 is provided as described above, it is possible to suppress heat dissipation in the upward direction from the ceiling surface of the heating chamber 11. The heat insulation part 50 is placed in the space between the waveguide 46 and the ceiling surface of the heating chamber 11, which prevents the waveguide 46 from being directly heated by heat dissipated through the ceiling surface of the heating chamber 11. This can largely reduce the amount of heat conducted from the heating chamber 11 to the magnetron 16 through the waveguide 46, during heating at higher temperatures. As a result thereof, the heating cooker according to the second embodiment is structured to largely improve the heating efficiency of the magnetron 16.

[0061] Further, by setting the horizontal propagation distance H in the horizontal part 47 of the waveguide 46 to be larger than half the wavelength ($\lambda g/2$), it is possible to stabilize the state of coupling between the magnetron 16 and the feeding part 22, thereby realizing a structure capable of maintaining higher efficiency, even in cases of changes of operating states, such as load changes.

[0062] Further, in the heating cooker according to the second embodiment, by setting the vertical propagation distance V to the folding position C from the center of the magnetron output part 44 in the waveguide 46 to be shorter than $1/4$ the wavelength ($\lambda g/4$), it is possible to improve the oscillation efficiency. Further, by setting the vertical propagation distance V to be equal to or less than $1/4$ the wavelength corresponding to the oscillation frequency, in the waveguide 46, it is possible to prevent occurrences of electric fields in the opposite direction within the area from the magnetron output part 44 to the folding portion including the folding position C, which can prevent occurrences of complicated reflections within the propagation path in the waveguide 46. As a result thereof, the heating cooker according to the second embodiment can have largely improved oscillation efficiency.

[0063] As described above, in the heating cooker according to the second embodiment, the waveguide 46 is shaped to be folded in an L shape, and the antenna room 49 is protruded upwardly from the ceiling surface of the heating chamber 11. This enables provision of the heat insulation part 50 in the space between the horizontal part 47 of the waveguide 46 and the ceiling surface of the heating chamber 11. Accordingly, it is possible to provide the heat insulation part 50 for preventing heat conduction in the space between the heating chamber 11 and the waveguide 46, since the heating chamber 11 and the waveguide 46 are coupled to each other with the antenna room 49 interposed therebetween. Since the heat insulation part 50 is provided as described above, it is possible to form the heating cooker with excellent heating efficiency and with a compact structure.

[0064] Further, in the heating cooker according to the second embodiment, the waveguide 46 folded upwardly is provided on the upper end portion of the antenna room 49 which is protruded from the ceiling surface of the heating chamber 11, which can secure a space for providing the heat insulation part 50 on the ceiling surface of the heating chamber 11, thereby enabling placing the heat insulation part 50 with a larger thickness therein. Further, the heating cooker according to the second embodiment is provided with a ventilation fan 61 for exhausting air within the heating chamber, and a lamp 62 adapted to provide illumination within the heating chamber.

[0065] With the heating cooker having the structure according to the second embodiment, it is possible to largely improve the heating efficiency, in cooking processing using high-temperature heating means such as heaters as the radiant heating part, since heat dissipated upwardly from the heating chamber 11 is interrupted due to the heat insulation effect of the heat insulation part 50. Further, the heating cooker according to the second embodiment is structured to largely reduce the amount of heat conducted from the heating chamber 11 to the magnetron 16 and, therefore, forms a compact cooker having excellent heating efficiency, in cases of cooking using induction heating in combination with convection heating and radiative heating through heaters.

[0066] Further, the heating cooker according to the second embodiment is structured such that an upper heater 12 is provided at an upper portion within the heating chamber 11, and a lower heater 13 is provided under the bottom surface wall of the heating chamber 11. Further, the heating cooker according to the second embodiment is structured to heat the bottom surface wall of the heating chamber 11 through the lower heater 13. Further, the heating cooker according to the second embodiment includes a back-surface heater 30 and a circulation fan 31 for circulating hot air flows for oven cooking, near the back surface of the heating chamber 11. As described above, the heating cooker according to the second embodiment is enabled to directly heat food through radiant heat and convective heat, in addition to heating through induction heating. Accordingly, the heating cooker according to the second embodiment forms a sophisticated cooker capable of coping with a plurality of cooking menus.

[0067] The upper heater 12 provided at an upper portion in the heating chamber 11 is fixed, at its one end (near the terminal), to the back surface of the heating chamber 11 and, further, the upper heater 12 is held at its front-surface side by upper heater supporting tools 51. The upper-heater supporting tools 51 are structured to hold the upper heater 12 with degrees of freedom enough to cope with the thermal expansion of the upper heater 12. Further, as the material of the upper-heater supporting tools 51, the upper-heater supporting tools 51 are formed from ceramic members such as insulators according to the required heat-resistant temperature and, further, are made of a material which exerts smaller influences on microwaves than those of metal tools.

[0068] As illustrated in Fig. 3 and Fig. 4, the lower end portion of the antenna room 49 is protruded into the heating chamber 11 from the ceiling surface, and the upper heater 12 is placed around the lower end portion of the antenna room 49. Namely, the upper heater 12 is provided so as not be beneath the opening part at the lower end portion of the antenna room 49. Thus, the upper heater 12 is provided outside the shield wall formed by the lower end portion of the antenna room 49 protruded into the heating chamber. Therefore, the upper heater 12 is prevented from being directly heated by microwaves from the feeding part 22. This can prevent occurrences of losses in microwave heating.

[0069] Fig. 5 is a placement view illustrating the lower surface side of the ceiling surface of the heating chamber 11, illustrating the feeding part 22 provided in the ceiling surface, the antenna room 49, the upper-heater supporting tools 51, the upper heater 12, and the like. In Fig. 5, the front surface side of the apparatus is in the upper side. As illustrated

in Fig. 5, the upper heater 12 is placed so as to avoid the opening part at the lower end portion of the antenna room 49 and, further, the upper heater 12 is held by the upper-heater supporting tools 51 at a plurality of positions so as to be movable.

[0070] In the heating cooker according to the second embodiment, the lower heater 13 provided under the bottom surface wall of the heating chamber 11 is adapted to heat the bottom surface wall of the heating chamber 11. The lower heater 13 is adapted to heat the bottom surface wall of the heating chamber 11, in order to generate convective heat within the heating chamber 11.

[0071] Further, the heating cooker according to the second embodiment is structured to include the back-surface heater 30 and the circulation fan 31 for circulating hot air flows for oven cooking, which are provided near the back surface of the heating chamber 11, thereby forming a convection heating part. The convection heating part is structured to heat air within the heating chamber 11 and to circulate hot air flows within the heating chamber 11, through heat generation from the back surface heater 30 and through the rotation of the circulation fan 31. The heating cooker according to the second embodiment is structured to circulate hot air flows within the heating chamber 11 for performing heating cooking on food as an object to be heated, with the convection heating part having the aforementioned structure.

[0072] Further, as illustrated in Fig. 4, the heating cooker according to the second embodiment is provided, at its front surface side, with a door 32 for opening and closing it, which enables taking in and out the object to be heated into and from the heating chamber 11 by opening and closing the door 32. Above the door 32, there is provided a manipulation part 33 for making settings of various conditions and the like for heating cooking.

[0073] As illustrated in Fig. 4, in the heating cooker according to the second embodiment, a gap 34 is formed between the door 32 and the manipulation part 33. The gap 34 forms a cooling passage for exhausting cooling air flows from a cooling fan 35, which is provided at a back position in the space above the heating chamber 11. Cooled air flows from the cooking fan 35 flow while coming in contact with the upper surface of the heat insulation part 50, further pass through small through holes 36a and 36b formed in the opposite wall surfaces of the waveguide 46 which are faced to each other and, further, are exhausted in the forward direction through the gap 34. In this case, the small through holes 36a and 36b are holes having a size which prevents leakages of microwaves through the small through holes 36a and 36b, such as a diameter of 2 to 5 mm, for example. Accordingly, cooling air flows from the cooling fan 35 are caused to cool the heat insulation part 50 and, further, caused to flow through the waveguide 46 to cool the waveguide 46.

[0074] As described above, the heating cooker according to the second embodiment is provided with the cooling fan 35 and the cooling passage and, therefore, is capable of cooling the ceiling surface of the heating chamber 11 from the outside, by driving the cooling fan 35, even when the inside of the heating chamber has been raised to higher temperatures during oven cooking, for example. Therefore, the heating cooker according to the second embodiment is capable of preventing temperature rises in various types of components which constitute the control part 20 and the like, which are placed above the ceiling surface of the heating chamber 11. Further, the heating cooker according to the second embodiment is adapted to suppress temperature rises therein, even in cases of densely mounting and placing components above the ceiling surface of the heating chamber 11. Therefore, the heating cooker according to the second embodiment can be structured compactly, in the entirety of the apparatus.

[0075] In the heating cooker according to the second embodiment, the antenna room 49 is structured to protrude into the heating chamber 11 at its lower end portion, and the upper heater 12 is placed around the outer periphery of the lower end portion of the antenna room 49. Since the upper heater 12 is placed as described above, microwaves radiated from the feeding part 22 are radiated directly to the food 15 and, thus, are not interrupted by the upper heater 12. Thus, with the structure according to the second embodiment, the upper heater 12 is prevented from interrupting microwaves from the feeding part 22, which can prevent microwaves from the feeding part 22 from heating the upper heater 12 to induce losses therein. This can improve the heating efficiency.

[0076] Further, in the heating cooker according to the second embodiment, the portion of the antenna room 49 which protrudes into the heating chamber 11 functions as a microwave shield wall. This shield wall is made of a material which interrupts microwaves radiated from the antenna part 22a. Therefore, microwaves radiated in substantially-horizontal directions from the feeding part 22 as the rotational antenna are certainly interrupted by the shield wall, which prevents the upper heater 12 and the upper-heater supporting tools 51 provided around the antenna room 49 from being directly heated by microwaves from the feeding part 22. Namely, the shield wall reflects microwaves from the antenna part, which prevents these microwaves from directly heating the radiant heating part in the upper heater 12 placed around the outer peripheral portion of the antenna room 49. As a result thereof, the heating cooker according to the second embodiment is adapted to largely suppress microwave losses and, thus, is enabled to perform heating cooking on food as objects to be heated, with higher heating efficiency.

(Third Embodiment)

[0077] Hereinafter, a heating cooker according to a third embodiment of the present invention will be described. The heating cooker according to the third embodiment is largely different from the heating cookers according to the first and

second embodiments, in terms of the structure for supplying microwaves to a heating chamber. The structures according to the first and second embodiments are applied to the other structures in the heating cooker according to the third embodiment.

[0078] The heating cooker according to the third embodiment will be described, hereinafter, by designating components having the same functions and structures as those of the components of the heating cookers according to the first and second embodiments by the same reference characters, and by substituting the descriptions about the first and second embodiments for detailed descriptions thereof. Fig. 6 is a front cross-sectional view illustrating the microwave feeding structure in the heating cooker according to the third embodiment.

[0079] As illustrated in Fig. 6, in the heating cooker according to the third embodiment, an upper heater 12 is placed so as to be housed within a concave part 52, wherein the concave part 52 is formed by outwardly (upwardly) protruding a portion of the ceiling surface 37 of the heating chamber 11. An antenna room 53 provided on the upper side of the heating chamber 11 is structured to have a square planar shape, which is the shape of its lower end portion and, further, to have a rectangular-parallelepiped shape in its entirety. On the upper end portion of the antenna room 53, there is provided an L-shaped waveguide 21 having a horizontal part 42 and a vertical part 43. In the waveguide 21 according to the third embodiment, similarly to in the waveguide 21 according to the first embodiment, a feeding port 25 in the horizontal part 42 in the waveguide 21 is coupled to an opening in the protruding end portion of the antenna room 53 which is protruded upwardly from the ceiling surface 37 of the heating chamber 11, and the lower end portion of the vertical part 43 in the waveguide 21 is placed on the ceiling surface 37 (the concave part 52) of the heating chamber 11 in such a way as to interpose a slight gap between a lower end face of the vertical part 43 and an upper face of the ceiling surface 37. Accordingly, in the third embodiment, the heightwise size of the vertical part 43 of the waveguide 21 is set, in length, in such a way as to cancel the protruding portion of the antenna room 53.

[0080] A magnetron output part 44 as an oscillation antenna is inserted in the horizontal direction into the vertical part 43 of the waveguide 21, so that a magnetron 16 is coupled thereto. Accordingly, the magnetron 16 is coupled in a lateral orientation (coupled horizontally) to the waveguide 21, so that its heightwise size in the vertical direction is smaller than that in a case where the magnetron is coupled longitudinally (coupled vertically) to the waveguide.

[0081] The heating cooker according to the third embodiment is provided with ventilation areas 21a including pluralities of through holes 36a and 36b, in the opposite wall surfaces of the waveguide 21 which are faced to each other. Although Fig. 6 illustrates only the ventilation area 21a formed from the plurality of the through holes 36a in one of the wall surfaces, there is also formed the ventilation area 21a formed from the plurality of through holes 36b (see Fig. 4), similarly, in the other wall surface which is faced to the one wall surface. The ventilation areas 21a are areas in the wall surfaces in which there are arranged the pluralities of small through holes 36a and 36b with a diameter of about 2 to 5 mm, in order to prevent leakages of microwaves to the outside of the waveguide 21. Due to the provision of the ventilation areas 21a including the pluralities of the through holes 36a and 36b in the wall surfaces of the waveguide 21, it is possible to increase the heat transfer resistance in the wall surfaces of the waveguide 21 and, further, it is possible to allow air to move through the through holes 36a and 36b in the ventilation areas 21a. This results in movement of air through the waveguide 21, which exerts a cooling effect thereon, thereby reducing heat conducted from the heating chamber 11 to the magnetron 16 through the waveguide 21. The heating cooker according to the third embodiment is structured to further improve the microwave heating efficiency of the magnetron 16, since the magnetron 16 exhibits higher efficiency at lower temperatures in general.

[0082] The heating cooker according to the third embodiment can be provided with a cooling fan 35 and a cooling passage as described in the second embodiment, which enables cooling the waveguide 21 and, further, cooling the ceiling surface of the heating chamber 11 from the outside, by driving the cooling fan 35, even when the inside of the heating chamber 11 has been raised to higher temperatures during oven cooking, for example.

[0083] In the heating cooker according to the third embodiment, since the upper heater 12 is provided within the concave part 52 in the ceiling surface 36, the upper heater 12 is placed at a position at the same height as that of the lower end portion of the antenna room 53 or at a greater height than that of the lower end portion. This can eliminate a wasted space in the upward and downward size in the heating space under the antenna room 53, thereby compacting the entire apparatus. Further, since the upper heater 12 is placed at the same height as that of the lower end portion of the antenna room 53 or at a greater height than the lower end portion, it is possible to prevent the upper heater 12 from obstructing microwaves radiated from the feeding part 22 as the rotational antenna toward the food therebelow. Accordingly, the heating cooker according to the third embodiment is adapted to prevent microwaves from the feeding part 22 from directly heating the upper heater 12 to induce losses therein. Therefore, the heating cooker according to the third embodiment is capable of performing heating cooking of food with higher efficiency.

[0084] Further, the concave part 52 at a portion of a wall surface of the heating chamber 11 can also have an inner surface shape having such an angle as to reflect radiant heat from the upper heater 12 toward the food, as illustrated in Fig. 6.

[0085] Further, although the third embodiment has been described with respect to an example where the antenna room 53 has a square planar shape, the planar shape of the antenna room 53 can be any shape which does not interfere

with the rotation of the antenna part 22a and can also be an elliptical shape, a polygonal shape or a combination thereof, as well as a circular shape or a square shape.

(Fourth Embodiment)

[0086] Hereinafter, a heating cooker according to a fourth embodiment of the present invention will be described. The heating cooker according to the fourth embodiment is largely different from the heating cookers according to the first to third embodiments, in terms of the structure for supplying microwaves to a heating chamber. The structures according to the first or second embodiment are applied to the other structures in the heating cooker according to the fourth embodiment.

[0087] The heating cooker according to the fourth embodiment will be described, hereinafter, by designating components having the same functions and structures as those of the components of the heating cookers according to the first and second embodiments by the same reference characters, and by substituting the descriptions about the first and second embodiments for detailed descriptions thereof. Fig. 7 is a front cross-sectional view illustrating the microwave feeding structure in the heating cooker according to the fourth embodiment.

[0088] As illustrated in Fig. 7, in the heating cooker according to the fourth embodiment, an upper heater 12 is housed within a concave part 52 which is formed by outwardly (upwardly) protruding a portion of a ceiling surface 37 of the heating chamber 11. An antenna room 53 provided in the upper side of the heating chamber 11 has a square planar shape at its lower end portion and, further, the antenna room 53 has a rectangular-parallelepiped shape in its entirety. Further, the fourth embodiment will be described with respect to an example where the antenna room 53 has a square planar shape at its lower end portion, but the shape thereof is not limited in the present invention and can also be other shapes, such as circular shapes, polygonal shapes and the like.

[0089] On the upper end portion of the antenna room 53, there is provided an L-shaped waveguide 46 having a horizontal part 47 and a vertical part 48. In the waveguide 46 according to the fourth embodiment, the vertical part 48 is extended to protrude upwardly from the horizontal part 47, similarly to in the waveguide 46 according to the second embodiment. Further, a magnetron 16 is coupled in a lateral orientation (horizontally coupled) to the vertical part 48 of the waveguide 46, such that a magnetron output part 44 is inserted the vertical part 48 in the horizontal direction.

[0090] As illustrated in Fig. 7, the antenna room 53 is formed such that its upper end portion is protruded upwardly from the ceiling surface 37 of the heating chamber 11. A feeding port 25 formed in the horizontal part 47 of the waveguide 46 is coupled to an opening formed in the upper end portion of the antenna room 53. Therefore, the waveguide 46 is coupled to the heating chamber 11 with the antenna room 53 interposed between the waveguide 46 and the heating chamber 11.

[0091] In the fourth embodiment, the waveguide 46 is fixed only to the antenna room 53 and, thus, is adapted to be supported by the antenna room 53. The waveguide 46 and the magnetron 16 are placed in such a way as to interpose a space with a predetermined length between them and the ceiling surface 37 of the concave part 52 which houses the upper heater 12. Due to this placement, cooling air flows from a cooling fan 35 in a back side of the apparatus are caused to flow through the space between the ceiling surface 37 and the waveguide 46 and through the space between the ceiling surface 37 and the magnetron 16, similarly to in the second embodiment. This inhibits heat from the upper heater 12 from being conducted to the magnetron 16, which prevents temperature rises in the magnetron 16. This improves the microwave heating efficiency of the magnetron 16, since the magnetron 16 exhibits higher efficiency at lower temperatures, in general.

[0092] The heating cooker according to the fourth embodiment is provided with ventilation areas 46a including pluralities of small through holes 36a and 36b, in the opposite wall surfaces of the waveguide 46 which are faced to each other, similarly to the heating cooker according to the third embodiment. Although Fig. 7 illustrates only the ventilation area 46a formed from the plurality of the through holes 36a in one of the wall surfaces, there is also formed the ventilation area 46a formed from the plurality of through holes 36b (see Fig. 4), similarly, in the other wall surface which is faced to the one wall surface. The ventilation areas 46a are areas in the wall surfaces in which there are arranged the pluralities of small through holes 36a and 36b with a diameter of about 2 to 5 mm, in order to prevent leakages of microwaves to the outside of the waveguide 46. Due to the provision of the ventilation areas 46a including the pluralities of the through holes 36a and 36b in the wall surfaces of the waveguide 46, it is possible to increase the heat transfer resistance in the wall surfaces of the waveguide 46 and, further, it is possible to allow air to move through the through holes 36a and 36b in the ventilation areas 46a. This results in movement of air through the waveguide 46, which exerts a cooling effect thereon, thereby reducing heat conducted to the magnetron 16 through the waveguide 46. This can certainly cool the magnetron 16 and the waveguide 46.

[0093] Further, in the heating cooker according to the fourth embodiment, air flows are blown from the cooling fan 35 (see Fig. 4) through the ventilation areas 46a into the waveguide 46 which communicates with the heating chamber 11, which maintains the pressure within the waveguide 46 higher than the pressure within the heating chamber 11. Due to the provision of this pressure difference, it is possible to prevent intrusions of greasy fumes and the like from the heating

chamber 11 into the space housing the control part 20 and the like which are placed above the ceiling surface 37 of the heating chamber 11. Furthermore, heat generated from the magnetron 16 during microwave heating is transferred to the heating chamber 11, which realizes a structure having higher heating efficiency.

5 (Fifth Embodiment)

[0094] Hereinafter, a heating cooker according to a fifth embodiment of the present invention will be described. The heating cooker according to the fifth embodiment is largely different from the heating cookers according to the first to fourth embodiments, in terms of the structure for supplying microwaves to a heating chamber. The structures according to the first or second embodiment are applied to the other structures in the heating cooker according to the fifth embodiment.

[0095] The heating cooker according to the fifth embodiment will be described, hereinafter, by designating components having the same functions and structures as those of the components of the heating cookers according to the first and second embodiments by the same reference characters, and by substituting the descriptions about the first and second embodiments for detailed descriptions thereof. Fig. 8 is a front cross-sectional view illustrating the microwave feeding structure in the heating cooker according to the fifth embodiment.

[0096] In the heating cooker according to the fifth embodiment, the microwave feeding structure is formed such that an antenna room 54 is provided within the heating chamber 11 and, thus, the microwave feeding structure has a significantly-compacted structure.

[0097] As illustrated in Fig. 8, in the fifth embodiment, an antenna-room structural member 54a having a cylindrical shape is secured to the ceiling surface 37 of the heating chamber 11 to form the antenna room 54. The antenna-room structural member 54a functions as a wall for interrupting microwaves radiated in substantially-horizontal directions from an antenna part 22a in a feeding part 22, which prevents microwaves from the feeding part 22 from directly heating an upper heater 12 and upper-heater supporting tools 51 (see Fig. 5) which are provided around the outer periphery of the antenna room 54. Further, the planar shape of the antenna room 54 is not limited to a circular shape and can also be a square shape, a rectangular shape, other polygonal shapes, and the like.

[0098] The ceiling surface 37 of the heating chamber 11 is provided with an opening in, its portion over which the antenna room 54 is formed, and a feeding port 25 formed in a horizontal part 47 of a waveguide 46 is coupled to this opening. In the fifth embodiment, the waveguide 46 includes the horizontal part 47 and a vertical part 48 to have an L shape, wherein the vertical part 48 is extended to protrude upwardly from the horizontal part 47, similarly to the waveguide 46 according to the second embodiment. Further, a magnetron 16 is coupled in a lateral orientation (horizontally coupled) to the vertical part 48 of the waveguide 46, such that a magnetron output part 44 is horizontally inserted in the vertical part 48.

[0099] The heating cooker according to the fifth embodiment is provided with ventilation areas 46a including pluralities of small through holes 36a and 36b, in the opposite wall surfaces of the waveguide 46 which are faced to each other, similarly to the heating cookers according to the third and fourth embodiments. This results in movement of air through the waveguide 46, which exerts a cooling effect thereon, thereby reducing heat conducted to the magnetron 16 through the waveguide 46. This can certainly cool the magnetron 16 and the waveguide 46.

[0100] The heating cooker according to the fifth embodiment is structured such that the antenna room 54 is not protruded upwardly from the heating chamber 11, and such that the horizontal part 47 of the waveguide 46 is provided on the upper surface of the ceiling surface 37 of the heating chamber 11, and the vertical part 48 of the waveguide 46 is upwardly extended. Further, a heat insulation part for intercepting heat can be also provided between the horizontal part 47 of the waveguide 46 and the ceiling surface 37 of the heating chamber 11, in order to inhibit heat from the heating chamber 11 from being conducted to the waveguide.

[0101] In the heating cooker according to the fifth embodiment, as illustrated in Fig. 8, the antenna room 54 and the upper heater 12 are placed substantially at the same height, and the magnetron 16 and a motor 23 are placed within the heightwise size of the vertical part 48 of the waveguide 46. The heating cooker having the structure according to the fifth embodiment has a minimized heightwise size and, thus, has a compact structure, in comparison with the heating cookers according to the other embodiments.

[0102] The heating cooker according to the fifth embodiment is not provided with a cover which covers the lower end portion of the antenna room 54, which prevents the occurrence of slight dielectric losses in such a cover, thereby further improving the heating efficiency. Further, in the heating cooker according to the fifth embodiment, the antenna room 54 is constituted by the antenna-room structural member 54a provided on the ceiling surface 37 of the heating chamber 11, and the antenna-room structural member 54a is placed between the antenna room 54 and the upper heater 12 to function as a shield wall for interrupting microwaves radiated in substantially-horizontal directions from the antenna part 22a.

[0103] This inhibits microwaves radiated from the feeding part 22 within the heating chamber 11 from being influenced by the presence or absence of members around the feeding part 22 within the heating chamber and from being influenced

by the shapes and placement of members around the feeding part 22. Due to the provision of the antenna room 54, microwaves radiated from the feeding part 22 are prevented from directly heating the upper heater 12, which reduces losses thereof in the upper heater 12, thereby enabling heating the object to be heated, with higher efficiency.

5 (Sixth Embodiment)

[0104] Hereinafter, a heating cooker according to a sixth embodiment of the present invention will be described. The heating cooker according to the sixth embodiment is largely different from the heating cookers according to the first and second embodiments, in terms of the structure for supplying microwaves to a heating chamber. The structures according to the first or second embodiment are applied to the other structures in the heating cooker according to the sixth embodiment.

[0105] The heating cooker according to the sixth embodiment will be described, hereinafter, by designating components having the same functions and structures as those of the components of the heating cookers according to the first and second embodiments by the same reference characters, and by substituting the descriptions about the first and second embodiments for detailed descriptions thereof. Fig. 9 is a front cross-sectional view illustrating the microwave feeding structure in the heating cooker according to the sixth embodiment.

[0106] In the microwave feeding structure in the heating cooker according to the sixth embodiment, as illustrated in Fig. 9, a magnetron 16 is placed in the space between a waveguide 21 and an antenna room 53.

[0107] In the heating cooker according to the sixth embodiment, similarly to in the third embodiment (Fig. 6), an upper heater 12 is placed so as to be housed within a concave part 52, wherein the concave part 52 is formed by outwardly protruding a portion of a ceiling surface 37 of the heating chamber 11. The antenna room 53 provided in the upper side of the heating chamber 11 is structured to have a square planar shape, which is the shape of its lower end portion and, further, to have a rectangular parallelepiped shape in its entirety. On the upper end portion of the antenna room 53, there is provided an L-shaped waveguide 21 having a horizontal part 42 and a vertical part 43. In the waveguide 21 according to the sixth embodiment, a feeding port 25 formed in the lower surface of the horizontal part 42 in the waveguide 21 is coupled to an opening in the protruding end portion of the antenna room 53. The lower end portion of the vertical part 43 in the waveguide 21 is placed above the concave part 52 in the ceiling surface 37 of the heating chamber 11 in such a way as to interpose a space therebetween. Accordingly, in the sixth embodiment, the waveguide 21 is coupled to only the antenna room 53 and, thus, is supported only by the antenna room 53.

[0108] Further, a magnetron output part 44 is inserted in the horizontal direction into the side surface of the vertical part 43 of the waveguide 21 which is faced to the antenna room 53, so that the magnetron 16 is coupled (horizontally coupled) thereto. Accordingly, the magnetron 16 is placed in the space sandwiched between the antenna room 53 and the vertical part 43 of the waveguide 21.

[0109] The heating cooker according to the sixth embodiment is provided with ventilation areas 21a including pluralities of small through holes 36a and 36b, in the opposite wall surfaces of the waveguide 21 which are faced to each other, similarly to in the third embodiment (Fig. 6). The formation of these ventilation areas 21a induces movement of air through the waveguide 21, which exerts a cooling effect thereon. This results in reduction of heat conducted from the heating chamber 11 to the magnetron 16 through the waveguide 21.

[0110] Further, as illustrated in Fig. 9, the magnetron output part 44 in the magnetron 16 which is inserted into the waveguide 21 is surrounded by the ventilation areas 21a, which causes the magnetron output part 44 to be cooled by cooling air flows passing through the ventilation areas 21a. With the heating cooker according to the sixth embodiment, it is possible to improve the heating efficiency of the magnetron 16, since the magnetron 16 exhibits higher efficiency at lower temperatures, in general.

[0111] As described above, the heating cooker according to the sixth embodiment is structured to include the waveguide 21 which is orthogonally folded in an L shape, such that the vertical part 43 of the waveguide 21 is extended downwardly in the vertical direction, and the magnetron 16 is provided in the space between the waveguide 21 and the antenna room 53. Therefore, in the structure of the heating cooker according to the sixth embodiment, the magnetron 16 is placed within the range of the horizontal part 42, in the direction of the extension of the horizontal part 42 in the waveguide 21. Accordingly, the heating cooker according to the sixth embodiment is adapted to effectively utilize the space above the heating chamber 11, which eliminates wasted spaces and attains compaction of the heating cooker.

[0112] With the heating cooker according to the sixth embodiment, even when the horizontal propagation distance H (see Fig. 2) in the horizontal part 42 of the waveguide 21 is set to be longer than half the wavelength ($\lambda_g/2$), it is possible to compactly form the entire apparatus. Accordingly, with the heating cooker according to the sixth embodiment, it is possible to stabilize the coupling in the microwave feeding structure, which enables maintaining higher heating efficiency. Therefore, with the structure according to the sixth embodiment, it is possible to structure a heating cooker capable of having both improved heating efficiency and improved compactness.

[0113] As described above, as described in the respective embodiments, by setting the horizontal propagation distance (H) of the horizontal propagation path in the waveguide to be longer than 1/2 the wavelength of microwaves which

propagates through the waveguide ($\lambda_g/2$), in the microwave heating device according to the present invention, the distance to the feeding port in the horizontal propagation path in the waveguide is made to be sufficiently longer with respect to the wavelength of propagated waves. This results in an increase of the stability of the coupling in the microwave feeding structure, which can maintain higher efficiently for heating operations, regardless of changes of operating states, such as load changes.

[0114] Further, since the microwave heating device according to the present invention is provided with the waveguide having a folded shape which is folded in an L shape, the microwave generating part which is horizontally coupled to the vertical propagation path in the waveguide, and the antenna room which houses the feeding part, such that the antenna room is coupled to the horizontal propagation path in the waveguide, it is possible to compact the microwave feeding structure and, also, it is possible to reduce the amount of heat conducted from the heating chamber to the microwave generating part. As a result thereof, the microwave heating device according to the present invention is capable of improving the heating efficiency of the microwave generating part and, also, is capable of attaining both compaction and heating-efficiency improvement in the microwave feeding structure including the microwave generating part.

Industrial Applicability

[0115] The present invention can be applied to heating cookers for inductively heating food through radiation of microwaves, particularly heating cookers using other heating through ovens, grills, superheated steams and the like. Furthermore, the present invention can be applied to microwave heating devices for various industrial applications, such as drying apparatuses, ceramic-art heating apparatuses, garbage disposers, semiconductor fabrication apparatuses, and the like.

Reference Signs List

[0116]

10	Cabinet
11	Heating chamber
12	Upper heater
13	Lower heater
15	Object to be heated (food)
16	Magnetron
17	Upper-heater thermocouple
18	Lower-heater thermocouple
19	Thermistor
21	Waveguide
22	Feeding part
22a	Antenna part
22b	Shaft part
23	Motor
24	Antenna room
25	Feeding port
26	Hook
27	Cover
42	Horizontal part (horizontal propagation path)
43	Vertical part (vertical propagation path)

Claims

1. A microwave heating device comprising:

a heating chamber for housing an object to be heated and for radiating a microwave toward the object to be heated for performing high-frequency heating on the object to be heated;
a microwave generating part adapted to generate a microwave for performing high-frequency heating on the object to be heated within the heating chamber;

a waveguide having a horizontal propagation path and a vertical propagation path orthogonal to each other such that the microwave generating part is horizontally coupled to the vertical propagation path, for propagating a microwave from the microwave generating part through the horizontal propagation path;
 a feeding part which is coupled to the horizontal propagation path and includes an antenna part for radiating, within the heating chamber, the microwave propagated through the waveguide; and
 an antenna room which is provided in a ceiling surface of the heating chamber, further is adapted to reflect the microwave radiated in a horizontal direction from the antenna part, and is opened at its lower end portion such that the microwave from the antenna part is radiated within the heating chamber;
 wherein
 the waveguide is structured such that a horizontal propagation distance in the horizontal propagation path is longer than $1/2$ the wavelength of the microwave which propagates through the waveguide.

2. The microwave heating device according to Claim 1, further comprising a radiant heating part for heating the object to be heated through radiant heat from above the object to be heated, the radiant heating part being provided within the heating chamber, wherein the radiant heating part is placed in an area which is not beneath the antenna room.
3. The microwave heating device according to Claim 1 or 2, further comprising a convection heating part adapted to circulate a hot air flow within the heating chamber, for heating the object to be heated.
4. The microwave heating device according to any one of Claims 1 to 3, wherein the antenna part in the feeding part is adapted to rotate within the antenna room for stirring and radiating a microwave within the heating chamber.
5. The microwave heating device according to any one of Claims 1 to 4, wherein the waveguide is adapted such that the vertical propagation path is extended downwardly with respect to the horizontal propagation path, and a feeding port in the horizontal propagation path is coupled to an opening in an upper end portion of the antenna room which is formed to protrude upwardly from the ceiling surface of the heating chamber.
6. The microwave heating device according to any one of Claims 1 to 4, wherein the waveguide is adapted such that the vertical propagation path is extended upwardly with respect to the horizontal propagation path, and a feeding port in the horizontal propagation path is coupled to an opening in an upper end portion of the antenna room which is formed to protrude upwardly from the ceiling surface of the heating chamber, and such that the microwave from the microwave generating part coupled horizontally to the vertical propagation path is radiated within the heating chamber from the feeding part through the horizontal propagation path.
7. The microwave heating device according to any one of Claims 1 to 4, further comprising a heat insulation part provided in a space between the waveguide and the heating chamber, outside the antenna room.
8. The microwave heating device according to any one of Claims 1 to 4, wherein the antenna room includes a shield wall protruding downwardly from the ceiling surface of the heating chamber, and the radiant heating part is placed around the outer peripheral portion of the shield wall.
9. The microwave heating device according to any one of Claims 1 to 4, wherein the waveguide is provided with through holes having a diameter which prevents the microwave from being leaked through the through holes, in its surfaces facing each other, such that a cooling air flow created by a cooling fan passes through the through holes.
10. The microwave heating device according to any one of Claims 1 to 4, wherein the waveguide is provided with a ventilation area having a plurality of through holes having a diameter which prevents the microwave from being leaked through the through holes.
11. The microwave heating device according to any one of Claims 1 to 4, wherein the waveguide is adapted such that the vertical propagation path is extended downwardly with respect to the horizontal propagation path, and a feeding port in the horizontal propagation path is coupled to an opening in an upper end portion of the antenna room which is formed to protrude upwardly from the ceiling surface of the heating chamber, and such that the microwave generating part is placed in a space between the antenna room and the vertical propagation path.

- 12.** The microwave heating device according to any one of Claims 1 to 4, wherein the waveguide is adapted such that a vertical propagation distance in the vertical propagation path is shorter than $1/4$ the wavelength of the microwave which propagates through the waveguide.

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Fig.1

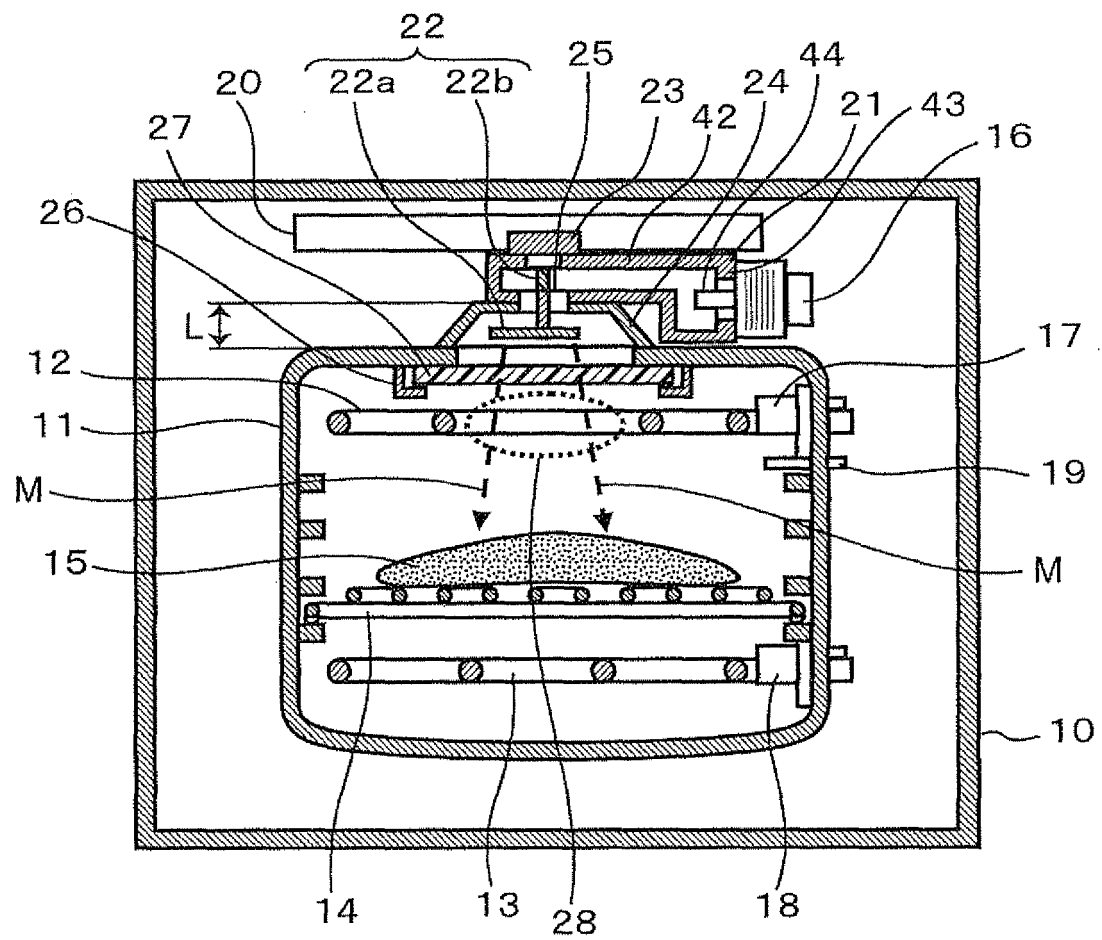


Fig.2

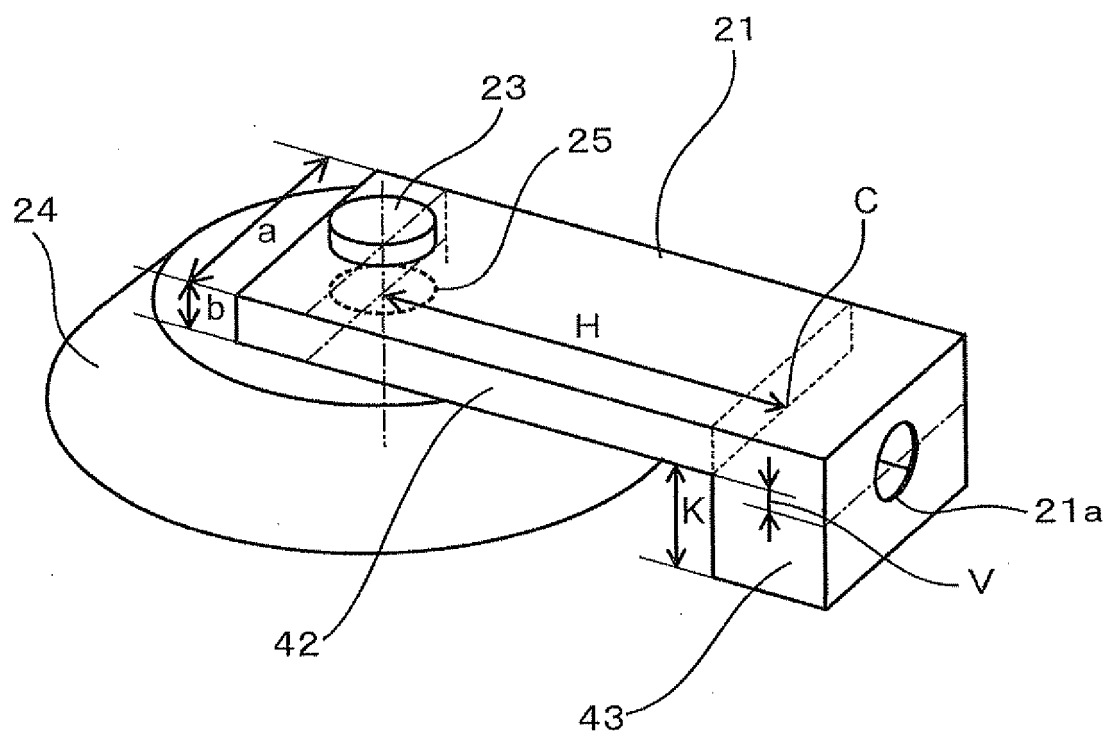


Fig.3

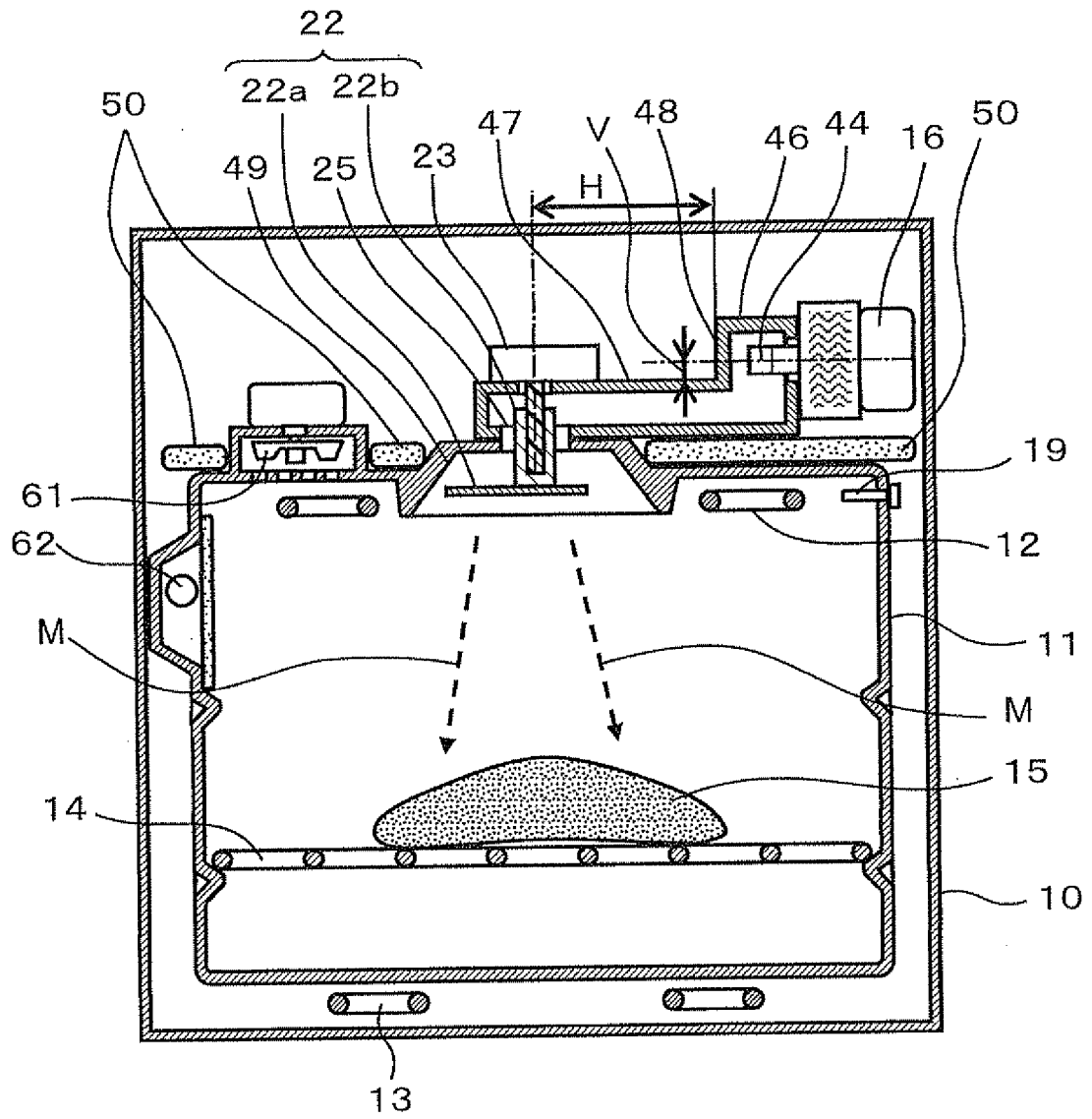


Fig.4

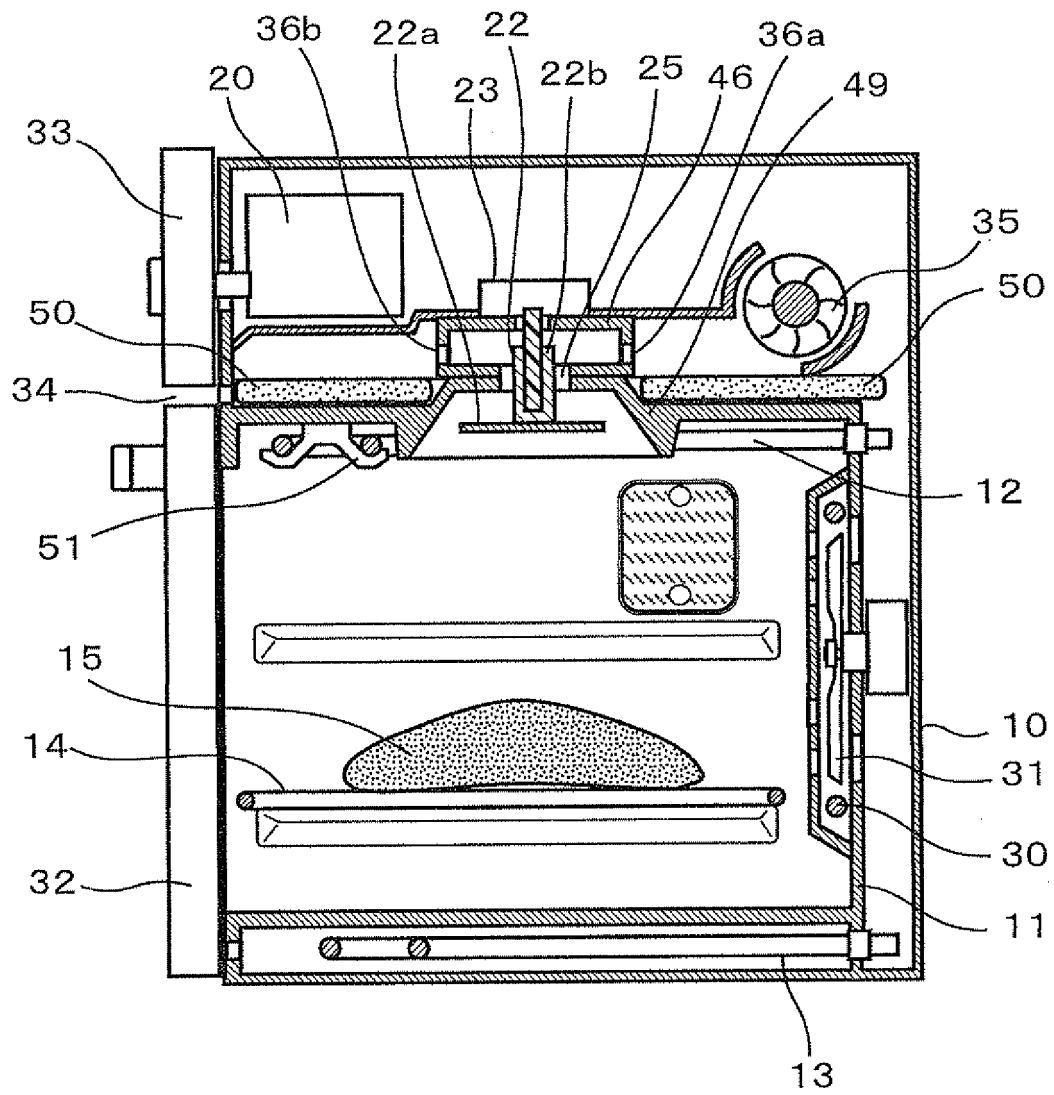


Fig.5

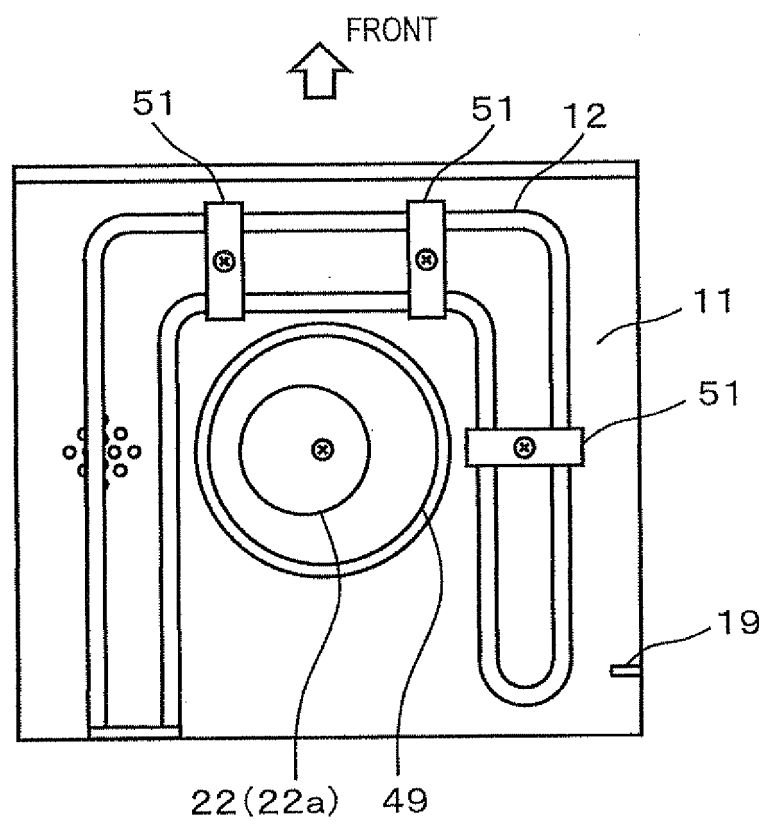


Fig.6

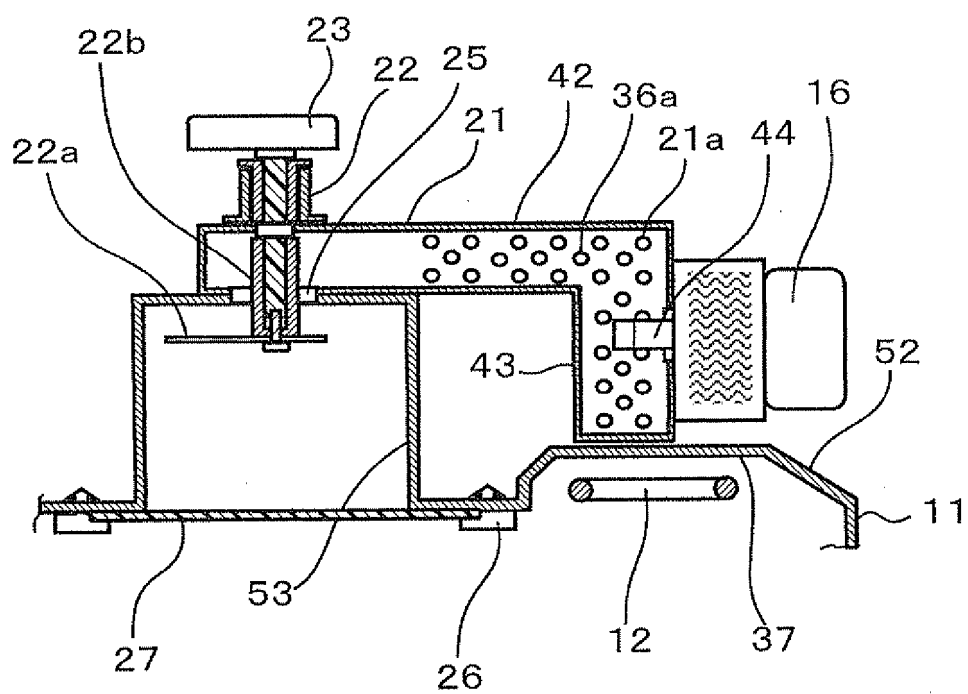


Fig.7

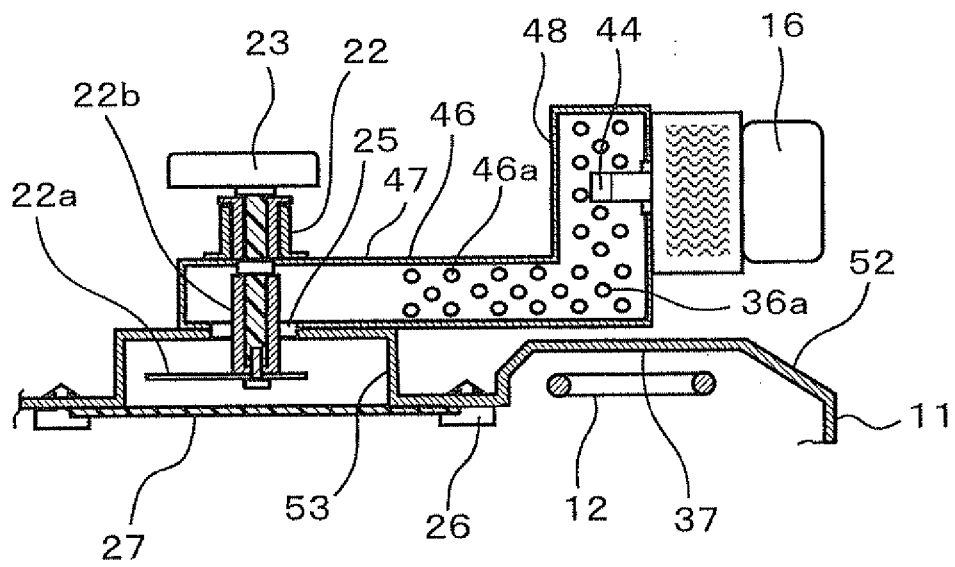


Fig.8

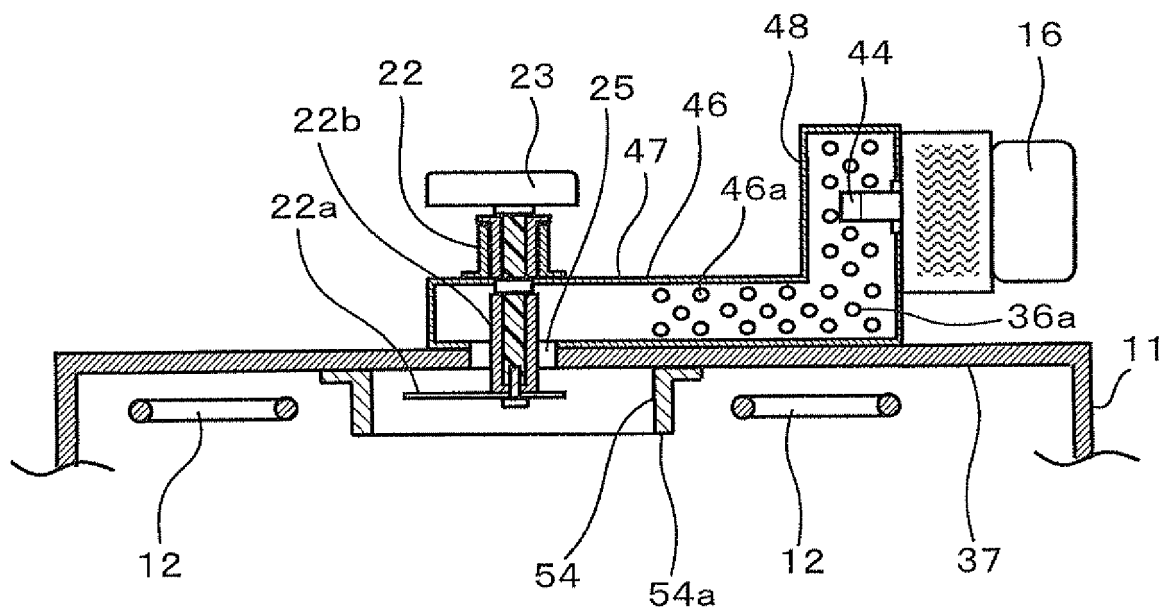


Fig.9

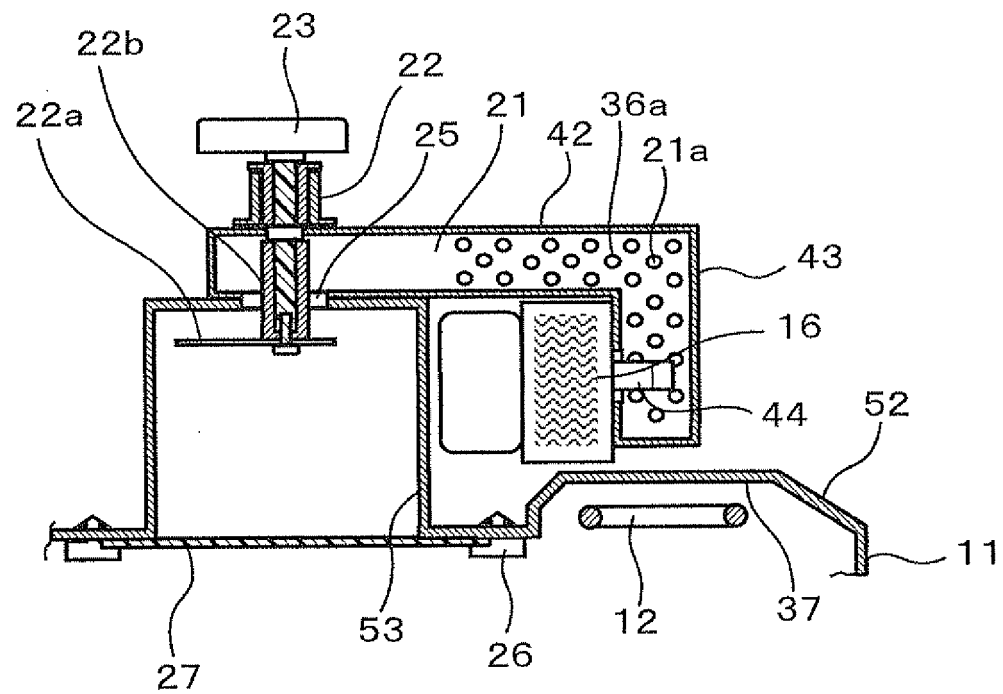
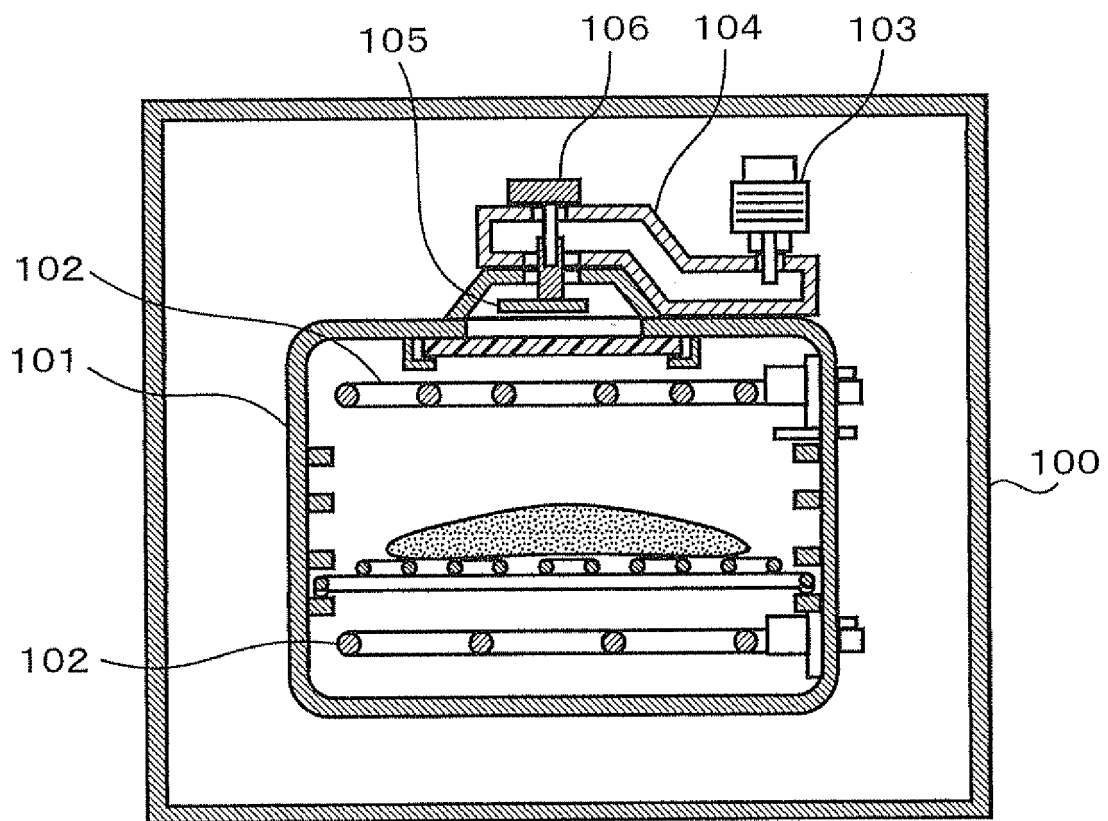


Fig.10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/003831

A. CLASSIFICATION OF SUBJECT MATTER

H05B6/70 (2006.01) i, F24C7/02 (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)

H05B6/70, F24C7/02

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	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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 2004-265616 A (Matsushita Electric Industrial Co., Ltd.), 24 September 2004 (24.09.2004), paragraphs [0022] to [0033]; fig. 1 to 3 & US 2006/0081626 A1 & EP 1592286 A1 & WO 2004/071133 A1 & CN 1736128 A	1-12
Y	JP 9-26140 A (Samsung Electronics Co., Ltd.), 28 January 1997 (28.01.1997), fig. 3 & US 5786577 A & EP 753984 A2 & DE 69633541 T2 & KR 10-0152145 B1	1-12

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

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Date of the actual completion of the international search
12 September, 2011 (12.09.11)Date of mailing of the international search report
20 September, 2011 (20.09.11)Name and mailing address of the ISA/
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International application No.

PCT/JP2011/003831

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 2000-164337 A (Matsushita Electric Industrial Co., Ltd.), 16 June 2000 (16.06.2000), fig. 1 (Family: none)	1-12
Y	JP 2003-109744 A (Matsushita Electric Industrial Co., Ltd.), 11 April 2003 (11.04.2003), paragraphs [0004], [0015]; fig. 3 to 4 (Family: none)	3-12
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Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 97617/1984 (Laid-open No. 13498/1986) (NGK Insulators, Ltd.), 25 January 1986 (25.01.1986), fig. 1 to 2 & US 4629849 A & EP 166622 A2	8
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REFERENCES CITED IN THE DESCRIPTION

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