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(71) Applicant: **Panasonic Corporation**
Osaka 571-8501 (JP)

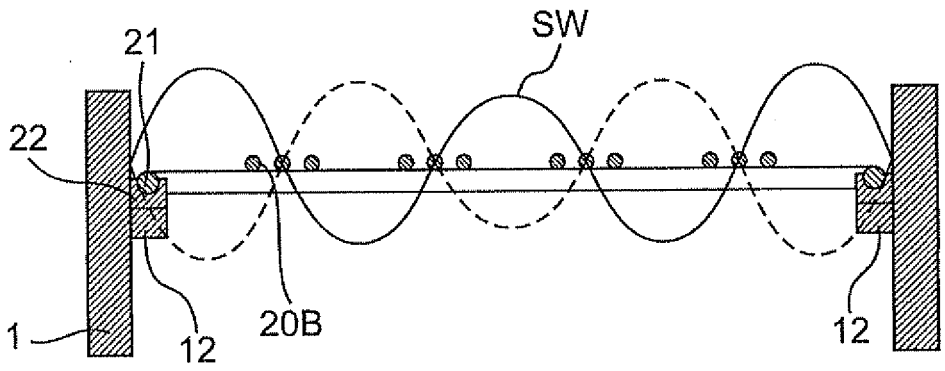
(72) Inventors:
- **SHIBUYA, Masaki**
  2-1-61 Shiromi
  Chuo-ku
  Osaka 540-6207 (JP)
- **KAWAI, Hiroshi**
  2-1-61 Shiromi
  Chuo-ku
  Osaka 540-6207 (JP)
- **KONDO, Ryuta**
  2-1-61 Shiromi
  Chuo-ku
  Osaka 540-6207 (JP)
- **NISHIMURA, Makoto**
  2-1-61 Shiromi
  Chuo-ku
  Osaka 540-6207 (JP)

(74) Representative: **Schwabe - Sandmair - Marx**
Patentanwälte
Stuntzstraße 16
81677 München (DE)

(54) **MICROWAVE HEATING DEVICE**

(57) A heating cooker according to the present invention is structured such that an outer frame (21) and bridge members (20) which constitute a gridiron are provided outside the vicinities of antinodes of standing waves (SW), such that the gridiron is opened in the vicinities of antinodes of the standing waves (SW) induced within a heating chamber (1), in order to suppress heat generation from the gridiron (4) as a grid member for realizing heating with higher efficiency and with lower energy losses.

Fig.3



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Description

Technical Field

[0001] The present invention relates to microwave heating devices for performing microwave heating.

Background Art

[0002] For conventional microwave heating devices such as, for example, heating cookers for performing heating cooking on foods as objects to be heated, there have been suggested structures using grid members (rotational grids) which are formed from metal rod members combined with each other through welding, in order to suspend objects to be heated, at desired positions, from the heating chamber bottom surface (refer to Unexamined Japanese Patent Publication No. H9-145064 (Patent Literature 1)).

Citation List

Patent Literatures

[0003]

Patent Literature 1: Unexamined Japanese Patent Publication No. H9-145064
Patent Literature 2: Unexamined Japanese Utility Model Application Publication No. S55-059209

Summary of Invention

Technical Problem

[0004] A heating cooker described in the aforementioned Patent Literature 1 is structured, such that a rotational plate made of a glass is placed on a rotational grid in a microwave heating mode, while a rectangular plate made of a metal is placed on the rotational grid in an oven heating mode, in order to place objects to be heated at desired positions within the heating chamber, for enabling heating cooking thereon.

[0005] In the conventional heating cooker described in Patent Literature 1, a circular grid unit 100 with fine meshes as illustrated in Fig. 12, for example, is provided within the heating chamber. In the microwave heating mode, standing waves are induced within the heating chamber of the heating cooker, due to microwaves from an antenna and waves reflected by the wall surfaces. Therefore, a grid-shaped member 101 constituting the metal grid unit 100 is placed, in areas in the vicinities of antinodes of standing waves induced within the heating chamber in the microwave heating mode (areas which are subjected to larger electric fields). As a result thereof, in the microwave heating mode, larger electric currents flow through the grid-shaped member 101 in the grid unit 100, which causes the grid unit 100 to generate heat, thereby inducing energy losses. This has caused degradations of the heating efficiency of the conventional heating cooker.

[0006] Further, there have been conventional heating cookers structured to be provided with gridirons as metal grid members for placing, thereon, objects to be heated, which are housed within the heating chamber (refer to Unexamined Japanese Utility Model Application Publication No. S55- 059209 (Patent Literature 2), for example) . Fig. 13 is a plan view illustrating the structure of an ordinary gridiron 102 provided within the heating chamber in a conventional heating cooker. As illustrated in Fig. 13, the gridiron 102 is structured to include an outer frame 103 which conforms to the shape of the heating chamber, and a plurality of rod- shaped members 104 placed at smaller intervals with respect to the outer frame 103. In the gridiron 102, similarly, the rod- shaped members 104 constituting the metal gridiron 102 are placed in areas in the vicinities of antinodes of standing waves which are induced within the heating chamber in a microwave heating mode (areas designated as "MA" as examples in Fig. 13) . As a result thereof, in the microwave heating mode, larger electric currents flow through the rod- shaped members 104 in the gridiron 102, which has induced the problem of abnormal heat generation from the gridiron 102. Accordingly, the conventional heating cooker has had the problem of occurrence of significant energy losses and, therefore, degradations of the heating efficiency of the heating cooker, in cases of using the gridiron in the microwave heating mode.

[0007] The present invention is made to overcome the aforementioned problems in conventional microwave heating devices and aims at providing a microwave heating device with higher efficiency which can suppress abnormal heat generation from grid members and the like which are placed within the heating chamber, thereby reducing energy losses.

Solution to Problem

[0008] A microwave heating device according to the present invention includes:

a heating chamber adapted to heat an object to be heated;
a microwave generating portion adapted to supply a microwave to an inside of the heating chamber; and
a gridiron as a grid member which is formed from a metal rod-shaped member and is adapted to place the object to be heated within the heating chamber;
wherein the gridiron is constituted by an outer frame secured to the inside of the heating chamber at a predetermined position, and bridge members secured to the outer frame, and
the outer frame and the bridge members are provided outside the vicinities of antinodes of a standing wave which is induced within the heating chamber, such that the gridiron is opened in the vicinities of

the antinodes of the standing wave.

[0009] According to the present invention having the aforementioned structure, it is possible to provide a microwave heating device with higher efficiency which prevents larger electric currents from flowing through the bridge members, thereby suppressing abnormal heat generation from the gridiron and reducing energy losses, in a microwave heating mode.

Advantageous Effects of Invention

[0010] The microwave heating device according to the present invention can provide a heating apparatus with higher efficiency which can suppress abnormal heat generation from the grid member and the like which are placed within the heating chamber, thereby inducing less energy losses.

Brief Description of Drawings

[0011]

Fig. 1 is a front cross-sectional view illustrating a microwave heating device according to a first embodiment of the present invention.
Fig. 2 is a plan view illustrating a gridiron in the microwave heating device according to the first embodiment of the present invention.
Fig. 3 is a schematic cross-sectional view of the gridiron illustrated in Fig. 2, taken along the line III-III.
Fig. 4 is a cross-sectional view of the gridiron illustrated in Fig. 2, taken along the line IV-IV.
Fig. 5 is a plan view illustrating a gridiron for use in a microwave heating device according to a second embodiment of the present invention.
Fig. 6 is a plan view illustrating a gridiron having a different structure for use in the microwave heating device according to the second embodiment of the present invention.
Fig. 7 is a plan view illustrating a gridiron having a different structure for use in the microwave heating device according to the second embodiment of the present invention.
Fig. 8 is a plan view illustrating a gridiron having a different structure for use in the microwave heating device according to the second embodiment of the present invention.
Fig. 9 is a main-part cross-sectional view of the heating cooker according to the second embodiment, when viewed at a side surface thereof.
Fig. 10 is a plan view illustrating a gridiron for use in a microwave heating device according to a third embodiment of the present invention.
Fig. 11 is a main-part cross-sectional view of the heating cooker according to the third embodiment, when viewed at a side surface thereof.
Fig. 12 is a perspective view illustrating a rotational grid as a grid member for use in a conventional microwave heating device.
Fig. 13 is a plan view illustrating a gridiron as a grid member for use in the conventional microwave heating device.

Description of Embodiments

[0012] According to a first invention, there is provided a microwave heating device including:

a heating chamber adapted to heat an object to be heated;
a microwave generating portion adapted to supply a microwave to an inside of the heating chamber; and
a gridiron which is formed from a metal rod-shaped member and is adapted to place the object to be heated within the heating chamber;
wherein the gridiron comprises an outer frame secured to the inside of the heating chamber at a predetermined position, and bridge members secured to the outer frame, and
the outer frame and the bridge members are provided outside the vicinities of antinodes of a standing wave which is induced within the heating chamber, such that the gridiron is opened in the vicinities of the antinodes of the standing wave.
With the microwave heating device having the aforementioned structure according to the first invention, it is possible to prevent larger electric currents from flowing through the bridge members in the gridiron, thereby suppressing abnormal heat generation, in the microwave heating mode. Therefore, the microwave heating device forms a heating apparatus with higher efficiency which induces less energy losses.

[0013] According to a second invention, particularly in the first invention, the outer frame and at least one of the bridge members are provided in the vicinities of nodes of the standing wave. According to the second invention having the aforementioned structure, it is possible to inhibit electric currents from flowing through the outer frame and/or the bridge members which are provided in the vicinities of nodes, which prevents abnormal heat generation from the gridiron. This provides a microwave heating device with higher efficiency which induces less energy losses.

[0014] According to a third invention, particularly in the first or second invention, the bridge members are provided at positions spaced apart from an inner wall of the heating chamber, by a length equal to or more than 3/8 the wavelength of the standing wave. With the microwave heating device according to the third invention having the aforementioned structure, it is possible to certainly evade the vicinities of areas at a distance equal to 1/4 the wavelength of standing wave from the inner wall of the heating chamber, which are coincident with the positions of the antinodes of the standing wave. This suppresses heat

generation from the gridiron. This can provide a microwave heating device with higher efficiency which induces less energy losses.

[0015] According to a fourth invention, particularly in any one of the first to third inventions, within the heating chamber, there is provided a rail portion which enables the gridiron to be inserted in the inside of the heating chamber, and there is provided an insulating structure between the rail portion and the gridiron. With the microwave heating device according to the fourth invention having the aforementioned structure, since the rail portion and the gridiron are insulated from each other, it is possible to suppress concentrations of electric fields, which can suppress abnormal heat generation. Thus, the microwave heating device forms a heating apparatus with higher efficiency which induces less energy losses.

[0016] According to a fifth invention, particularly in the first invention, the gridiron is structured such that a plurality of the bridge members are secured to the outer frame in parallel with each other, the bridge members adjacent to each other are formed from a single rod-shaped member, and end portions of the rod-shaped members are not protruded from the outer frame toward a side-surface wall of the heating chamber. With the microwave heating device according to the fifth invention having the aforementioned structure, the rod-shaped members are adapted such that their end portions are not protruded within the heating chamber, which can suppress concentration of electric fields in the gridiron, thereby preventing abnormal heat generation. Thus, the microwave heating device forms a heating apparatus with higher efficiency which induces less energy losses.

[0017] According to a sixth invention, particularly in the fifth invention, the bridge members are formed from rod-shaped members having an annular shape. With the microwave heating device having the aforementioned structure according to the sixth invention, the bridge members have no end portion, which prevents abnormal heat generation from the gridiron. Thus, the microwave heating device forms a heating apparatus with higher efficiency which induces less energy losses.

[0018] According to a seventh invention, particularly in the sixth invention, the annular shape of the bridge members forms an elongated track shape. According to the seventh invention having the aforementioned structure, there remain straight-line portions as in such a track shape (elongated annular shape), which can reduce the distance over which the bridge members form bridges in the outer frame as much as possible, thereby reducing the fabrication costs. This can suppress flexures thereof when objects to be heated are placed thereon. This can provide a microwave heating device with higher efficiency which induces less energy losses.

[0019] According to an eighth invention, particularly in the fifth invention, the bridge members are formed to have a turned-back meandering shape. According to the eighth invention having the aforementioned structure, it is possible to reduce the welded portions, which can suppress heat generation due to concentrations of electric fields at the welded portions. This can provide a microwave heating device with higher efficiency which induces less energy losses.

[0020] According to a ninth invention, particularly in any one of the fifth to eighth inventions, the bridge members are secured to the outer frame, such that the bridge members are in contact with an inner periphery of the outer frame. According to the ninth invention having the aforementioned structure, it is possible to eliminate gaps formed by the intersection of the outer frame and the bridge members, which can suppress heat generation due to concentration of electric fields at gaps in the gridiron. This can provide a microwave heating device with higher efficiency which induces less energy losses.

[0021] According to a tenth invention, particularly in any one of the sixth to eighth inventions, the bridge members are placed such that arc portions of the bridge members are protruded to an outside of the outer frame. According to the tenth invention having the aforementioned structure, the bridge members are structured such that their arc portions are protruded, and end portions of the bridge members are not protruded, which prevents abnormal heat generation from the gridiron. This can provide a microwave heating device with higher efficiency which induces less energy losses.

[0022] According to an eleventh invention, particularly in the first invention, the gridiron is adapted to come in point-to-point contact with the heating chamber. According to the eleventh invention having the aforementioned structure, the gridiron is structured to create a larger gap which is less prone to induce concentrations of electric fields, over its portion other than its point-to-point contact portions. In view of processes, it is significantly hard to fabricate both the gridiron and the heating chamber such that their contact surfaces are parallel with each other and, also, straightly come in contact with each other. However, according to the eleventh invention, the gridiron is structured such that it comes in point-to-point contact with the heating chamber, such that even a small gap is not induced between the gridiron and the heating chamber. With this structure, it is possible to prevent concentrations of electric fields, thereby suppressing abnormal heat generation. This can provide a microwave heating device with higher efficiency which induces less energy losses.

[0023] According to a twelfth invention, particularly in the eleventh invention, the outer frame is provided with a protruding portion, such that the gridiron comes in point-to-point contact with a rear-surface wall of the heating chamber. As described above, in view of processes, in cases where the gridiron and the rear-surface wall of the heating chamber are made to come in line-to-line contact with each other over their contact surfaces, it is significantly hard to fabricate both the contact surfaces such that they are parallel with each other and, also, are straight. Thus, a small gap may be induced therebetween, and electric fields may be concentrated at these

gaps. However, according to the twelfth invention, the gridiron and the rear-surface wall of the heating chamber are structured such that they come in point-to-point contact with each other at their contact surfaces, which prevents concentrations of electric fields, thereby suppressing abnormal heat generation. This can provide a microwave heating device with higher efficiency which induces less energy losses.

[0024] According to a thirteenth invention, particularly in the eleventh invention, the rear-surface wall is provided with a protruding portion with a hemispherical shape, such that the gridiron comes in point-to-point contact with the rear-surface wall of the heating chamber. As described above, in view of processes, in cases where the gridiron and the rear-surface wall of the heating chamber are made to come in line-to-line contact with each other over their contact surfaces, it is significantly hard to fabricate both the contact surfaces such that they are parallel with each other and, also, are straight. Thus, a small gap may be induced therebetween, and electric fields may be concentrated at these gaps. However, according to the thirteenth invention, the gridiron and the rear-surface wall of the heating chamber are structured such that they come in point-to-point contact with each other at their contact surfaces, which prevents concentrations of electric fields, thereby suppressing abnormal heat generation. This can provide a microwave heating device with higher efficiency which induces less energy losses.

[0025] According to a fourteenth invention, particularly in the twelfth invention, the protruding portion formed on the outer frame in the gridiron is formed by bending a portion of a rod-shaped member in a U shape. According to the fourteenth invention having the aforementioned structure, it is possible to form the protruding portion as a point-to-point contact portion, only by bending the rod-shaped member in the gridiron in a U shape. This facilitates the fabrication, thereby reducing the fabrication costs. Further, in cases where the protruding portion is provided on the gridiron through welding, the protruding portion may come off therefrom during use. However, in the microwave heating device according to the fourteenth invention, the protruding portion is formed integrally with the gridiron, which prevents the protruding portion from coming off therefrom. This can provide a heating apparatus with higher reliability.

[0026] According to a fifteenth invention, particularly in any one of the eleventh to fourteenth inventions, within the heating chamber, there is provided a rail portion which enables the gridiron to be inserted in the inside of the heating chamber, and the rail portion and the gridiron are adapted to come in point-to-point contact with each other. As described above, in view of processes, in cases where the rail portion and the gridiron are made to come in line-to-line contact with each other over their contact surfaces, it is significantly hard to fabricate both the contact surfaces such that they are parallel with each other and, also, are straight. Thus, a small gap may be induced therebetween, and electric fields may be concentrated at these gaps. However, according to the fifteenth invention, the rail portion and the gridiron are structured such that they come in point-to-point contact with each other, which prevents concentrations of electric fields between the rail portion and the gridiron, thereby suppressing abnormal heat generation. This can provide a heating apparatus with higher efficiency which induces less energy losses.

[0027] Hereinafter, preferred embodiments of a microwave heating device according to the present invention will be described, with reference to the accompanying drawings. Further, while, as the microwave heating devices according to the following embodiments, microwave ovens having oven functions will be described as heating cookers, these microwave ovens are merely illustrative, and the microwave heating devices according to the present invention are not limited to such microwave ovens and also include various types of heating apparatuses which utilize induction heating. In the following embodiments, the structures of heating cookers will be described in detail, but the present invention is not limited to the structures according to the embodiments and also includes structures based on technical concepts similar thereto.

(First Embodiment)

[0028] Fig. 1 is a front cross-sectional view illustrating a microwave oven having oven functions, as a heating cooker which is a microwave heating device according to a first embodiment of the present invention.

[0029] The microwave oven having the oven functions, as the heating cooker according to the first embodiment, includes, in its front surface, an openable door (not illustrated) for introducing and removing an object to be heated thereinto and therefrom and, further, includes a heating chamber 1 for performing microwave heating on the object 5 to be heated, which has been housed and enclosed therein through the door.

[0030] In the heating cooker according to the first embodiment illustrated in Fig. 1, the heating chamber 1 for housing a food as an object 5 to be heated and for heating it is constituted by steel plates having surfaces coated with a porcelain enamel. Within the heating chamber 1, an upper heater 2 and a lower heater 3 are provided. In the heating space between the upper heater 2 and the lower heater 3, a gridiron 4 is provided such that it can be introduced into and removed from the heating chamber 1, wherein the gridiron 4 is constituted by stainless-steel rod members combined with one another through welding. Further, a plurality of rails 12 and 13 are provided on the opposite side wall surfaces of the heating chamber 1, in order to enable placing the gridiron 4 at a plurality of positions in the upward and downward directions within the heating chamber 1. In an oven heating mode, a food as an object 5 to be heated is placed on the gridiron 4 housed within the heating chamber 1 and is sandwiched between the upper heater 2 and the lower heater 3 to be

heated thereby. In this oven heating mode, between the gridiron 4 and the lower heater 3, it is also possible to provide a receiving plate for receiving juices exuded from the object 5 to be heated, during the roasting.

[0031] The heating chamber 1 is structured such that the corners of the inner wall surfaces have curved surfaces with R, and the bottom surface of the heating chamber 1 is formed to have a larger arc shape (in Fig. 1, the curved-surface structure in the bottom surface is not illustrated). Further, although the first embodiment has been described with respect to an example where the wall surfaces of the heating chamber 1 are coated with a porcelain enamel, other heat-resistant coatings may be also applied thereto.

[0032] Further, as the material of the wall surfaces of the heating chamber 1, it is possible to employ stainless steels or PCM steel plates. The gridiron 4 can be constituted by plated steel members and the like.

[0033] In the heating cooker according to the first embodiment, a magnetron 6 as a microwave generating portion is provided above the right side of the heating chamber 1, such that it generates outputs in the horizontal direction. Microwaves generated from the magnetron 6 are propagated through a waveguide 14 and, further, are radiated within the heating chamber 1 through a rotational antenna 11 coupled to the waveguide 14. The microwave heating device according to the first embodiment is adapted to perform heating operations, through microwave heating and through at least one of radiant heating and convection heating with the upper heater 2 and the lower heater 3, for performing heating processes on the food as the object 5 to be heated. In the first embodiment, the microwave generating portion includes the antenna 11 and the waveguide 14 in addition to the magnetron 6 and, thus, includes means for generating microwaves and supplying the generated microwaves to the heating chamber 1.

[0034] The upper heater 2 is provided with an upper-heater thermocouple 7 as an upper-heater temperature detection portion, such that it is in contact with the surface of the upper heater 2. The upper-heater thermocouple 7 is covered with a metal tube, in order not to be influenced by microwaves from the magnetron 6. This enables detection of the heater temperature of the upper heater 2 with higher accuracy.

[0035] Further, the lower heater 3 is provided with a lower- heater thermocouple 8 as a lower- heater temperature detection portion, such that it is in contact with the surface of the lower heater 3. To a wall surface of the heating chamber 1, a thermistor 9 as means for detecting the temperature within the heating chamber 1 is secured. The upper- heater thermocouple 7, the lower- heater thermocouple 8 and the thermistor 9 are electrically connected to a control portion 10. The control portion 10 controls the supply of electricity to the upper heater 2 and the lower heater 3, based on respective outputs from the upper- heater thermocouple 7, the lower- heater thermocouple 8 and the thermistor 9. The heating cooker according to the first embodiment is structured to be capable of control for increasing and decreasing the amount of heating, in the oven heating mode.

[0036] In Fig. 1, the magnetron 6 has an output portion which is protruded in the horizontal direction and is coupled to an end portion of the waveguide 14. The waveguide 14 includes a vertical portion including the end portion to which the output portion of the magnetron 6 is coupled, and a horizontal portion extending in the horizontal direction and, thus, is provided with an internal path having an L shape. The waveguide 14 is provided with the rotational antenna 11 as a radio-wave stirring means, near the center of the heating chamber 1 in the horizontal direction. The rotational antenna 11 has a shaft portion 11B which is mechanically coupled to the rotational shaft of a motor 18, so that an antenna portion 11A provided on an end portion of the shaft portion 11B is rotated through the shaft portion 11B of the rotational antenna 11 by driving the motor 18. Further, the waveguide 14 is provided with a feeding port 17, and a dome 15 with a conical shape is provided in such a way as to surround the feeding port 17. The shaft portion 11B of the rotational antenna 11 penetrates through the feeding portion 17 in the waveguide 14, and the antenna portion 11A is placed within the dome 15.

[0037] As described above, the rotational antenna 11 is constituted by the antenna portion 11A and the shaft portion 11B, wherein the antenna portion 11A is formed, from a metal plate with a thickness of 1 mm, to have a substantially-disk shape with a diameter of about ϕ 62. Further, the shaft portion 11B is secured to the antenna portion 11A, at a position deviated from the center of the disk by about 12 mm.

[0038] The shaft portion 11B has a portion formed from a fluorocarbon resin, which is closer to the motor 18, and, further, has a portion formed from a metal, which is closer to the antenna portion 11A. In the first embodiment, the metal portion of the shaft portion 11B, which is closer to the antenna portion 11A, penetrates through the feeding portion 17 in the dome 15 into the waveguide 14 by about 11 mm and, further, protrudes toward the heating chamber 1 by about 15 mm, and this protruding end portion is provided with the antenna portion 11A. There is secured a gap of 5 mm or more, between the shaft portion 11B and the feeding portion 17.

[0039] Further, the heating cooker according to the first embodiment has been described with respect to an example where the magnetron 6, the rotational antenna 11, the waveguide 14, the dome 15 and the feeding portion 17 are provided above the heating chamber 1. However, the present invention is not limited to this structure and, for example, they can be provided near the bottom surface of the heating chamber 1 or near the side surfaces thereof. Further, the waveguide 14 and the like can be installed in any orientations.

[0040] The heating cooker according to the first embodiment is provided with a cover 16 made of a mica, at the lower end portion of the dome 15, in order to prevent

contaminations from the object 5 to be heated from adhering to the rotational antenna 11. The cover 16 is formed such that it can be attached to and detached from a hook 19 made of an insulating material, which is secured to the heating chamber 1.

[0041] In the heating cooker according to the first embodiment, the upper heater 2 is placed such that it evades the position beneath the lower opening portion in the dome 15, in order that the upper heater 2 is not directly influenced by microwaves.

Further, although the structure according to the first embodiment has been described with respect to an example where the cover 16 is formed from a mica, which is a low loss dielectric material, it can be similarly formed from ceramics or glasses.

[0042] Fig. 2 is a plan view illustrating the gridiron 4 in the heating cooker as the microwave heating device according to the first embodiment of the present invention. In Fig. 2, the lower side corresponds to the user side (the door side) of the heating cooker, while the upper side corresponds to the rear-surface side. Further, Fig. 2 illustrates an example of standing waves SW induced within the heating chamber 1, in a contour-line manner, wherein areas hatched in a dark color represent areas in which the standing waves have larger amplitudes (areas in which there are larger electric fields : MA).

[0043] Referring to Fig. 2, the gridiron 4 is constituted by an outer frame 21 formed from a rod member with a diameter of ϕ6 which is made of a metal, and a plurality of bridge members 20 (20A, 20B) formed from rod members with a diameter of ϕ3 which are made of a metal. As illustrated in Fig. 2, in the gridiron 4, insulating members 22 are secured to the left and right opposite side portions (21B) of the outer frame 21. Further, two bridge members 20A are provided in parallel with the front and rear opposite side portions (21A) of the outer frame 21, in such a way as to form bridges between the left and right opposite side portions (21B) of the outer frame 21. Further, twelve bridge members 20B are bonded, through welding, to the two bridge members 20A in such a way as to orthogonally form bridges therebetween, at predetermined intervals which will be described later.

[0044] The intervals between the left and right opposite side portions (21B) of the outer frame 21 and the respective bridge members 20B at the opposite ends are set to be equal to or more than about 3/8 the wavelength λ of standing waves SW. Further, as illustrated in Fig. 2, the twelve bridge members 20B are placed in such a way as to interpose a larger interval (a first interval : A) between each three bridge members 20B and the other three bridge members 20B adjacent thereto. Further, the intervals between the respective three bridge members are set to be second intervals B. In the structure according to the first embodiment, the first intervals A are placed in such a way as to sandwich, therebetween, the vicinities of antinodes MA at which standing waves SW have larger amplitudes and there are 80 % or more of a largest electric field and, further, the first intervals A are set to be about 1/4 the wavelength λ of standing waves SW. Further, the second intervals B, which are the smaller intervals between the bridge members 20B, are set to be about 1/8 the wavelength λ of standing waves SW.

[0045] In this case, standing waves are wave motions induced inside the heating chamber and are, basically, induced by superimposition of waves radiated from the antenna and waves reflected by the inner wall surfaces of the heating chamber. Such standing waves are wave motions which hardly involve waveform progressions and seem to vibrate while staying at the current positions. Accordingly, such standing waves are induced in a state which is determined to some degree by the structure of the heating chamber, the structure of the antenna and the like.

[0046] Further, the heating cooker according to the first embodiment is structured such that, in the heating space in the heating chamber 1, the bridge members 20B are at different intervals (the first intervals A and the second intervals B), in the areas which sandwich the vicinities of antinodes MA of standing waves and in the other areas, as described above. However, in the present invention, it is necessary only that the bridge members 20B are placed in areas which evade the vicinities of antinodes MA of standing waves SW which are induced within the heating chamber 1. Provided that this condition is satisfied, the bridge members 20B can be also at even intervals, which can also offer the same effects.

[0047] Further, the wavelength of standing waves SW is changed depending on the shape of the internal space within the heating chamber 1. In the structure according to the first embodiment, the wavelength of standing waves SW in the leftward and rightward direction in the heating chamber 1 is about 14 cm. Accordingly, 3/8 the wavelength λ of standing waves is about 5.3 cm, 1/4 λ is about 3.5 cm, and 1/8 λ is about 1.8 cm.

[0048] Further, standing waves SW which are induced within the heating chamber 1 are also changed by the food as the object 5 to be heated, which is being placed on the gridiron 4, as well as by the structure of the inner surfaces of the heating chamber 1. However, in outer peripheral areas of the gridiron 4, the positions at which the vicinities of antinodes MA of standing waves SW are induced are not largely changed.

[0049] Fig. 3 is a schematic cross-sectional view of the gridiron 4 illustrated in Fig. 2, taken along the line III-III, schernatically illustrating a standing wave SW which is induced within the heating chamber 1.

[0050] As illustrated in Fig. 3, within the heating chamber 1, microwaves radiated from the antenna and microwaves reflected within the heating chamber 1 are superimposed on each other, thereby inducing a standing wave SW which seems to vibrate while staying at the current position without involving progressions of the waveform. Accordingly, within the heating chamber 1, there is formed a standing wave SW having node positions and antinode positions, wherein, at the node positions, its amplitude is zero since electric fields are super-

imposed on each other and, thus, are hardly vibrated, while, at the antinode positions, its amplitude is largely changed.

[0051] As illustrated in Fig. 2 and Fig. 3, in the heating cooker according to the first embodiment, four bridge members 20B, out of the bridge members 20B in the gridiron 4, are placed in the vicinities of nodes of standing waves SW. Further, the insulating members 22 constituted by insulators are secured to the outer frame 21 in such a way as to pinch the outer frame 21 therein and, further, these insulating members 22 are adapted to be slidable on the plurality of rails 12 (12A and 12B) secured to the heating chamber 1. Accordingly, the insulating members 22 electrically insulate the rails 12 and the outer frame 21 in the gridiron 4 from each other and, also, electrically insulate the outer frame 21 and the heating chamber 1 from each other.

[0052] Further, while, as the standing wave SW illustrated in Fig. 3, there is illustrated a standing wave SW having five antinodes and six nodes, the numbers of antinodes and nodes in the standing wave SW and the intervals therebetween are varied, depending on various conditions in the heating chamber and the like. Accordingly, the structure of the gridiron 4 should be properly changed, according to the specifications of the heating cooker.

[0053] Although the first embodiment has been described with respect to an example where insulators are employed as the materials of the insulating members 22, it is also possible to employ glasses, plastics and other materials, provided that they form insulating members.

[0054] Further, in this case, the term "the wavelength λ of a standing wave" refers to the periodic length including two antinodes and two nodes, and the periodic length including a single antinode and a single node corresponds to 1 / 2 the wavelength.

[0055] Fig. 4 is a main-part cross-sectional view of structures, such as the gridiron 4 and the like, within the heating chamber 1, taken along the line IV-IV in Fig. 2. In Fig. 4, the left side corresponds to the front-surface side provided with the door, while the right side corresponds to the rear-surface side of the heating chamber 1. As illustrated in Fig. 4, the outer frame 21 in the gridiron 4 is placed such that it is sandwiched, upwardly and downwardly, between the lower rails 12 (12A and 12B) and the upper rail 13. Since the gridiron 4 is sandwiched between the upper and lower rails 12 and 13 as described above, the gridiron 4 is prevented from being inclined halfway through being pulled outwardly from the heating chamber 1.

[0056] Next, there will be described the heating cooker having the aforementioned structure according to the first embodiment, with respect to operations and effects thereof.

[0057] In the heating cooker according to the first embodiment, if a user selects a microwave heating mode and, further, turns on a switch for starting heating operations, the magnetron 6 generates microwaves, and the microwaves from the magnetron 6 are propagated through the waveguide 14. The microwaves having propagated through the waveguide 14 are directed to the rotational antenna 11 and, further, are supplied to the inside of the heating chamber 1 while being stirred by the rotational antenna 11 which is being rotated by the motor 18.

[0058] Microwaves having been supplied to the inside of the heating chamber 1 are directed to the object 5 to be heated, such as a food, and the food absorbs microwaves, so that the food is heated by the microwaves.

[0059] On the other hand, in the heating cooker according to the first embodiment, if the user selects the oven heating mode and, further, turns on the switch for starting heating operations, the upper heater 2 and the lower heater 3 are supplied with electricity and, thus, are caused to generate heat. Since the upper heater 2 and the lower heater 3 generate heat, radiant heat from the upper heater 2 and the lower heater 3 is transmitted to the food within the heating chamber 1, so that this food is heated in an oven manner.

[0060] As described above, in the heating cooker according to the first embodiment, the gridiron 4 for placing the object 5 to be heated thereon for performing heating cooking thereon, which is placed within the heating chamber 1, is formed to have a shape, in consideration of standing waves SW which are induced within the heating chamber 1. More specifically, the gridiron 4 is formed to be opened in the vicinities of antinodes of standing waves SW which are induced within the heating chamber 1 and, thus, the outer frame 21 and the bridge members 20 in the gridiron 4 are provided in areas outside the vicinities of antinodes MA of standing waves SW induced within the heating chamber 1, in such a way as to evade the vicinities of antinodes MA. As a result thereof, in the heating cooker according to the first embodiment, the outer frame 21 and the bridge members 20 in the gridiron 4 are not provided in areas in which there are larger electric fields in the microwave heating mode, which prevents abnormally-larger electric currents from flowing through the gridiron 4 in the microwave heating mode, thereby largely suppressing heat generation from the gridiron 4. This can provide a heating cooker with higher efficiency which induces less energy losses.

[0061] Further, in the heating cooker according to the first embodiment, most of the bridge members 20B are placed near nodes of standing waves SW which are induced within the heating chamber 1. Accordingly, larger electric currents are not flowed through the bridge members 20B provided near the nodes, which causes these bridge members 20B to generate less heat in the microwave heating mode. This can realize higher efficiency in the entire heating cooker.

[0062] In the heating cooker according to the first embodiment, the bridge members 20A and 20B are spaced apart from the inner wall surfaces of the heating chamber 1, by lengths equal to or more than 3/8 the wavelength λ of standing waves SW. With this structure, the bridge members 20A and 20B are not placed in the areas at a

distance equal to 1/4 the wavelength λ of standing waves SW from the inner wall surfaces of the heating chamber 1, which are coincident with the positions of antinodes of standing waves SW induced within the heating chamber 1. Therefore, in the microwave heating mode, it is possible to suppress heat generation from the gridiron 4, thereby realizing higher efficiency.

[0063] As described above, in the heating cooker according to the first embodiment, the gridiron 4 has the insulating structure having the insulating members 22 provided between the outer frame 21 and the lower rails 12 and between the outer frame 21 and the heating chamber 1. If the gridiron 4 were not insulated, this would cause concentration of electric fields in smaller gaps, thereby inducing abnormal heat generation therefrom. However, in the heating cooker according to the first embodiment, the gridiron 4 has the insulating structure, which can certainly provide insulation between the rails 12 and the gridiron 4 and between the heating chamber 1 and the rails 12, thereby suppressing electric-field concentrations and suppressing heat generation. This can realize higher efficiency.

[0064] Further, although the heating cooker according to the first embodiment has been described with respect to an example where there is an insulating structure between the gridiron 4 and the side walls of the heating chamber 1, it is also possible to provide an insulating structure between the gridiron 4 and the rear- surface wall of the heating chamber 1, which can further suppress heat generation from the gridiron 4.

[0065] As described above, as described with respect to the heating cooker according to the first embodiment, the microwave heating device according to the present invention can suppress abnormal heat generation from the grid member and the like which are placed within the heating chamber. This can provide a heating apparatus with higher efficiency which induces less energy losses.

(Second Embodiment)

[0066] As described with respect to the gridiron 102 in the conventional microwave heating device with reference to the aforementioned Fig. 13, the conventional gridiron 102 is constituted by the plurality of metal rod-shaped members 104 which are densely placed. Accordingly, as illustrated in Fig. 13, the conventional gridiron 102 is structured such that the plurality of rod-shaped members 104 are exposed within the heating chamber, at their protruding end surfaces 104a and 104b. Therefore, in the microwave heating mode, electric fields are concentrated in the protruding end surfaces 104a and 104b of the rod-shaped members 104, which induces heat generation, thereby inducing significant energy losses therein. This has caused degradations of the heating efficiency of the heating cooker.

[0067] Also, it is possible to contrive to form a gridiron from a punched metal steel plate, in order to prevent formation of protruding end surfaces in the gridiron. However, in this structure, electric fields are liable to be concentrated at edge portions of holes formed by the punching. This causes the problem that these edge portions generate heat, thereby inducing energy losses.

[0068] A microwave heating device according to the second embodiment of the present invention is a heating apparatus with higher heating efficiency which includes a gridiron 4 formed in consideration of standing waves SW induced within the heating chamber 1 as described in the aforementioned first embodiment and, further, alleviates concentrations of electric fields in the gridiron 4, thereby further reducing energy losses.

[0069] Hereinafter, there will be described a heating cooker as a microwave heating device according to the second embodiment of the present invention, with reference to the accompanying drawings. Further, although the heating cooker according to the second embodiment will be described hereinafter with respect to a microwave oven having oven functions, the microwave oven is merely illustrative, and the microwave heating device according to the present invention is not limited to such a microwave oven and also includes heating apparatuses which utilize induction heating.

[0070] In the following description about the heating cooker according to the second embodiment, there will be described differences thereof from the structure of the heating cooker according to the first embodiment illustrated in Fig. 1, while components having the same functions and structures as those of the components in the heating cooker according to the first embodiment will be designated by the same reference characters, and the description about the first embodiment is substituted for detailed descriptions thereof.

[0071] The heating cooker as the microwave heating device according to the second embodiment is different from the structure according to the first embodiment, in terms of the shape and the structure of the gridiron 4, but the other structures are the same as those of the heating cooker according to the first embodiment. Accordingly, the second embodiment will be described with respect to the shape and the structure of the gridiron 4.

[0072] Figs. 5 to 8 illustrate plan views of four types of gridirons (4A, 4B, 4C and 4D) for use in the heating cooker according to the second embodiment of the present invention.

[0073] The gridiron 4A illustrated in Fig. 5 is constituted by an outer frame 21 with a substantially-rectangular shape, and a plurality of bridge members 200A formed to have an annular elongated track shape. As illustrated in Fig. 5, the plurality of bridge members 200A are placed in parallel with each other and, further, are provided in such a way as to form bridges between the opposite longer side portions of the outer frame 21 having the substantially-rectangular shape. In the gridiron 4A illustrated in Fig. 5, the bridge members 200A are placed such that the straight-line portions in their longitudinal portions extend up to the outside of the outer frame 21 and, further, the bridge members 200A are adapted such that their

arc portions at the opposite ends are not intersected with the outer frame 21.

[0074] The gridiron 4A illustrated in Fig. 5 is constituted by the outer frame 21 formed from a metal rod member with a diameter of ϕ6, and the bridge members 200A formed from metal rod members with a diameter of ϕ3. The five bridge members 200A provided in such a way as to form bridges between the opposite longer side portions of the outer frame 21 are formed to have an annular elongated track shape (a substantially track elliptical shape), the straight-line portions of the bridge members 200A extend up to the outside of the outer frame 21, and the arc portions of the bridge members 200A at the opposite ends are placed outside the outer frame 21.

[0075] The gridiron 4B illustrated in Fig. 6 is constituted by an outer frame 21 with a substantially-rectangular shape, and a plurality of bridge members 200B formed to have an annular elongated track shape. As illustrated in Fig. 6, the plurality of bridge members 200B are placed in parallel with each other and, further, are bonded to the opposite longer side portions of the outer frame 21 having the substantially-rectangular shape. The gridiron 4B illustrated in Fig. 6 is adapted such that the respective bridge members 200B are in contact with the inner side of the outer frame 21. Namely, in the gridiron 4B illustrated in Fig. 6, the respective bridge members 200B having the annular elongated track shape are bonded to the outer frame 21, such that each of their arc portions at the opposite end portions is in contact with the inner side of the outer frame 21 at a single point on its outer periphery.

[0076] The gridiron 4B illustrated in Fig. 6 is constituted by the outer frame 21 formed from a metal rod member with a diameter of ϕ6, and the bridge members 200B formed from metal rod members with a diameter of ϕ3. The five bridge members 200B provided in such a way as to form bridges between the opposite longer side portions of the outer frame 21 are formed to have an annular elongated track shape (a substantially track elliptical shape), and the bridge members 200B are bonded to the outer frame 21 such that their arc shaped portions are in contact with the inner side of the outer frame 21.

[0077] The gridiron 4C illustrated in Fig. 7 is constituted by an outer frame 21 with a substantially-rectangular shape, and a bridge member 200C formed to have a turned-back meandering shape. The straight-line portions of the bridge member 200C extend up to the outside of the outer frame 21, and the bridge member 200C is structured such that its arc portions at the opposite end portions are not intersected with the outer frame 21.

[0078] The gridiron 4C illustrated in Fig. 7 is constituted by the outer frame 21 formed from a metal rod member with a diameter of ϕ6, and the bridge member 200C formed from a metal rod member with a diameter of ϕ3. In the gridiron 4C illustrated in Fig. 7, the bridge member 200C in a turned-back meandering shape is bonded to the outer frame 21, the straight-line portions of the bridge member 200C extend up to the outside of the outer frame 21, and the arc portions of the bridge member 200C are placed outside the outer frame 21. In this case, the opposite end portions of the bridge member 200C having the turned-back meandering shape are bonded to the outer frame 21 and, preferably, are bonded to the inner side of the outer frame 21.

[0079] The gridiron 4D illustrated in Fig. 8 is constituted by an outer frame 21 with a substantially-rectangular shape, and a bridge member 200D formed to have a turned-back meandering shape. As illustrated in Fig. 8, the bridge member 200D is bonded, at their arc portions, in a butting manner, to the outer frame 21, and the arc portions of the bridge member 200D are bonded to the outer frame 21 such that their outer peripheries are in contact with the inner surface of the outer frame 21.

[0080] The gridiron 4D illustrated in Fig. 8 is constituted by the outer frame 21 formed from a metal rod member with a diameter of ϕ6, and the bridge member 200D formed from a metal rod member with a diameter of ϕ3. In the gridiron 4D illustrated in Fig. 8, the bridge member 200D is provided in a turned-back meandering shape inside the outer frame 21, and the arc portions of the bridge member 200D are bonded to the inner side of the outer frame 21, in a butting manner. Further, the bridge member 200D having the turned-back meandering shape is bonded at their opposite end portions to the inner side of the outer frame 21.

[0081] As described above, in the heating cooker according to the second embodiment, based on standing waves λ which are induced within the heating chamber 1, the intervals between the rod-shaped members in the bridge members 200A to 200D in the gridirons 4A to 4D are set to have lengths equal to or more than about 1/4 the wavelength λ of standing waves. Further, in the structure according to the second embodiment, the numbers of the rod-shaped members in the gridirons 4 are properly changed, according to the size of the heating chamber 1, and the object to be heated, which is placed thereon.

[0082] Fig. 9 is a main-part cross-sectional view of the heating cooker according to the second embodiment, when viewed at a side surface thereof. Fig. 9 illustrates a case where the gridiron 4B illustrated in Fig. 6 is employed. In Fig. 9, the left side corresponds to the front-surface side provided with the door, while the right side corresponds to the rear-surface side of the heating chamber 1.

[0083] As illustrated in Fig. 9, the outer frame 21 in the gridiron 4 (4A to 4D) is placed such that it is sandwiched, upwardly and downwardly, between lower rails 12 and an upper rail 13. The upper rail 13 prevents the gridiron 4 from being inclined halfway through being pulled outwardly from the heating chamber 1. Further, the gridiron 4 is provided, on its lower side, with hemispherical portions 23 which come in point-to-point contact with the rails 12, at two positions in each single side and, thus, at four positions in the left and right sides.

[0084] Next, there will be described the heating cooker having the aforementioned structure according to the second embodiment, with respect to operations and ef-

fects thereof.

[0085] In the heating cooker according to the second embodiment, if a user selects a microwave heating mode and, further, turns on a switch for starting heating operations, a magnetron 6 generates microwaves, and the microwaves from the magnetron 6 are propagated through a waveguide 14. The microwaves having propagated through the waveguide 14 are directed to a rotational antenna 11 and, further, are supplied to the inside of the heating chamber 1 while being stirred by the rotational antenna 11 being rotated by a motor 18.

[0086] Microwaves having been supplied to the inside of the heating chamber 1 are directed to the object 5 to be heated, such as a food, and the food absorbs microwaves, so that the food is heated by the microwaves.

[0087] On the other hand, in the heating cooker according to the second embodiment, if the user selects the oven heating mode and, further, turns on the switch for starting heating operations, an upper heater 2 and a lower heater 3 are supplied with electricity and, thus, are caused to generate heat. Since the upper heater 2 and the lower heater 3 generate heat, radiant heat from the upper heater 2 and the lower heater 3 are transmitted to the food within the heating chamber 1, so that this food is heated in an oven manner.

[0088] As described above, in the microwave heating mode, in cases where the metal rod-shaped members in the gridiron are exposed at their end surfaces having acuteness, electric fields are concentrated at these portions to generate heat, thereby inducing significant energy losses. In the heating cooker according to the second embodiment, the gridiron 4 is structured to have no protruding end surface with acuteness, and the gridiron 4 is constituted by the members having the annular elongated shape or the turned-back meandering shape, which largely restricts portions of the gridiron 4 which cause concentrations of electric fields therein. As a result thereof, the heating cooker according to the second embodiment forms a heating cooker with higher efficiency which is capable of suppressing heat generation from the gridiron 4, thereby inducing less energy losses.

[0089] Further, in the structure according to the second embodiment, in cases where the bridge portions 200B and 200D are structured such that their arc portions are in contact with the outer frame 21, as illustrated in Fig. 6 and Fig. 8, there is no gap formed by the intersection of the bridge members 200B and 200D and the outer frame 21. Therefore, the heating cookers having the structures illustrated in Fig. 6 and Fig. 8 are adapted to alleviate concentrations of electric fields, which can further reduce energy losses. Therefore, these heating cookers form heating cookers with higher heating efficiency.

[0090] Further, in the structure according to the second embodiment, as illustrated in Fig. 8, the bridge member 200D is formed to have a turned- back meandering shape, the arc portions of the bridge member 200D are bonded to the inner side of the outer frame 21 in a butting manner, and the arc portions of the bridge member 200D are bonded, at their outer peripheries, to the inner periphery of the outer frame 21 such that they are in contact with each other. Therefore, with the heating cooker having the structure illustrated in Fig. 8, the gridiron 4 can be formed to have a smaller thickness and, further, the gridiron 4 is formed to have opposite surfaces which are capable of placing objects 5 to be heated thereon and have less level differences therein, thereby offering the advantage of ease of cleaning.

[0091] In the structure according to the second embodiment, in cases where the bridge portions 200A and 200C are structured such that their straight-line portions extend up to the outside of the outer frame 21 as illustrated in Fig. 5 and Fig. 7, there are larger gaps between the outer frame 21 and the arc portions of the bridge portions 200A and 200C, which makes it easier to clean them when dirt has been accumulated in these gaps. This facilitates maintenance.

[0092] Further, although, in the structure according to the second embodiment, the bridge members 200A to 200D are placed such that their longitudinal directions are coincident with the forward and rearward direction of the heating chamber 1, the bridge members 200A to 200D can be also placed such that their longitudinal directions are coincident with any directions, such as the leftward and rightward direction of the heating chamber 1, oblique directions of the heating chamber 1, and the like, which can also offer the same effects.

[0093] Further, in the structure according to the second embodiment, the intervals between the rod- shaped members in the bridge members 20 in the gridiron 4 are set to be equal to or more than $1/4\lambda$, microwaves are caused to come around to below the gridiron 4, and the object 5 to be heated is caused to absorb microwaves from therebelow, so that the heating cooker according to the second embodiment is adapted to realize higher efficiency.

[0094] As described above, in the structure according to the second embodiment, the gridiron 4 is provided with the hemispherical portions 23 such that they can slide on the lower rails 12. In cases where no hemispherical portion is provided thereon, the outer frame 21 and the rails 12 are brought into line-to-line contact with each other. In view of processes, it is significantly hard to fabricate the outer frames 21 and the rails 12 such that their left and right contact surfaces are all parallel with each other and, also, have completely-straight shapes. Accordingly, in actual, these contact surfaces are bent and, therefore, are brought into contact with each other with slight gaps interposed therebetween, rather than being brought into line-to-line contact with each other. As a result thereof, electric fields are liable to be concentrated at the slight gaps induced between the contact surfaces of the outer frame 21 and the rails 12, thereby causing significant energy losses.

[0095] In the structure according to the second embodiment, the gridiron 4 is provided with the hemispherical portions 23, so that the hemispherical portions 23 in the

gridiron 4 come in contact with the lower rails 12 at two positions in each single side and, thus, come in point-to-point contact therewith at four positions, in total, in the left and right sides. Therefore, the outer frame 21 in the gridiron 4 is placed in such a way as to interpose a larger gap between it and the rails 12, over its portions other than the portions which come in point-to-point contact with the rails 12. Accordingly, in the structure according to the second embodiment, there is a larger gap between the gridiron 4 and the rails 12 over their entirety, which prevents concentrations of electric fields between the gridiron 4 and the rails 12, thereby realizing higher efficiency.

[0096] Further, the structure according to the second embodiment has been described with respect to an example where the gridiron 4 is provided with the hemispherical portions 23 at two positions in each single side and, therefore, at four positions in the left and right sides. However, the present invention is not limited to this structure. It is possible to support the gridiron 4 at least at three positions, and it is also possible to increase the number of the hemispherical portions 23 for improving the balance of the gridiron 4 when objects 5 to be heated are placed thereon, which can also offer the same effects.

[0097] Further, although the structure according to the second embodiment has been described with respect to an example where the gridiron 4 is provided with the hemispherical portions 23, it is also possible to provide insulating members thereon, instead of the hemispherical portions 23, in order to prevent concentrations of electric fields. In this case, these insulating members can be provided on the roasting gird 4 in areas between it and the lower rails 12, and in areas near the wall surfaces of the heating chamber 1, which can prevent concentrations of electric fields, thereby increasing the heating efficiency.

[0098] Further, as illustrated in Fig. 9, in the structure according to the second embodiment, the upper rails 12 (12A and 12B) and the lower rail 13 are placed, such that they are staggered with respect to each other. Since the upper rails 12 (12A and 12B) and the lower rail 13 are placed such that they are staggered with respect to each other as described above, it is possible to prevent the occurrence of concentrations of electric fields between the rails, thereby realizing higher efficiency.

[0099] Further, in the structure according to the second embodiment, the wall surfaces of the heating chamber 1 are formed such that their corner portions have curved surfaces (R), and the bottom surface is formed to have a larger arc shape. Therefore, microwaves reflected by the wall surfaces of the heating chamber 1 are directed toward the object 5 to be heated, so that the object 5 to be heated is liable to be irradiated with the reflected waves, which enables heating with higher efficiency.

[0100] As described above, as described with respect to the heating cooker according to the second embodiment, the microwave heating device according to the present invention is adapted such that the rod-shaped members in the gridiron are less exposed at their end surfaces within the heating chamber, which alleviates concentrations of electric fields, thereby reducing heat generation from the gridiron. This enables heating cooking with higher efficiency and with lower energy losses.

(Third Embodiment)

[0101] The structure of the heating cooker according to the aforementioned second embodiment has been described with respect to an example where the gridiron 4 is provided with the hemispherical portions 23, so that the gridiron 4 comes in point-to-point contact with the lower rails 12 (12A and 12B). A microwave heating device according to a third embodiment of the present invention is structured such that a gridiron 4 is provided with hemispherical portions and, also, is structured to alleviate the occurrence of concentrations of electric fields between the gridiron 4 and the heating chamber 1.

[0102] As described in the aforementioned second embodiment, in cases where there are not provided the hemispherical portion 23, the outer frame 21 in the gridiron 4 and the lower rails 12 are brought into line-to-line contact with each other. However, in view of processes, it is significantly hard to fabricate the outer frames 21 and the rails 12 such that their left and right contact surfaces are all parallel with each other and, also, have completely-straight shapes. Accordingly, the outer frame 21 and the rails 12 are brought into contact with each other with slight gaps interposed therebetween, rather than being brought into line-to-line contact with each other. As a result thereof, electric fields are liable to be concentrated at the slight gaps induced between these contact surfaces, thereby inducing significant energy losses. This results in the problem of degradations of the heating efficiency of the heating cooker.

[0103] Further, as described in the aforementioned first embodiment, it is a preferable measure to provide insulating members 22 (see Fig. 3) between the gridiron 4 and the rails 12, in order to prevent occurrences of electric discharges, between the outer frame 21 and the rails 12. However, the structure which provides the insulating members 22 has the problem that the number of members is increased, which involves an increase of fabrication processes, thereby increasing the cost of the apparatus. Furthermore, the gridiron 4 is caused to have an increased weight, which has caused the problem of an increase of the difficulty of handling thereof.

[0104] The microwave heating device according to the third embodiment of the present invention is made to overcome the aforementioned problems and, thus, forms a lower-cost and higher-efficiency heating apparatus which induces lower energy losses and, further, is easy to handle.

[0105] The heating cooker as the microwave heating device according to the third embodiment is different from the structure according to the first embodiment, in terms of the shape and the structure of a gridiron 4, but the other structures are the same as those of the heating

cooker according to the first embodiment. Accordingly, the third embodiment will be described, with respect to the shape and the structure of the gridiron 4.

[0106] In the following description about the heating cooker according to the third embodiment, components having the same functions and structures as those of the components of the heating cooker according to the first embodiment will be designated by the same reference characters, and the description about the first embodiment is substituted for detailed descriptions thereof.

[0107] Fig. 10 is a plan view illustrating the gridiron 4E in the heating cooker according to the third embodiment of the present invention.

[0108] The gridiron 4E illustrated in Fig. 10 is constituted by an outer frame 21 formed from a rod member with a diameter of ϕ6 which is made of a metal, and bridge members 20 formed from rod members with a diameter of ϕ3 which are made of a metal. The eight bridge members 20 are provided in such a way as to form bridges between the opposite longer side portions of the outer frame 21 with a substantially-rectangular shape.

[0109] Further, the outer frame 21 is provided with two protruding portions 21C with a U shape, such that they protrude toward the rear- surface wall 1A of the heating chamber 1. The two protruding portions 21C are provided in the outer frame 21 near the left and right end portions at positions faced to the rear- surface wall 1A of the heating chamber 1, wherein these protruding portions 21C have been formed by performing a bending process on the outer frame 21.

[0110] When the gridiron 4E having the aforementioned structure is mounted in the heating chamber 1 at a predetermined position (see Fig. 10), the two protruding portions 21C come in point-to-point contact with the rear-surface wall 1A of the heating chamber 1. At this time, the gap L between the rear-surface wall 1A of the heating chamber 1 and the portion of the outer frame 21 near the rear-surface wall 1A is set to be about 5 mm, except the portions of the protruding portions 21C.

[0111] In the heating cooker according to the third embodiment, based on standing waves λ which are induced within the heating chamber 1, the intervals between the rod-shaped members in the bridge members 20 in the gridiron 4E are set to have lengths equal to or more than about 1/4 the wavelength λ of standing waves. Further, in the structure according to the third embodiment, the number of the rod-shaped members in the gridiron 4 is properly changed, according to the size of the heating chamber 1, and the object to be heated, which is placed thereon.

[0112] Fig. 11 is a main-part cross-sectional view of the heating cooker according to the third embodiment, when viewed at a side surface thereof. In Fig. 11, the left side corresponds to the front-surface side provided with the door, while the right side corresponds to the rear-surface side of the heating chamber 1.

[0113] Referring to Fig. 11, the outer frame 21 in the gridiron 4E is placed such that it is sandwiched, upwardly and downwardly, between lower rails 12 and an upper rail 13. The upper rail 13 prevents the gridiron 4E from being inclined halfway through being pulled outwardly from the heating chamber 1. Further, the outer frame 21 is provided, on its lower side, with hemispherical portions 23 which come in point-to-point contact with the rails 12, at two positions in each single side and, thus, at four positions in the left and right sides.

[0114] As illustrated in Fig. 11, when the gridiron 4 is in a mounted state where the protruding portions 21C are in contact with the rear-surface wall 1A, after having been inserted in the heating chamber 1, there is formed a gap L between the rear-surface wall 1A of the heating chamber 1 and the portion of the outer frame 21 near the rear-surface wall 1A. In the heating cooker according to the third embodiment, the gap L is set to be about 5 mm, but it can be at least 3 mm or more, which can prevent concentrations of electric fields.

[0115] Next, there will be described the heating cooker having the aforementioned structure according to the third embodiment, with respect to operations and effects thereof.

[0116] In the heating cooker according to the third embodiment, if a user selects a microwave heating mode and, further, turns on a switch for starting heating operations, a magnetron 6 generates microwaves, and the microwaves from the magnetron 6 are propagated through a waveguide 14. The microwaves having propagated through the waveguide 14 are directed to a rotational antenna 11 and, further, are supplied to the inside of the heating chamber 1 while being stirred by the rotational antenna 11 being rotated by a motor 18.

[0117] Microwaves having been supplied to the inside of the heating chamber 1 are directed to the object 5 to be heated, such as a food, and the food absorbs microwaves, so that the food is heated by the microwaves.

[0118] On the other hand, in the heating cooker according to the third embodiment, if the user selects the oven heating mode and, further, turns on the switch for starting heating operations, the upper heater 2 and the lower heater 3 are supplied with electricity and, thus, are caused to generate heat. Since the upper heater 2 and the lower heater 3 generate heat, radiant heat from the upper heater 2 and the lower heater 3 are transmitted to the food within the heating chamber 1, so that this food is heated in an oven manner.

[0119] As described above, in the structure according to the third embodiment, the gridiron 4 is provided with the hemispherical portions 23 such that they can slide on the rails 12. In cases where there are not provided with the hemispherical portions, the outer frame 21 and the lower rails 12 are brought into line-to-line contact with each other. However, in view of processes, it is significantly hard to fabricate the outer frames 21 and the rails 12 such that their left and right contact surfaces are all parallel with each other and, also, have completely-straight shapes. Accordingly, in actual, these contact surfaces are bent and, therefore, are brought into contact

with each other with slight gaps interposed therebetween, rather than being brought into line-to-line contact with each other. As a result thereof, electric fields are liable to be concentrated at the slight gaps induced between the contact surfaces of the outer frame 21 and the rails 12, thereby inducing significant energy losses.

[0120] In the structure according to the third embodiment, the gridiron 4 is provided with the hemispherical portions 23, so that the hemispherical portions 23 in the gridiron 4 come in contact with the lower rails 12 at two points in each single side and, thus, come in point-to-point contact therewith at four points, in total, in the left and right sides. Therefore, the outer frame 21 in the gridiron 4 is placed in such a way as to interpose a larger gap between it and the rails 12, over its portion other than the portions which come in point-to-point contact with the rails 12. Accordingly, in the structure according to the third embodiment, there is formed a larger gap (of 5 mm or more) between the gridiron 4 and the rails 12, which prevents concentrations of electric fields between the gridiron 4 and the rails 12, thereby realizing higher efficiency.

[0121] Further, the structure according to the third embodiment has been described with respect to an example where the gridiron 4 is provided with the hemispherical portions 23 at two positions in each side and, therefore, at four positions in the left and right sides. However, the present invention is not limited to this structure. It is possible to support the gridiron 4 at least at three positions, and it is also possible to increase the number of the hemispherical portions 23 for improving the balance of the gridiron 4 when objects 5 to be heated are placed thereon, which can also offer the same effects.

[0122] Further, in the structure according to the third embodiment, the gridiron 4 is brought into point- to- point contact with the rails 12, which reduces the friction between the gridiron 4 and the rails 12, thereby offering the advantage that the gridiron 4 can be easily pulled out.

[0123] In the structure according to the third embodiment, the outer frame 21 is provided with the U-shaped protruding portions 21C, so that the gridiron 4 comes in point-to-point contact with the rear-surface wall 1A of the heating chamber 1, only at the protruding portions 21C. Therefore, the outer frame 21 is placed in such a way as to interpose a larger gap between it and the rear-surface wall 1C of the heating chamber 1, over its potion other than the protruding portions 21C. Accordingly, with the structure according to the third embodiment, it is possible to prevent concentrations of electric fields between the gridiron 4 and the heating chamber 1, thereby realizing higher efficiency.

[0124] In the structure according to the third embodiment, the protruding portions 21C formed in the outer frame 21 can be formed only by bending the outer frame 21 into a U shape. This facilitates the fabrication thereof, which can reduce the fabrication costs. Furthermore, the protruding portions 21C are formed integrally with the outer frame 21 and, therefore, cannot be separated from the outer frame 21. This can provide the gridiron 4 with higher reliability.

[0125] Further, the structure according to the third embodiment has been described with respect to an example where the gridiron 4 is provided with the U- shaped protruding portions 21 at two positions, it is also possible to increase the number of the protruding portions 21C, in order to prevent the gridiron 4 from being deformed when being strongly pressed against the rear- surface wall 1C. Further, the protruding portions 21C can have any shapes which can alleviate concentrations of electric fields and, thus, can be formed to have semicircular shapes, triangular shapes and the like, as well as U shapes, which can also offer the same effects.

[0126] Although the structure according to the third embodiment has been described with respect to an example where the gridiron 4 is provided with the protruding portions 21C, it is also possible to provide them on the rear-surface wall of the heating chamber 1. In the case of this structure, protrusions with a hemispherical shape can be formed on the rear-surface wall of the heating chamber 1 such that the outer frame 21 of the gridiron 4 comes in point-to-point contact with these protrusions. In the case of forming such protrusions on the rear-surface wall of the heating chamber 1, it is possible to form them at the same time as the fabrication of the heating chamber 1 through press forming, which facilitates the fabrication, thereby largely reducing the fabrication costs.

[0127] Although the structure according to the third embodiment has been described with respect to an example where the hemispherical portions 23 are formed from additional members, it is also possible to perform a bending process on the outer frame 21 in the gridiron 4 such that it is protruded downwardly in a U shape. In this case, it is possible to provide the same effects as those provided by provision of the hemispherical portions 23 and, furthermore, it is possible to simplify the structure, thereby reducing the fabrication costs.

[0128] The structure according to the third embodiment has been described with respect to an example where the gap between the outer frame 21 of the gridiron 4 and the rear-surface wall 1A of the heating chamber 1, and the gap between the outer frame 21 and the lower rails 12 are set to be about 5 mm, except the portions which are in point-to-point contact with each other. However, these gaps can be set to be only 3 mm or more, which can suppress concentrations of electric fields, thereby offering substantially the same effects.

[0129] Further, in the structure according to the third embodiment, the intervals between the rod- shaped members in the bridge members 20 in the gridiron 4 are set to be equal to or more than $1/4\lambda$, so that microwaves are caused to come around to below the gridiron 4 and, thus, the object 5 to be heated is caused to absorb microwaves from therebelow. Therefore, the heating cooker according to the third embodiment is structured to realize higher efficiency.

[0130] Further, as illustrated in Fig. 11, in the structure

according to the third embodiment, the upper rails 12 (12A and 12B) and the lower rail 13 are placed, such that they are staggered with respect to each other. Since the upper rails 12A and 12B and the lower rail 13 are placed such that they are staggered with respect to each other as described above, it is possible to prevent the occurrence of concentrations of electric fields between the rails, thereby realizing higher efficiency.

[0131] Further, in the structure according to the third embodiment, the wall surfaces of the heating chamber 1 are formed such that their corner portions have curved surfaces (R), and the bottom surface is formed to have a larger arc shape. Therefore, microwaves reflected by the wall surfaces of the heating chamber 1 are directed toward the object 5 to be heated, so that the object 5 to be heated is liable to be irradiated with the reflected waves, which enables heating with higher efficiency.

[0132] As described above, as described with respect to the heating cooker according to the third embodiment, the microwave heating device according to the present invention is capable of preventing the occurrence of concentrations of electric fields in slight gaps and, thus, forms a heating apparatus with higher efficiency which can suppress abnormal heat generation from the gridiron, thereby inducing less energy losses.

Industrial Applicability

[0133] As described above, the microwave heating device according to the present invention is capable of heating with higher efficiency and with less energy losses and, therefore, is applicable to microwave ovens, oven-type microwave ovens and electric ovens as cooking appliances which utilize microwave functions and, also, is applicable to commercial microwave heating devices of various types, such as, for example, heating apparatuses in industrial fields, such as thawing apparatuses and drying apparatuses, ceramic-art heating and sintering apparatuses, biochemical reaction apparatuses, and the like.

Reference Signs List

[0134]

1	Heating chamber
2	Upper heater
3	Lower heater
4	Gridiron
5	Object to be heated
6	Magnetron
10	Control portion
11	Rotational antenna
12	Lower rail
13	Upper rail
20	Bridge member
21	Outer frame
22	Insulating member
SW	Standing wave
MA	Vicinity of antinode of standing wave

Claims

1. A microwave heating device comprising:

a heating chamber adapted to heat an object to be heated;
a microwave generating portion adapted to supply a microwave to an inside of the heating chamber; and
a gridiron which is formed from a metal rod-shaped member and is adapted to place the object to be heated within the heating chamber;
wherein the gridiron comprises an outer frame secured to the inside of the heating chamber at a predetermined position, and bridge members secured to the outer frame, and
the outer frame and the bridge members are provided outside the vicinities of antinodes of a standing wave which is induced within the heating chamber, such that the gridiron is opened in the vicinities of the antinodes of the standing wave.

2. The microwave heating device according to Claim 1, wherein
the outer frame and at least one of the bridge members are provided in the vicinities of nodes of the standing wave.

3. The microwave heating device according to Claim 1 or 2, wherein
the bridge members are provided at positions spaced apart from an inner wall of the heating chamber, by a length equal to or more than 3/8 the wavelength of the standing wave.

4. The microwave heating device according to any one of Claims 1 to 3, wherein
within the heating chamber, there is provided a rail portion which enables the gridiron to be inserted in the inside of the heating chamber, and there is provided an insulating structure between the rail portion and the gridiron.

5. The microwave heating device according to Claim 1, wherein
the gridiron is structured such that a plurality of the bridge members are secured to the outer frame in parallel with each other, the bridge members adjacent to each other are formed from a single rod-shaped member, and end portions of the rod-shaped members are not protruded from the outer frame toward a side-surface wall of the heating chamber.

6. The microwave heating device according to Claim 5, wherein
the bridge members are formed from rod-shaped members having an annular shape.

7. The microwave heating device according to Claim 6, wherein
the annular shape of the bridge members forms an elongated track shape.

8. The microwave heating device according to Claim 5, wherein
the bridge members are formed to have a turned-back meandering shape.

9. The microwave heating device according to any one of Claims 5 to 8, wherein
the bridge members are secured to the outer frame, such that the bridge members are in contact with an inner periphery of the outer frame.

10. The microwave heating device according to any one of Claims 6 to 8, wherein
the bridge members are placed such that arc portions of the bridge members are protruded to an outside of the outer frame.

11. The microwave heating device according to Claim 1, wherein
the gridiron is adapted to come in point-to-point contact with the heating chamber.

12. The microwave heating device according to Claim 11, wherein
the outer frame is provided with a protruding portion, such that the gridiron comes in point-to-point contact with a rear-surface wall of the heating chamber.

13. The microwave heating device according to Claim 11, wherein
the rear-surface wall is provided with a protruding portion with a hemispherical shape, such that the gridiron comes in point-to-point contact with the rear-surface wall of the heating chamber.

14. The microwave heating device according to Claim 12, wherein
the protruding portion formed on the outer frame in the gridiron is formed by bending a portion of a rod-shaped member in a U shape.

15. The microwave heating device according to any one of Claims 11 to 14, wherein
within the heating chamber, there is provided a rail portion which enables the gridiron to be inserted in the inside of the heating chamber, and the rail portion and the gridiron are adapted to come in point-to-point contact with each other.

Fig.1

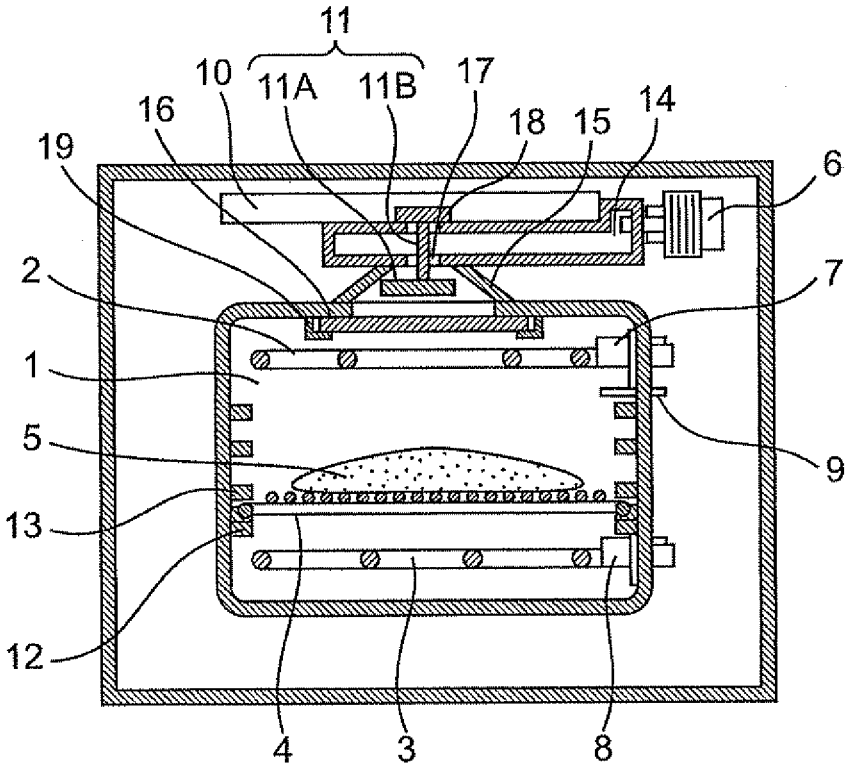
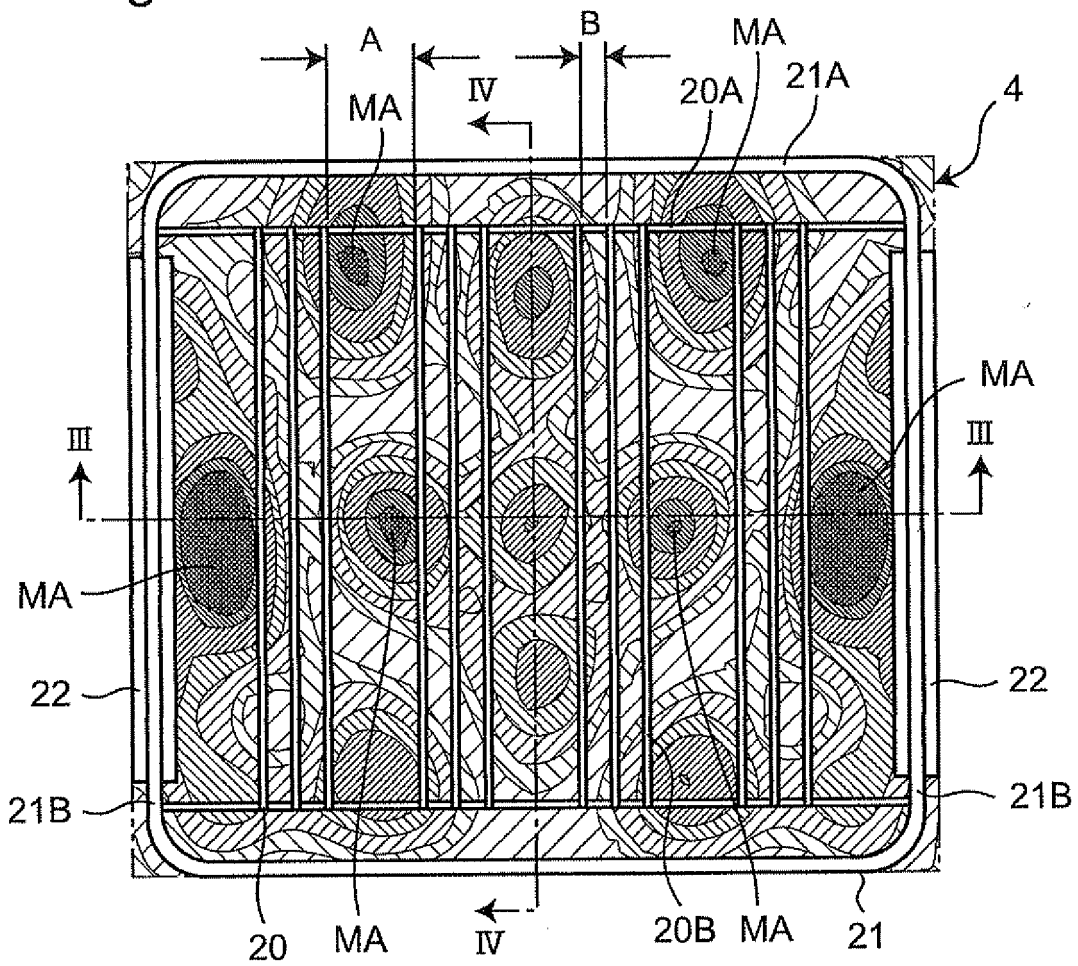


Fig.2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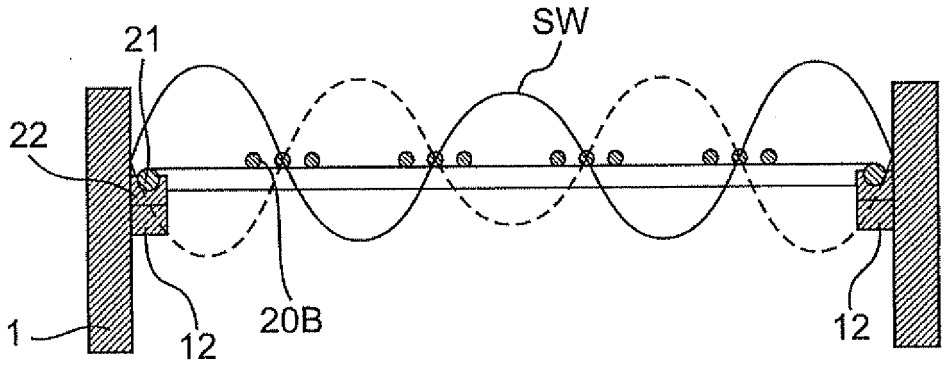
MA
21

Fig.3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12
20B
12

Fig.4

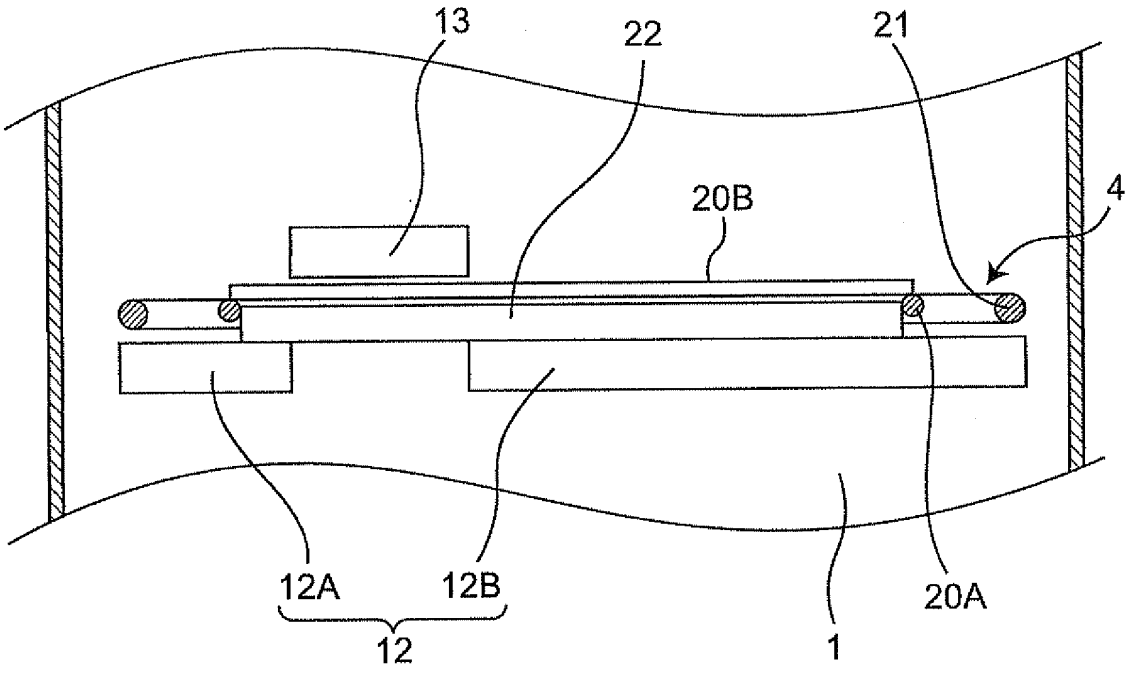


Fig.5

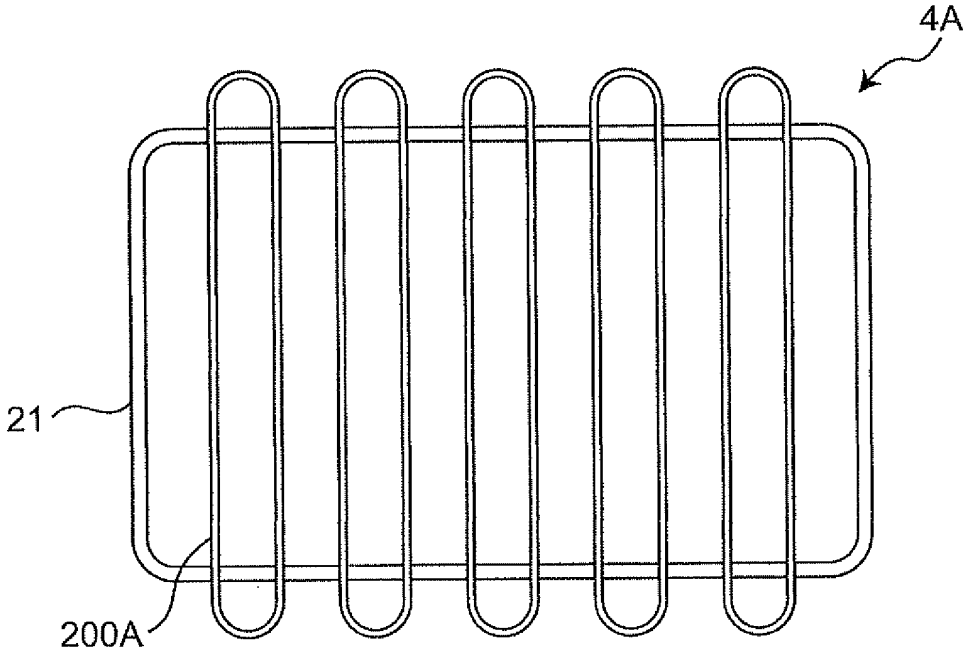
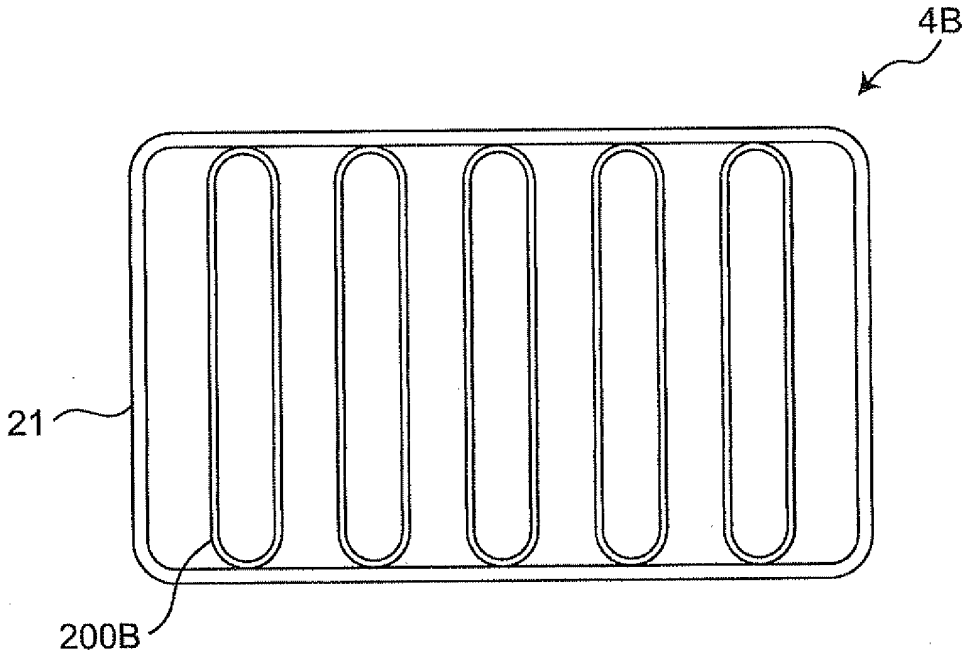


Fig.6



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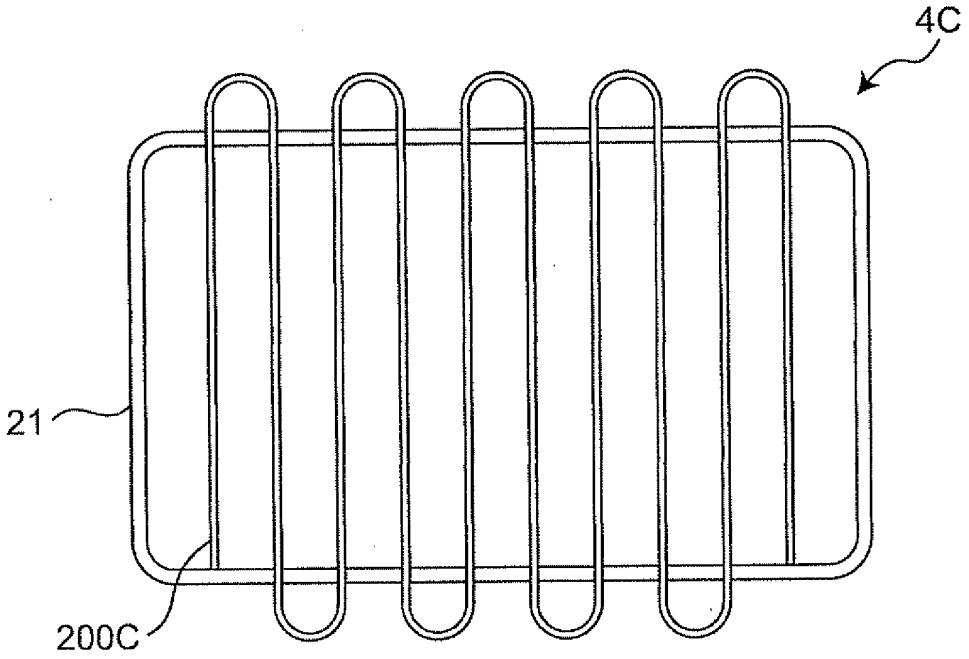


Fig.8

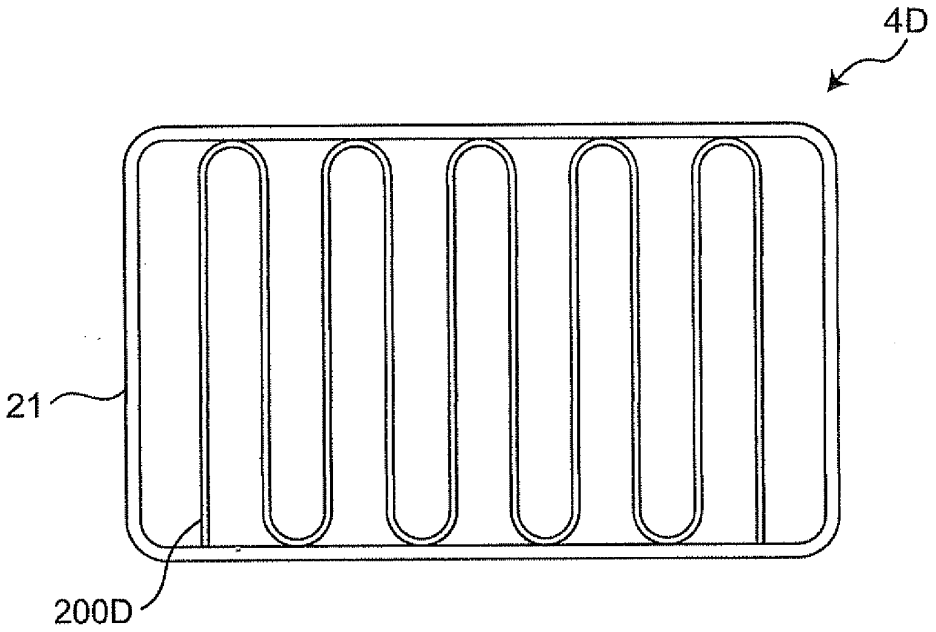


Fig.9

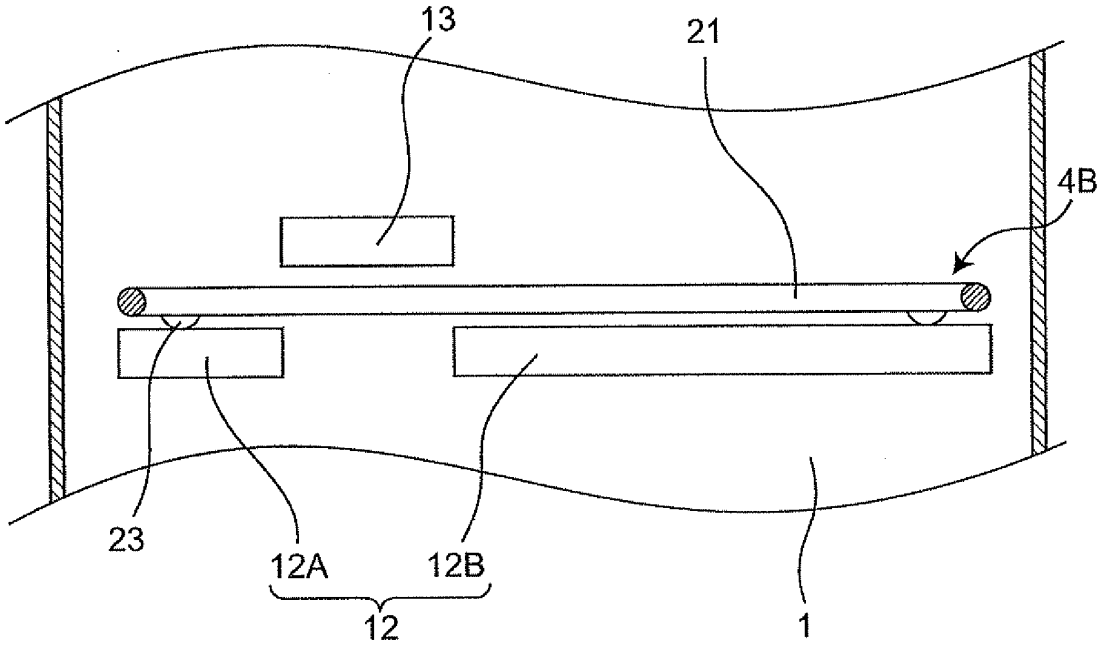


Fig.10

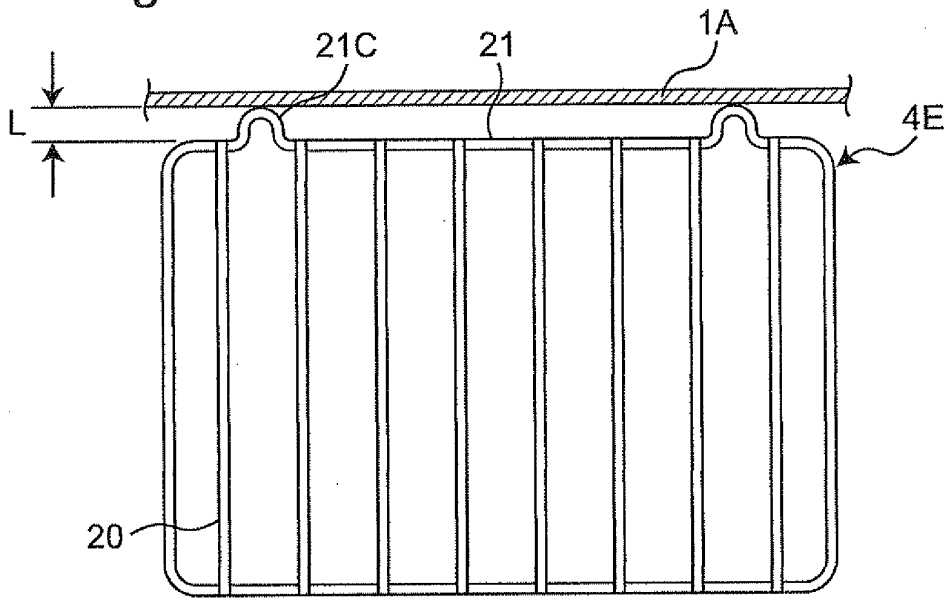


Fig.11

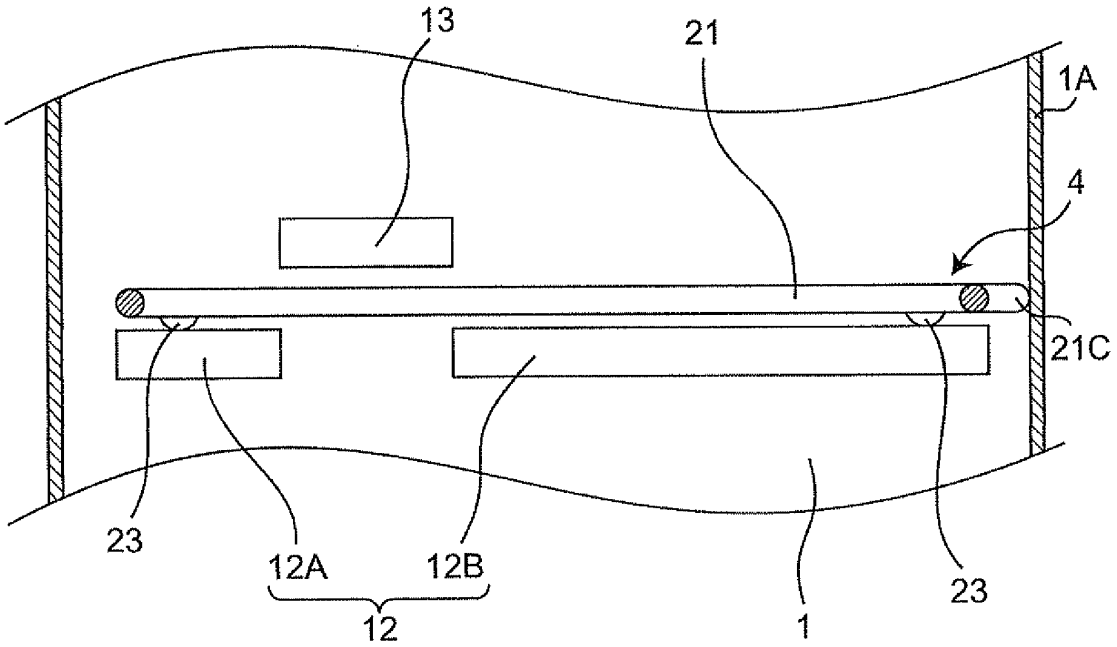


Fig.12

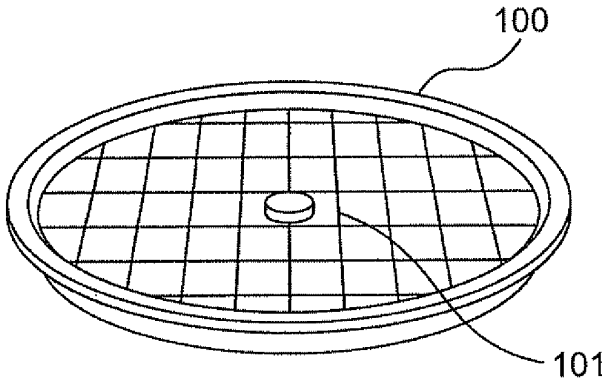
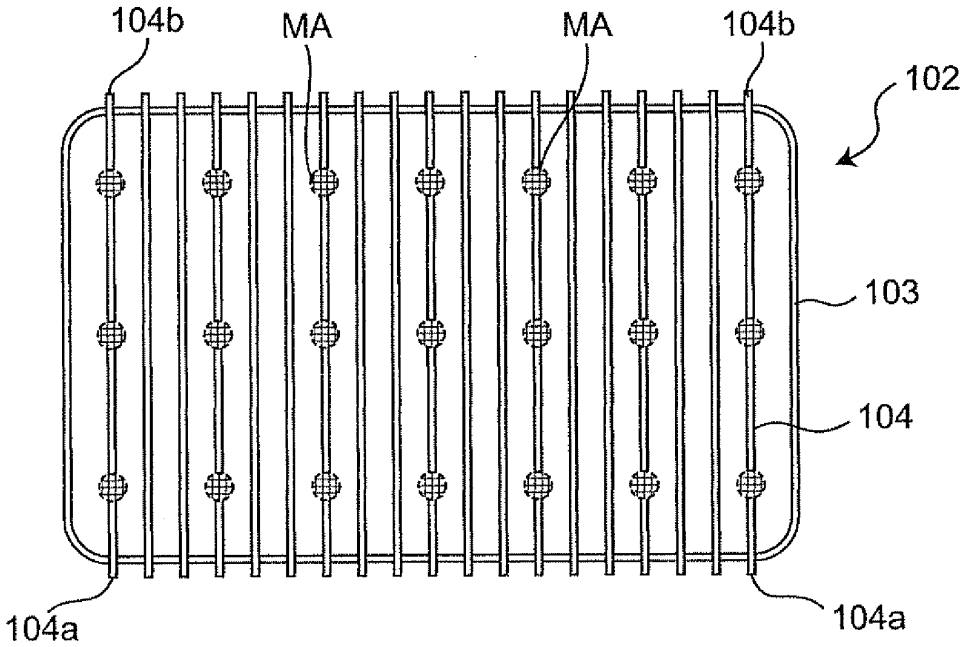


Fig.13



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/006434

A. CLASSIFICATION OF SUBJECT MATTER
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)
F24C7/02, H05B6/64, H05B6/74

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 1996-2012
Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 4-209494 A (Sanyo Electric Co., Ltd.), 30 July 1992 (30.07.1992), paragraph [0003]; fig. 3 (Family: none)	1-15
A	JP 10-112388 A (Matsushita Electric Industrial Co., Ltd.), 28 April 1998 (28.04.1998), paragraphs [0035], [0069]; fig. 2 (Family: none)	1-15
A	JP 2004-360986 A (Matsushita Electric Industrial Co., Ltd.), 24 December 2004 (24.12.2004), paragraph [0040] (Family: none)	1-15

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 January, 2012 (19.01.12)	31 January, 2012 (31.01.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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

REFERENCES CITED IN THE DESCRIPTION

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- JP H9145064 B **[0002] [0003]**
- JP S55059209 B **[0003] [0006]**