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(54) Heating apparatus with temperature sensor comprising infrared sensing elements

(57) A heating apparatus such as a microwave oven includes a generally rectangular box-shaped cooking chamber (4) in which food (11) to be cooked is accommodated, a magnetron (12) supplying microwaves into the cooking chamber (4) so that the food (11) is heated, and a temperature sensor (14) including a plurality of infrared sensing elements (19) and disposed on an up-

per portion of the cooking chamber (4) so as to be away from two center lines (A1, A2) passing centers of two pairs of opposite sides (4a, 4b; 4c, 4d) of the cooking chamber (4) as viewed from above, whereupon the temperature sensor (14) detects temperatures at a plurality of locations (23a) in the cooking chamber (4) respectively.

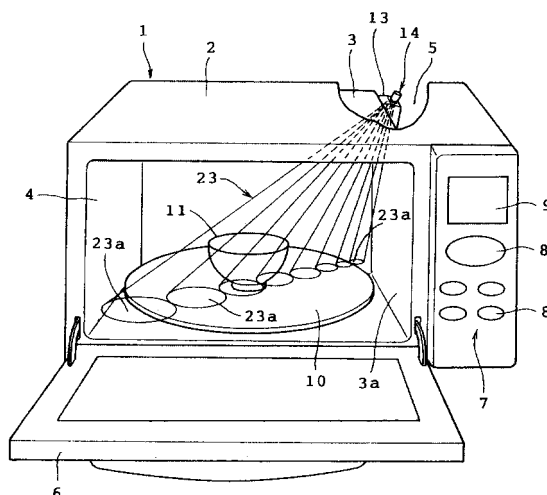


FIG. 1

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Description

[0001] This invention relates to a heating apparatus, such as microwave ovens, provided with a temperature sensor detecting a temperature of food to be cooked, and more particularly to such a heating apparatus in which the temperature sensor comprises a plurality of infrared sensing elements.

[0002] Heating apparatuses such as microwave ovens have conventionally been provided which comprise an infrared sensor serving as a temperature sensor detecting a temperature of food to be cooked and in which heating is controlled on the basis of the results of detection by the temperature sensor. However, in the microwave oven provided with the temperature sensor comprising a single infrared sensing element (a monocular infrared sensor), only a temperature at one location in a cooking chamber can be detected. Accordingly, when food is placed in the cooking chamber so as to be deviated from the location, a temperature of the food cannot be detected, whereupon a desired cooking cannot be performed.

[0003] The following arrangements have been proposed in order that temperatures may be detected at a plurality of locations in the cooking chamber and a desired heating control may be performed on the basis of the results of detection. The first arrangement provides a plurality of the temperature sensors comprising the aforesaid monocular infrared sensors respectively. In the second arrangement, the direction of a temperature sensor comprising the monocular infrared sensor is changed so that temperatures at a plurality of locations are sequentially detected at different times respectively. In the third arrangement, a single temperature sensor comprises a plurality of the infrared sensing elements. Japanese Patent No. 2827784 discloses a multi-element thermopile infrared sensor as the aforesaid third arrangement.

[0004] In the first arrangement, however, a plurality of the temperature sensors increase an installation space for the microwave oven, limiting its installation location. Furthermore, the total number of signal lines extending from the monocular infrared sensors is increased. The second arrangement requires a driving system, which complicates the arrangement of the system.

[0005] On the other hand, the third arrangement has no such disadvantages as described above. However, each infrared sensing element has a small visual angle (solid angle), for example, 5 degrees. Accordingly, when a mounting accuracy of the temperature sensor is low or a temperature change displaces the temperature sensor, a temperature detecting region of each infrared sensing element is displaced relative to a target region such that a sufficient detecting accuracy cannot be obtained. Further, the overall visual angle (overall solid angle) of the temperature sensor needs to be rendered larger as the temperature detecting region is increased in the cooking chamber. An increase in the overall visual

angle of the temperature sensor increases an opening provided in the cooking chamber for detection of infrared rays when the temperature sensor is disposed outside the cooking chamber, for example.

[0006] Therefore, an object of the present invention is to provide a heating apparatus in which temperatures at a plurality of locations in the cooking chamber can be detected with high accuracy by a temperature sensor comprising a plurality of infrared sensing elements, and the overall visual angle of the temperature sensor can be set at a relatively small value.

[0007] The present invention provides a heating apparatus comprising a generally rectangular box-shaped cooking chamber in which food to be cooked is accommodated, a microwave generating device supplying microwaves into the cooking chamber so that the food is heated, and a temperature sensor including a plurality of infrared sensing elements, characterized in that the temperature sensor is disposed on an upper portion of the cooking chamber so as to be away from two center lines passing centers of two pairs of opposite sides of the cooking chamber as viewed from above, whereupon the temperature sensor detects temperatures at a plurality of locations in the cooking chamber respectively.

[0008] In the above-described construction, the temperature sensor comprises a plurality of the infrared sensing elements detecting temperatures at a plurality of points in the cooking chamber respectively. Consequently, an installation space of the temperature sensor can be reduced as compared with the case where a plurality of temperature sensors comprising respective monocular infrared sensors are provided. Further, since the temperature sensor need not be moved, no driving system is required, whereupon complication of the system arrangement can be prevented. Additionally, since the temperatures are detected at a plurality of locations in the cooking chamber, a desired heating control can be achieved.

[0009] The temperature sensor is disposed on the obliquely upward portion of the cooking chamber with respect to the central portion of the cooking chamber, which portion is away from the two center lines passing centers of two pairs of opposite sides of the cooking chamber as viewed from above. According to this disposition of the temperature sensor, the distance between the temperature sensor and the food or is increased as compared with a case where the temperature sensor is disposed on an upper portion of a side wall of the cooking chamber just beside the cooking chamber, that is, on the aforesaid center line. As a result, since the temperature sensor is subjected to a smaller amount of thermal influence from the food to be cooked, the detection accuracy of each infrared sensing element can be improved. Further, since changes in the position of the temperature sensor due to thermal deformation of the mounting portion of the temperature sensor such that the detection accuracy of the temperature sensor can be improved. Furthermore, the overall angle of vis-

ibility of the temperature sensor can be rendered smaller. This is advantage when the temperature sensor is installed.

[0010] In a first preferred form, the temperature sensor is disposed near one of corners of the cooking chamber. Consequently, since the distance between the object to be measured and the temperature sensor is further increased, the detection accuracy of the temperature sensor can be further increased and the overall angle of visibility can further be reduced.

[0011] In a second preferred form, the temperature sensor is disposed outside the cooking chamber, and the cooking chamber has a wall formed with a detecting opening through which infrared rays produced in the cooking chamber pass to be received by the temperature sensor.

[0012] In a third preferred form, the cooking chamber has a wall including an outwardly convex protrusion formed with a detecting opening, and the temperature sensor is disposed outside the protrusion so that a temperature in the cooking chamber is detected through the detecting opening. According to this construction, since the temperature sensor gets away from the cooking chamber, it is not influenced by the temperature in the heating chamber. Further, the visual angle of the overall temperature sensor can further be reduced and accordingly, the size of the detecting opening can further be reduced. Consequently, an amount of electric wave leaking out of the opening can be reduced. Further, since an amount of soil scattered through the opening out of the cooking chamber is reduced, the temperature sensor can be prevented from being soiled.

[0013] In a fourth preferred form, the detecting opening is formed so that an open end thereof is substantially perpendicular to a center line extending in a direction of detection by the temperature sensor. This construction can render the opening as small as possible, thereby preventing the electric wave from leaking and the temperature sensor from being soiled.

[0014] In a fifth preferred form, the temperature sensor is disposed so that a temperature detecting region is substantially along a diagonal line of a bottom of the cooking chamber. In this construction, the temperature in a corner where food is not usually placed, that is, a background temperature for the food can be detected.

[0015] In a sixth preferred form, the heating apparatus is further characterized by a rotating member which is disposed on a bottom of the cooking chamber and on which the food is placed and driving means for driving the rotating member. In this construction, the temperature sensor is disposed so that a temperature detecting region thereof includes at least a central region of the rotating member and a radial region of the rotating member. The central portion of the rotating member is stationary in a system detecting the temperature of food placed on the rotating member while the rotating member is in rotation. Accordingly, if the detecting region of the temperature sensor should exclude the central area

of the rotating member, the temperature in the central area could not be detected even when the rotating member is rotated. Furthermore, since food is placed in the vicinity of the center of the rotating member, the detecting region of the temperature sensor preferably includes at least an area corresponding to the radius of the rotating member. Consequently, the overall area of the rotating member can be detected with rotation thereof.

[0016] In a seventh preferred form, the temperature sensor is disposed so that a level of the temperature detecting region at the center of the rotating member is equal to or higher than one third of a height of the cooking chamber. The temperature sensor detects an infrared ray reflected on the food placed on the rotating member from obliquely over the cooking chamber. Accordingly, the level of the detecting region of the temperature detector upon rotation of the rotating member is the lowest at the central portion of the rotating member. Consequently, when a sufficient level of the detecting region in the central portion of the rotating member is ensured (equal to or higher than one third of a height of the cooking chamber), a desired temperature detection can be carried out even if a relatively taller container such as cup or Japanese "tokkuri" (sake boiling container) is placed on the central portion of the rotating member.

[0017] In an eighth preferred form, the temperature sensor is disposed so that a temperature detecting region thereof includes a region where the food cannot be placed. As the result of this disposition, a background temperature of the food is detected. Using the background temperature, an error of detection by the temperature sensor due to reflection on the food can be compensated such that the accuracy in the detection by the temperature sensor can be improved.

[0018] In a ninth preferred form, the heating apparatus is further characterized by a rotating member which is disposed on a bottom of the cooking chamber and on which the food is placed and driving means for driving the rotating member, and characterized in that the temperature sensor comprises a plurality of rows of the temperature sensing elements each of which has a central portion of the rotating member as the temperature detecting region. As described above, the detecting region of the temperature sensor preferably includes at least an area corresponding to the radius of the rotating member. However, it is considered that the accuracy in the mounting of the temperature sensor shifts the central portion of the rotating member outside the detecting region. A high accuracy in the mounting is required so that the central portion of the rotating member is prevented from shifting outside the detecting region. As the result of the above-described construction, the detecting region can include the central portion of the rotating member with ease. Consequently, since the mounting accuracy of the temperature sensor is sufficient, the manufacturing efficiency can be improved.

[0019] In a tenth preferred embodiment, the cooking chamber has a pair of shelf supports on which an oven-

ware is placed, and the temperature sensor is disposed higher than the shelf supports so that a temperature of the food placed on the ovenware is detected when the ovenware is installed on the shelf supports. In this construction, even when an ovenware is used in the cooking, a temperature of food placed on the ovenware can be detected by the temperature sensor without intercept by the ovenware. Consequently, a desired heating control can be achieved.

[0020] In an eleventh preferred form, the opening has a surrounding wall made of an electrically conductive material and located along a peripheral edge thereof, the surrounding wall having a larger projecting dimension than a thickness of a plate on which the opening is made. Since the temperature sensor comprises a plurality of infrared sensing elements, the overall visual angle can be increased and accordingly, the detecting opening can be rendered larger. Consequently, microwaves can be prevented from leaking through the detecting opening and soil can be prevented from scattering through the detecting opening.

[0021] In a twelfth preferred form, the heating apparatus is further characterized by a rotating member which is disposed on a bottom of the cooking chamber and on which the food is placed and driving means supported on the bottom of the cooking chamber for driving the rotating member. In the apparatus, the temperature sensor is supported on a side wall of the cooking chamber, and the side wall on which the temperature sensor is supported and the bottom of the cooking chamber are formed by bending a single plate-shaped material. The mounting accuracy of the temperature sensor relative to the rotating member is improved as compared with a case where the side wall on which the temperature sensor is mounted is discrete from the bottom wall on which the rotating member is mounted. Consequently, the accuracy in the detection of the temperature sensor can be improved.

[0022] In a thirteenth preferred form, the temperature sensor is mounted on a mounting plate further mounted on a side wall of the cooking chamber, and the mounting plate is made of a material having a smaller thermal expansion coefficient or thermal conduction coefficient than a material of the side wall of the cooking chamber. An influence of the temperature in the cooking chamber is prevented from being transferred via the mounting plate to the temperature sensor. Consequently, the detecting accuracy of the temperature sensor mounted on the mounting plate is prevented from being reduced with variations in the position of the temperature sensor, or the detecting accuracy of the temperature sensor itself can be prevented from being reduced.

[0023] In a fourteenth preferred form, the cooking chamber includes a side wall having a plurality of stages of shelf supports for supporting shelf boards, the temperature sensor is disposed outside the cooking chamber, and the side wall of the cooking chamber has a detecting opening through which infrared rays produced in

the cooking chamber pass to be received by the temperature sensor, the detecting opening being located lower than the uppermost shelf support. When cooking is carried out with a shelf board being supported on the uppermost shelf supports, foreign matter due to fatty vapor produced by the food placed on the shelf board can be prevented from entering the detecting opening. Consequently, the temperature sensor can be prevented from being soiled and accordingly, the detecting accuracy of the temperature sensor can be improved.

[0024] The invention will be described, merely by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a partially broken perspective view of a microwave oven of a first embodiment in accordance with the present invention;

FIG. 2 is an enlarged longitudinal section of a temperature sensor;

FIG. 3 is a schematic transverse section of the microwave oven;

FIG. 4 is a longitudinal section taken along line 4-4 in FIG. 3;

FIG. 5 is a front view of the temperature sensor;

FIG. 6 is a side view of the temperature sensor;

FIG. 7 is a view similar to FIG. 3, showing a compared case;

FIG. 8 is a longitudinal section taken along line 8-8 in FIG. 7;

FIG. 9 is a view similar to FIG. 2, showing the microwave oven of a second embodiment in accordance with the invention;

FIG. 10 is a view similar to FIG. 3, showing the microwave oven of a third embodiment in accordance with the invention;

FIG. 11 is a view similar to FIG. 3, showing the microwave oven of a fourth embodiment in accordance with the invention;

FIG. 12 is a view similar to FIG. 3, showing the microwave oven of a fifth embodiment in accordance with the invention;

FIG. 13 is a view similar to FIG. 4, showing the microwave oven of a sixth embodiment in accordance with the invention;

FIG. 14 is an enlarged longitudinal section of a distal end of an expanded portion in the microwave oven of a seventh embodiment in accordance with the invention;

FIG. 15 is a view similar to FIG. 14, showing the microwave oven of an eighth embodiment in accordance with the invention;

FIG. 16 is a sectional view taken along line 16-16 in FIG. 17, showing the microwave oven of a ninth embodiment in accordance with the invention;

FIG. 17 is a transverse section of the microwave oven of the ninth embodiment; and

FIG. 18 is a perspective view of the microwave oven with a door open.

[0025] Several embodiments of the present invention will be described with reference to the drawings. FIGS. 1 to 8 show a first embodiment of the microwave oven in accordance with the invention. Referring to FIG. 1, the microwave oven comprises a body 1 including a transversely long rectangular box-shaped outer casing 2 and a rectangular box-shaped inner casing 3 made of a steel plate and having a front opening. An interior of the inner casing 3 serves as a cooking chamber 4. An interior of the outer casing 2 on the right of the inner casing 3 is defined as a component chamber 5. A door 6 is movably mounted on the front of the body 1 so that the front opening of the cooking chamber 4 is opened and closed by the door. An operation panel 7 is also mounted on the front of the body 1 to be located in front of the component chamber 5. Various keys 8 and a display 9 are mounted on the operation panel 7.

[0026] As shown in FIG. 3, the cooking chamber 4 has a generally rectangular or substantially square shape as viewed from the top thereof. A turntable 10 serving as a rotating member is rotatably mounted on the bottom of the cooking chamber 4. The turntable 10 is driven by driving means comprising an electric motor 24 (see FIG. 4). Food 11 to be cooked is placed on the turntable 10. The motor 24 is mounted in the same manner as an electric motor 52 (see FIG. 16) employed in a ninth embodiment as will be described later. A magnetron 12 is mounted on the component chamber side of a right side wall 3a of the inner casing 3. The magnetron 12 supplies microwaves into the cooking chamber 4 so that the food 11 is heated.

[0027] Referring now to FIG. 2, the right side wall 3a has a through opening 27 formed in an upper rear portion thereof so as to be located near an upper rear corner of the inner casing 3. A protrusion 13 convex outward or protruding to the component chamber 5 side is welded to the side wall 3a so as to surround the opening 27. The protrusion 13 includes a mount 13a inclined relative to the side wall 3a. A temperature sensor 14 is mounted on a sensor mounting member 15 which is further mounted on the mount 13a so that the temperature sensor is located outside the protrusion 13 or at the component chamber 5 side. The sensor mounting member 15 has a detecting opening 16 formed so as to correspond to the temperature sensor 14. Accordingly, the temperature sensor 14 is located over the cooking chamber 4 so as to. turn aside from two center lines A1 and A2 passing opposed two sides 4a and 4b and opposed two sides 4c and 4d respectively when the cooking chamber 4 is viewed from above as shown in FIG. 3. Thus, the temperature sensor 14 is disposed obliquely upward relative to the cooking chamber 4 to detect a temperature therein.

[0028] The temperature sensor 14 comprises a cylindrical casing 17, an IC chip 18 on which a plurality of or more particularly eight infrared sensing elements 19 comprising a plurality of or eight thermopiles respectively are mounted, and a single focusing lens 20 provided

at an incidence side of the elements 19 and made from silicon. The eight infrared sensing elements 19 are aligned in a row such that the temperature sensor 14 is composed into a line sensor. The temperature sensor 14 is mounted on a substrate 21 which is further mounted on the sensor mounting member 15 by a screw 22.

[0029] The detecting opening 16 is formed into the shape of a slit extending along the aligned sensing elements 19. The direction in which the opening 16 and the sensing elements 19 are arranged corresponds with the direction of radius of the turntable 10. As shown in FIG. 2, a center line B of the temperature sensor 14 is substantially perpendicular to an open end C of the opening 16. Further, the opening 16 has an opening degree or diameter D1 set to be larger than a range D2 of effective transmission face 20a (see FIG. 5) of the lens 20 effectively transmitting infrared rays.

[0030] The overall detecting region 23 of the temperature sensor 14 is a sum of individual detecting regions 23a of the respective infrared sensing elements 19 and extends generally along a diagonal line on the bottom of the cooking chamber 4, as shown in FIGS. 3 and 4. One of the individual detecting regions 23a is a region which is outside the turntable 10 toward the temperature sensor 14 and where food cannot be placed in the cooking chamber 4. The other detecting regions 23a covers a range defined by the diameter of the turntable 10 and including a central region 10a of the turntable. Regarding the height of the detecting region 23, the height H1 of the region at the central region 10a is set so as to be equal to or larger than one third of the height H0 of the cooking chamber 4 (about one half in the embodiment).

[0031] A control device (not shown) comprising a microcomputer is provided at the backside of the operation panel 7. The control device controls the overall operation of the microwave oven.

[0032] When cooking is to be performed by the above-described microwave oven, the food 11 is placed on the turntable 10, and the door 6 is then closed. One or more keys 8 are operated so that a desired cooking mode is set. On the basis of the set cooking mode, the turntable 10 is turned and the magnetron 12 is actuated to supply microwaves into the cooking chamber 4, so that the food 11 is heated thereby to be cooked. Further, the temperature of the food 11 is detected by the temperature sensor 14. Heating is controlled on the basis of the result of detection by the temperature sensor 14.

[0033] According to the above-described embodiment, the temperature sensor 14 detecting the temperature of the food 11 comprises a plurality of infrared sensing elements 19 which detect the temperatures at a plurality of detecting regions 23a in the cooking chamber 4 respectively. Since the visual angle of each infrared sensing element 19 is set at about 5 degrees, the overall visual angle $\alpha 1$ of the temperature sensor 14 becomes about 40 degrees. Consequently, since the temperature in a large region can be detected by the single temperature sensor 14, an installation space for the

temperature sensor 14 can be rendered smaller as compared with a case where a plurality of temperature sensors each of which comprises a monocular infrared sensor are provided. Moreover, since the temperature sensor 14 need not be moved, no drive system for driving the sensor is required. This can avoid the complication of the system. Additionally, since temperatures at a plurality of locations in the cooking chamber 4, a desired heating control can be carried out.

[0034] The temperature sensor 14 is disposed on the upper portion of the cooking chamber 4 so as to be located near the upper rear corner of the cooking chamber 4. The temperature sensor 14 is thus disposed obliquely upward relative to the cooking chamber 4. Accordingly, a distance between the temperature sensor 14 and an object whose temperature is detected, for example, the turntable 10 or food 11 is increased. Further, the temperature sensor 14 is located on the outside of the protrusion 13 formed on the right side wall 3a of the cooking chamber 4 so as to be convex outward. Since the temperature sensor 14 is spaced away from the interior of the cooking chamber 4, it is less affected by the heat from the food 11 to be heated. Consequently, the detection accuracy of the infrared sensing element can be improved and displacement of the temperature sensor 14 due to thermal deformation of the protrusion 13 can be prevented, whereupon the detection accuracy of the temperature sensor 14 can be improved.

[0035] FIGS. 7 and 8 illustrate a case where the temperature sensor 14 is disposed on an upper middle portion of the right side wall 3a so as to be located on the aforesaid center line A1. In this case, the distance between the temperature sensor 14 and the object whose temperature is detected is rendered shorter. In particular, when the detection region 25 includes a region near the end of the turntable 10 and the right side wall 3a, a detection angle needs to be increased near the right side wall 3a. This increases the overall visual angle of the temperature sensor 14. Furthermore, the protrusion 26 needs to be projected outward to a larger extent in order that an optical path for the infrared rays may be secured. This results in a structurally unnecessary space. Additionally, since a large ruggedness is formed on the side wall of the cooking chamber 4, the manufacturing efficiency and the cleaning efficiency are reduced.

[0036] When the construction of the embodiment is compared with the construction shown in FIGS. 7 and 8, the overall visual angle in the embodiment is smaller than that in the construction of FIGS. 7 and 8 in the case where the microwave oven of the embodiment and that shown in FIGS. 7 and 8 have the same detection range of the temperature sensor 14. Consequently, since the projection of the protrusion 13 is reduced and unnecessary space is reduced in the embodiment, the manufacturing efficiency and cleaning efficiency can be improved.

[0037] As shown in FIG. 4, the detecting region 23 of the temperature sensor is set to be larger than the di-

ameter of the turntable 10 in the embodiment. Accordingly, the overall visual angle α_1 of the temperature sensor 14 is approximately equal to the visual angle α_2 in the case of FIGS. 7 and 8 where the detecting region 25 is shown by virtue of the diameter of the turntable 10.

[0038] When the visual angle of the temperature sensor 14 is reduced as in the embodiment, the size of the opening 16 can be reduced. Further, since the center line B extending in the direction of detection by the temperature sensor 14 is substantially perpendicular to the open end C of the opening B, the size of the opening 16 can further be reduced. Consequently, an amount of microwave leaking from the opening 16 can be reduced and the detection accuracy can be prevented from reduction by electrical noise. Further, an amount of soil scattering through the opening 16 from the cooking chamber 4 can be reduced and the temperature sensor 14 can be prevented from being soiled.

[0039] The temperature detecting section (eight temperature sensing elements) of the temperature sensor 14 is generally small and is not exceeding 1 cm in the length. On the other hand, the overall detecting region 23 is 20 to 30 cm long. Accordingly, when the infrared rays are condensed by the lens 20, an optical path in the visual range spreads from the effective transmission face of the lens 20, reaching the detecting region 23. In the embodiment, the opening range D1 of the opening 16 located between the lens 20 and the object to be measured is set so as to be larger than the range D2 of the effective transmission face 20a of the lens 20. Accordingly, the infrared rays are prevented from being intercepted by the edge of the opening 16. Consequently, since the infrared rays are reflected on the object to effectively reach the temperature sensor 14, the temperature in the cooking chamber 4 can accurately be detected.

[0040] The detecting region 23 of the temperature sensor 14 includes the central portion 10a of the turntable 10 and covers the region defined along the diameter of the turntable. The height of the detecting region 23 at the central portion 10a is set so as to be about one half of the height of the cooking chamber 4. Consequently, the temperature of the food can reliably be detected. More specifically, the central portion 10a of the turntable 10 is immovable or stationary in the system detecting the temperature of the food 11 placed on the turntable 10 while the turntable is in rotation. Accordingly, in a case where the detecting region 23 does not include the region of the central portion 10a of the turntable 10, the temperature in the central portion 10a cannot be detected even when the turntable is rotated. Further, the food 11 is usually placed near the central portion 10a on the turntable 10. In view of this, the detecting region 23 should preferably include the central portion 10a. Additionally, when the detecting region 23 includes at least a region defined along the radius of the turntable 10, the temperatures in all the regions of the turntable 10 can be detected when the turntable is rotated.

[0041] The height of the detecting region 23 is lowest at the central portion 10a when the turntable 10 is in rotation, as shown in FIG. 4. Accordingly, in a case where a sufficient height of the detecting region 23 is ensured at the central portion 10a, a desired temperature detection can be performed even when a relatively tall container such as the Japanese "tokkuri" container or cup is placed on the central portion 10a of the turntable 10. Further, since the detecting region 23 includes the regions outside the turntable 10 in the embodiment, a background temperature of the food 11 is detected. A detection error due to reflection from the food 11 can be compensated by the background temperature. Consequently, the detection accuracy of the temperature sensor can be improved.

[0042] FIG. 9 illustrates a second embodiment of the invention. Only the difference between the first and second embodiments will be described. In the second embodiment, the right sidewall 3a of the cooking chamber 4 has an inwardly convex recess 30a formed in an upper portion thereof. The recess 30 is formed with a mount 30a having a slit-like opening 16. The temperature sensor 14 is located outside the cooking chamber 4 (at the component chamber 5 side) so as to correspond to the mount 30a. The same effect can be achieved from the second embodiment as from the first embodiment.

[0043] FIG. 10 illustrates a third embodiment. Only the first and third embodiments will be described. In the third embodiment, four infrared sensors 19 having detecting regions near the central portion 10a are further added to the temperature sensor 14. As a result, two rows of detecting regions 23 each of which includes three detecting regions are provided near the central portion 10a of the turntable 10. As described above, the detecting region of the temperature sensor 14 should preferably include the central portion 10a. However, it is considered that the central portion 10a may deviate from the detecting region by the influences of the mounting accuracy of the temperature sensor 14. A high level of mounting accuracy is required in order that the deviation of the central portion 10a may be prevented. For example, when the infrared sensors 19 each of which has a visual angle of 5 degrees are arranged in a row, as in the first embodiment, the temperature sensor needs to be mounted within a range of 5 degrees so that the central portion 10a can be detected. On the other hand, in the third embodiment, three rows of the infrared sensing elements 19 having the respective detecting regions near the central portion 10a. In this case, the temperature sensor 14 may be mounted within a range of 15 degrees. Consequently, since the detection range 32 easily includes the central portion 10a of the turntable 10, the mounting accuracy of the temperature sensor 14 has a sufficient margin and the manufacturing efficiency can be improved.

[0044] FIG. 11 illustrates a fourth embodiment. Only the difference between the third and fourth embodiments will be described. In the fourth embodiment, the

temperature sensor comprises ten infrared sensing elements 19 in total which are arranged in two rows. As a result, two rows of individual detecting regions 23a each of which includes four regions are arranged in the detecting region 33 near the central portion 10a of the turntable 10. The same effect can be achieved from the fourth embodiment as from the third embodiment.

[0045] FIG. 12 illustrates a fifth embodiment. Only the difference between the third and fourth embodiments and the fifth embodiment will be described. In the fifth embodiment, the temperature sensor 14 comprises twenty-four infrared sensing elements 19 arranged in three rows each of which includes eight elements. As a result, three rows of individual detecting regions 23a are arranged in the detecting region 34 near the central portion 10a. The same effect can be achieved from the fifth embodiment as from the third embodiment.

[0046] FIG. 13 illustrates a sixth embodiment. Only the difference between the first and sixth embodiments will be described. More specifically, shelf supports 36 are provided on vertically middle portions of the right and left side walls 3a and 3b respectively. An ovenware 35 is supported on the shelf supports 36. The temperature sensor 14 is located higher than the shelf supports 36 so that the temperature of the food placed on the ovenware 35 can be detected. Oven heaters (not shown) are provided on the ceiling and bottom of the inner casing 3 respectively.

[0047] According to the sixth embodiment, even in the cooking by use of the ovenware 35, the temperature sensor 14 can detect the temperature of the food placed on the ovenware 35 without interception by the ovenware. Consequently, a desired heating control can be carried out.

[0048] FIG. 14 illustrates a seventh embodiment. Only the difference between the first and seventh embodiments will be described. The protrusion 37 formed on the right side wall 3a of the cooking chamber 4 has a detection opening 16. A surrounding wall 38 is formed on a circumferential edge of the opening 16. The surrounding wall 38 has a projection dimension larger than the thickness of a panel composing the right side wall 3a. The surrounding wall 38 is formed integrally on the right side wall 3a by means of burring so as to project outward or to the temperature sensor 14 side. A shutter 40 made of an electrically conductive material is provided between the opening 16 and the temperature sensor 14. The shutter 40 is closed and opened by an electric motor (not shown). The shutter 40 is opened only when the temperature detection is carried out.

[0049] The overall visual angle is increased when the temperature sensor 14 comprises a plurality of infrared sensing elements 19, and accordingly, the size of the detecting opening 16 is also increased. With this, it is considered that influences of leakage of microwave through the opening 16 and soil are increased. In view of this problem, the surrounding wall 38 is formed along the circumferential edge of the opening 16 in the em-

bodiment. The right side wall 3a through which the opening 16 is formed is made of a steel plate which is electrically conductive. Consequently, since microwaves are damped by the surrounding wall 38, the leakage of the microwaves can be prevented and soil can be prevented from scattering. Since the shutter 40 made of the electrically conductive material is further provided in the embodiment, the leakage of microwaves and the scattering of the soil can be prevented more effectively.

[0050] FIG. 15 illustrates an eighth embodiment. Only the difference between the seventh and eighth embodiments will be described. In the eighth embodiment, a surrounding wall 39 made of an electrically conductive material is formed along the circumferential edge of the opening 16 so as to protrude toward the cooking chamber 4 side. The surrounding wall 39 is discrete from the right side wall 3a formed with the opening 16. Accordingly, the same effect can be achieved from the eighth embodiment as from the seventh embodiment.

[0051] FIGS. 16 to 18 illustrate a ninth embodiment in which the invention is applied to a microwave oven with oven and grilling functions. Referring to FIGS. 17 and 18, the microwave oven comprises a body 41 including a transversely long rectangular box-shaped outer casing 42 and a rectangular box-shaped inner casing 43 having a front opening. An interior of the inner casing 43 is defined as a cooking chamber 44. An interior of the outer casing 42 on the right of the inner casing 43 is defined as a component chamber 45. A door 46 is movably mounted on the front of the body 41 so that the front opening of the cooking chamber 44 is opened and closed by the door. An operation panel 47 is also mounted on the front of the body 41 to be located in front of the component chamber 45. Various keys 48 and a display 49 are mounted on the operation panel 47.

[0052] The inner casing 43 defining the cooking chamber 44 has a right sidewall 43a, left sidewall 43b, bottom 43c, rear wall 43d, ceiling 43e (see FIG. 16) and a frame-shaped front panel mounted on the periphery of the front thereof. The right sidewall 43a, left sidewall 43b and bottom 43c are made by bending a single steel plate into a generally U-shaped assembly with an upper opening. The rear wall 43d, ceiling 43e and front panel 43f each of which is made of a steel plate are welded to the U-shaped assembly, whereby the inner casing 43 is formed. The right sidewall 43a, left sidewall 43b, bottom 43c, rear wall 43d, ceiling 43e and the front panel are all coated with a black paint.

[0053] The bottom 43c has an insertion hole 50 formed through a central portion of the bottom 43c as shown in FIG. 16. A motor mount plate 51 is welded to the underside of the bottom 43c so as to cover the insertion hole 50. An electric motor 52 serving as the driving means is mounted on the motor mount plate 51. The motor 52 has a rotating shaft 52a extending through the insertion hole 50. A rotating member 53 is detachably attached to a distal end of the rotating shaft 52a so as to be located on the bottom of the cooking chamber 44.

A turntable 54 on which food to be cooked is placed is mounted on the rotating member 53. Accordingly, the rotating member 53 and the turntable 54 are rotated by the motor 52.

[0054] Two, upper and lower pairs of shelf supports 55 are formed on the right and left side walls 43a and 43b so as to protrude inward with respect to the cooking chamber 44 and horizontally extending in the direction of the depth of the cooking chamber, respectively. The shelf supports 55 are formed integrally on the side walls 43a and 43b by drawing the side walls as shown in FIG. 16. The right side wall 43a has an opening 56 formed through a rear upper portion thereof near a rear upper corner so as to be located between the upper and lower shelf supports 55. A mounting plate 57 is welded to the outside of the right side wall 43a at the component chamber 45 side so as to surround the opening 56. The mounting plate 57 is made of a material having a smaller thermal expansion coefficient and a smaller thermal conductivity coefficient than the steel plate made into the right side wall 43a, for example, a stainless steel plate in the embodiment. No paint is applied to the mounting plate 57.

[0055] A sensor holder made of a synthetic resin is mounted on the mounting plate 57 by a screw 59. A temperature sensor 60 is mounted on the sensor holder 58. The temperature sensor 60 has the same construction and electrical arrangement as the temperature sensor 14 employed in the first embodiment. The temperature sensor 60 has an overall detecting region 64 slightly broader than a radial region involving a central portion 54a of the turntable 54. The temperature sensor 60 is mounted on a substrate 61 which is further mounted on the sensor holder 58 by the screw 63 with a spacer 62 being interposed therebetween.

[0056] Referring to FIG. 17, a magnetron 65 is provided on the outside of the right side wall 43a in the component chamber 45 serving as a microwave generating device so as to be located centrally. The magnetron 65 supplies microwaves into the cooking chamber 44 in a range cooking so that food is heated. A fan 66 is provided in the component chamber 45 for cooling the magnetron 65 etc. Upper and lower heaters (neither shown) are provided on the ceiling and bottom of the cooking chamber 44. These heaters are used for a grill cooking and an oven cooking. A control device (not shown) comprising a microcomputer is provided at the backside of the operation panel 47. The control device controls the overall operation of the microwave oven.

[0057] The range cooking is carried out in the same manner as described in the first embodiment. Temperature detection by the temperature sensor 60 will hereinafter be described. The temperature sensor 60 comprises eight infrared sensing elements 19 comprising eight thermopiles respectively. When the temperature of the food is detected by the eight infrared sensing elements 19, an output voltage of each element is shown by the following equation (1):

$$V=v(T_{bb}^4 - T_{am}^4) \quad (1)$$

where V is an output voltage, v is a sensitivity, T_{bb} is an absolute temperature of food, and T_{am} is an absolute temperature of the temperature sensor 60. When equation (1) is transformed, the following equation (2) is obtained:

$$T_{bb}=\{(V/v) + T_{am}^4\}^{1/4} \quad (2)$$

[0058] According to the ninth embodiment, a high accuracy in the position of the temperature sensor 60 relative to the turntable 54 is required in order that the temperature of the food placed on the turntable may be detected by the temperature sensor 60. For example, when the right side wall 43a and the bottom 43c are discrete from each other and are welded or crimped together, it is considered that the accuracy in the position of the temperature sensor 60 relative to the turntable 54 varies to a large extent. In the above-described embodiment, however, the one and the same steel plate is bent to be formed into the right side wall 43a and the bottom 43c of the cooking chamber 44 on both of which the temperature sensor 60 and the turntable 54 are mounted respectively. This construction improves the accuracy in the mounting of the temperature sensor 60 relative to the turntable 54 and accordingly, the accuracy in the detection by the temperature sensor. Further, since the shelf supports 55 are formed integrally on the right side walls 43a with the opening 56 being located therebetween, the right side wall 43a is hard to deform and the accuracy in the location of the temperature sensor can further be improved.

[0059] The temperature sensor 60 is mounted on the right side wall 43a with the mounting plate 57 and sensor holder 58 being interposed therebetween. Accordingly, the location of the temperature sensor relative to the turntable 54 can be fine adjusted by the mounting plate 57 and the sensor holder 58. Further, if the temperature sensor 60 should directly be mounted on the right side wall 43a of the cooking chamber 44 or the mounting plate 57 should be integral with the right side wall 43a, heat produced in the cooking chamber would easily be transferred via the right side wall or the mounting plate to the temperature sensor 60. This would reduce the accuracy in the detection of the temperature sensor 60. In the embodiment, however, the mounting plate 57 on which the temperature sensor 60 is mounted is made of the stainless steel plate having a smaller thermal expansion coefficient and a smaller thermal conductivity coefficient than the steel plate made into the right side wall 43a. Accordingly, since the mounting plate 57 is less subjected to influences of the temperature in the cooking chamber 44, the mounting plate can be prevented from deformation. Furthermore, the temperature sensor

60 can be prevented from being subjected via the mounting plate 57 to the variations in the temperature in the cooking chamber 44. This can prevent the reduction in the detection accuracy of the temperature sensor 60 itself and due to changes in the location of the temperature sensor mounted on the mounting plate 57. Additionally, since no paint is applied to the mounting plate 57, the mounting plate is less affected by the heat as compared with the case where the mounting plate is coated in black. As a result, an increase in the temperature of the mounting plate 57 can be limited. The same effect can be achieved in the case where the mounting plate 57 is coated in white.

[0060] As obvious from equation (2), the temperature of the food detected by the temperature sensor 60 is directly affected by the absolute temperature T_{am} of the temperature sensor. In view of this problem, the temperature sensor 60 detects, by means of the infrared sensing elements 19, the temperatures around the respective elements 19 and that is, the temperature of the temperature sensor 60 as well as the temperature in the cooking chamber 44 (temperature of the food). Consequently, the temperature in the cooking chamber 44 (temperature of the food) can accurately be detected.

[0061] On the other hand, in a grill cooking mode, a gridiron 67 is placed on the upper shelf supports 55 as shown by two dot chain line in FIG. 16. Food is placed on the gridiron 67 and then heated by an upper heater (not shown). Since the detecting opening 56 is located slightly below the upper shelf support 55, fatty vapor produced by the food or fat is prevented from entering the mounting plate 57 side through the detecting opening 56. Consequently, the temperature sensor 60 can be prevented from reduction in the detecting accuracy due to soil.

[0062] Modified forms will now be described. In the first to eighth embodiments, the temperature sensor 14 may be mounted on the left side wall or the ceiling of the cooking chamber, instead of the right side wall. Further, the temperature sensor may be located on a front portion of the right side wall. In this case, the temperature sensor is preferably disposed near a front upper corner. In the ninth embodiment, too, the temperature sensor 60 may be mounted on the left side wall 43b of the cooking chamber 44, instead of the right side wall 43a thereof. In the ninth embodiment, the mounting plate 57 is made of the material (stainless steel plate) having a smaller thermal expansion coefficient and a smaller thermal conductivity coefficient than the steel plate made into the right side wall 43a. The material may have a smaller thermal expansion coefficient or a smaller thermal conductivity coefficient, instead.

[0063] The foregoing description and drawings are merely illustrative of the principles of the present invention and are not to be construed in a limiting sense. Various changes and modifications will become apparent to those of ordinary skill in the art. All such changes and modifications are seen to fall within the scope of the in-

vention as defined by the appended claims.

Claims

1. A heating apparatus comprising a generally rectangular box-shaped cooking chamber (4) in which food (11) to be cooked is accommodated, a microwave generating device (12) supplying microwaves into the cooking chamber (4) so that the food (11) is heated, and a temperature sensor (14) including a plurality of infrared sensing elements (19), characterized in that the temperature sensor (14) is disposed on an upper portion of the cooking chamber (4) so as to be away from two center lines (A1, A2) passing centers of two pairs of opposite sides (4a, 4b; 4c, 4d) of the cooking chamber (4) as viewed from above, whereupon the temperature sensor (14) detects temperatures at a plurality of locations (23a) in the cooking chamber (4) respectively.
2. The heating apparatus according to claim 1, characterized in that the temperature sensor (14) is disposed near one of corners of the cooking chamber (4).
3. The heating apparatus according to claim 1 or 2, characterized in that the temperature sensor (14) is disposed outside the cooking chamber (4), and the cooking chamber (4) has a wall (3a) formed with a detecting opening (16) through which infrared rays produced in the cooking chamber (4) pass to be received by the temperature sensor (14).
4. The heating apparatus according to claim 1 or 2, characterized in that the cooking chamber (4) has a wall (3a) including an outwardly convex protrusion (13) formed with a detecting opening (16), and the temperature sensor (14) is disposed outside the protrusion (13) so that a temperature in the cooking chamber (4) is detected through the detecting opening (16).
5. The heating apparatus according to claim 3 or 4, characterized in that the detecting opening (16) is formed so that an open end (C) thereof is substantially perpendicular to a center line (B) extending in a direction of detection by the temperature sensor (14).
6. The heating apparatus according to claim 1 or 2, characterized in that the temperature sensor (14) is disposed so that a temperature detecting region (23) is substantially along a diagonal line of a bottom of the cooking chamber (4).
7. The heating apparatus according to any one of claims 1, 2 and 6, further characterized by a rotating member (10) which is disposed on a bottom of the cooking chamber (4) and on which the food (11) is placed and driving means (24) for driving the rotating member (10), and characterized in that the temperature sensor (14) is disposed so that a temperature detecting region (23) thereof includes at least a central region of the rotating member (10) and a radial region of the rotating member (10).
8. The heating apparatus according to claim 7, characterized in that the temperature sensor (14) is disposed so that a level of the temperature detecting region (23) at the center of the rotating member (10) is equal to or higher than one third of a height of the cooking chamber (4).
9. The heating apparatus according to any one of claims 1, 2, 6, 7 and 8, characterized in that the temperature sensor (14) is disposed so that a temperature detecting region (23) thereof includes a region where the food cannot be placed.
10. The heating apparatus according to claim 1 or 2, further characterized by a rotating member (10) which is disposed on a bottom of the cooking chamber (4) and on which the food (11) is placed and driving means (24) for driving the rotating member (10), and characterized in that the temperature sensor (14) comprises a plurality of rows of the temperature sensing elements (19) each of which has a central portion of the rotating member (10) as the temperature detecting region (32, 33 and 34).
11. The heating apparatus according to claim 1 or 2, characterized in that the cooking chamber (4) has a pair of shelf supports (36) on which an ovenware (35) is placed, and the temperature sensor (14) is disposed higher than the shelf supports (36) so that a temperature of the food (11) placed on the ovenware (35) is detected when the ovenware (35) is placed on the shelf supports (36).
12. The heating apparatus according to any one of claims 3, 4 and 5, characterized in that the opening (16) has a surrounding wall (38) made of an electrically conductive material and located along a peripheral edge thereof, the surrounding wall (38) having a larger projection dimension than a thickness of a plate on which the opening (16) is made.
13. The heating apparatus according to claim 1 or 2, further characterized by a rotating member (53) which is disposed on a bottom of the cooking chamber (44) and on which the food (11) is placed and driving means (52) supported on the bottom of the cooking chamber (44) for driving the rotating member (53), and characterized in that the temperature sensor (60) is supported on a side wall (43a) of the

cooking chamber (44), and the side wall (43a) on which the temperature sensor (60) is supported and the bottom of the cooking chamber (44) are formed by bending a single plate-shaped material.

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14. The heating apparatus according to claim 1 or 2, characterized in that the temperature sensor (60) is mounted on a mounting plate (57) further mounted on a side wall (43a) of the cooking chamber (44), and the mounting plate (57) is made of a material having a smaller thermal expansion coefficient or thermal conduction coefficient than a material of the side wall (43a) of the cooking chamber (44).

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15. The heating apparatus according to claim 1 or 2, characterized in that the cooking chamber (44) includes a side wall (43a) having a plurality of stages of shelf supports (55) for supporting shelf boards (67), the temperature sensor (60) is disposed outside the cooking chamber (44), and the side wall (43a) of the cooking chamber (44) has a detecting opening (56) through which infrared rays produced in the cooking chamber (44) pass to be received by the temperature sensor (44), the detecting opening (56) being located lower than the uppermost shelf support (55).

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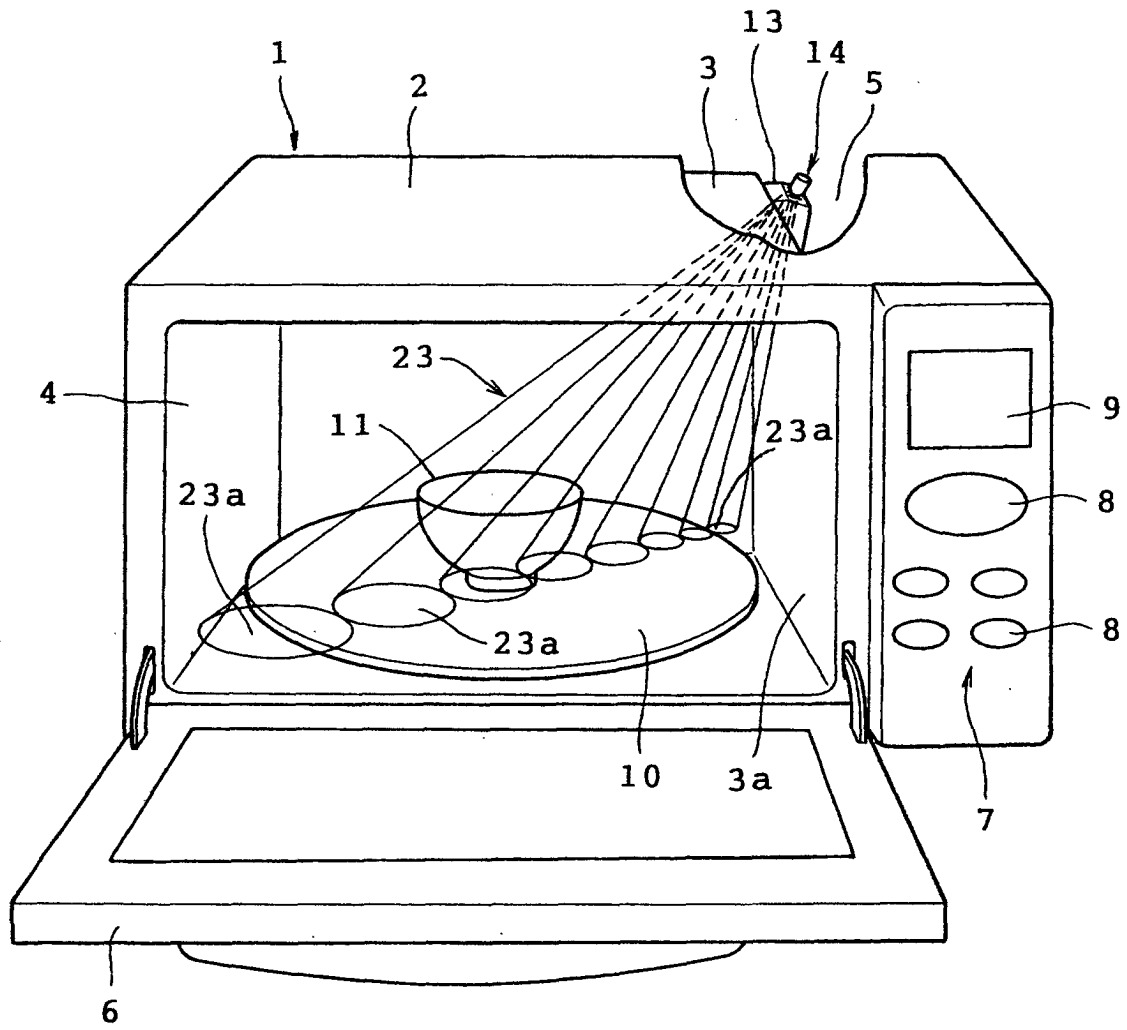


FIG. 1

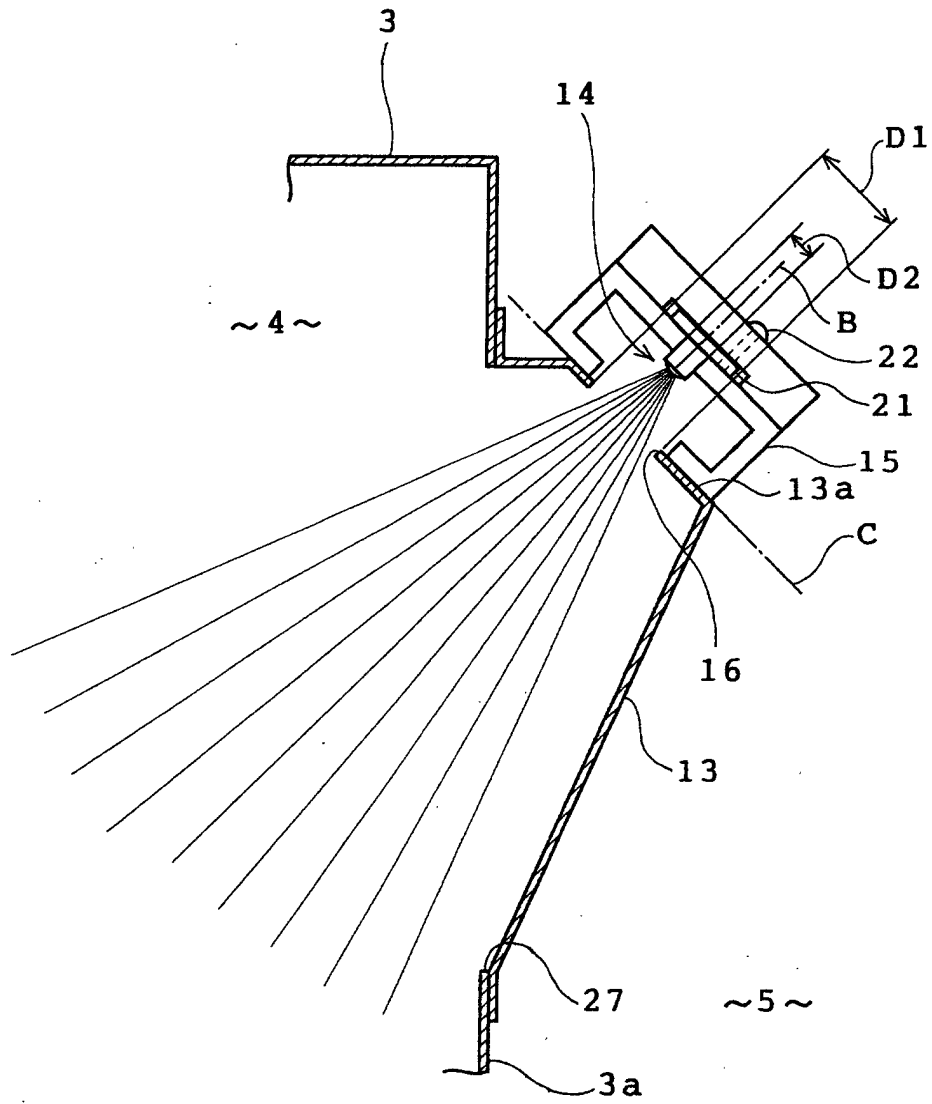


FIG. 2

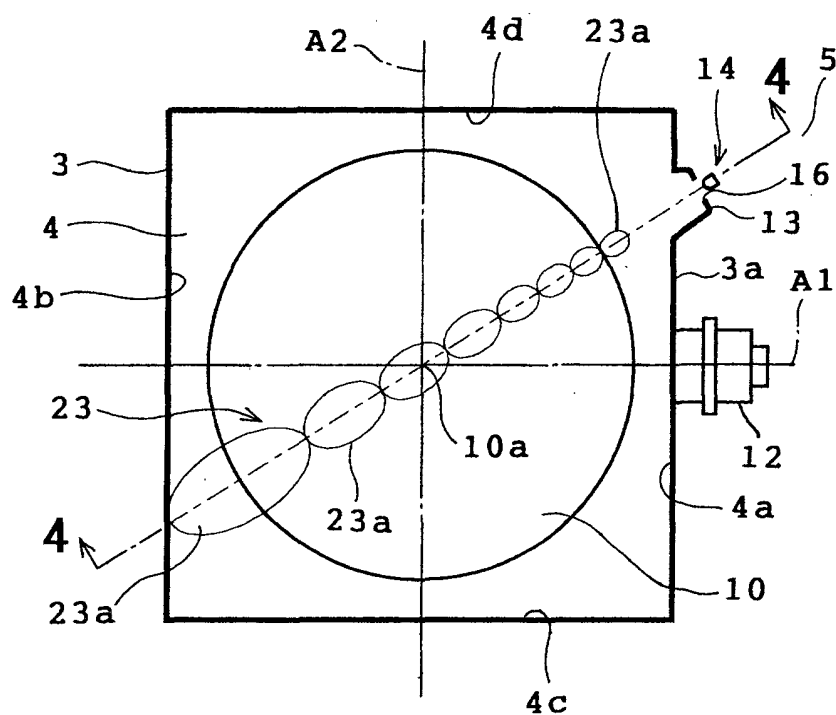


FIG. 3

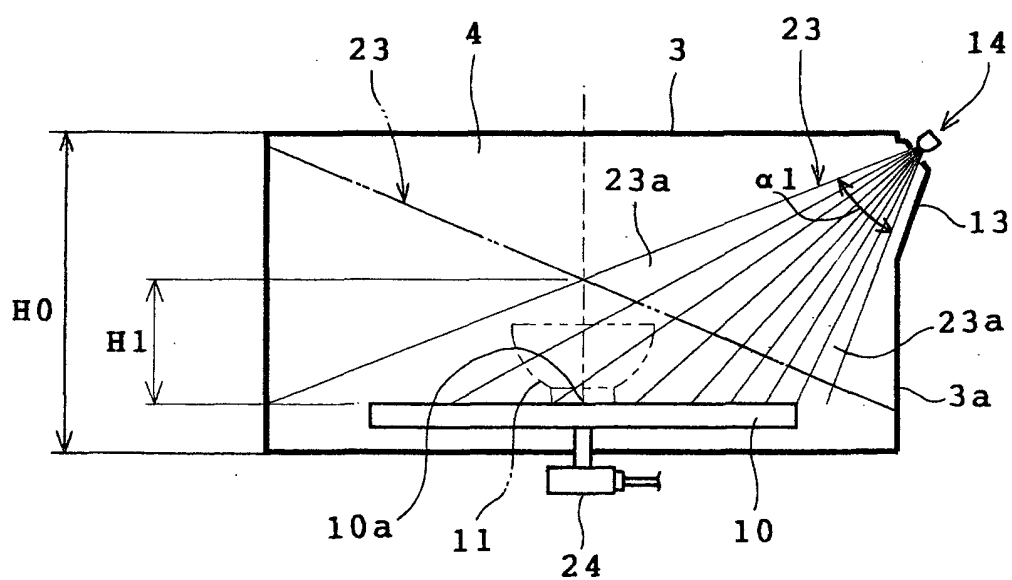


FIG. 4

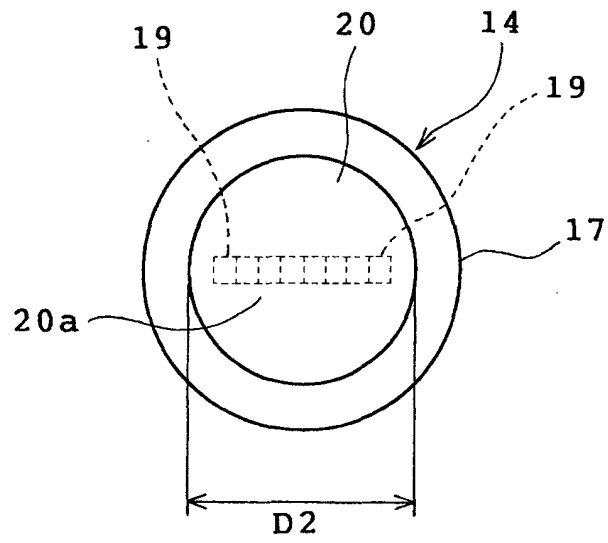


FIG. 5

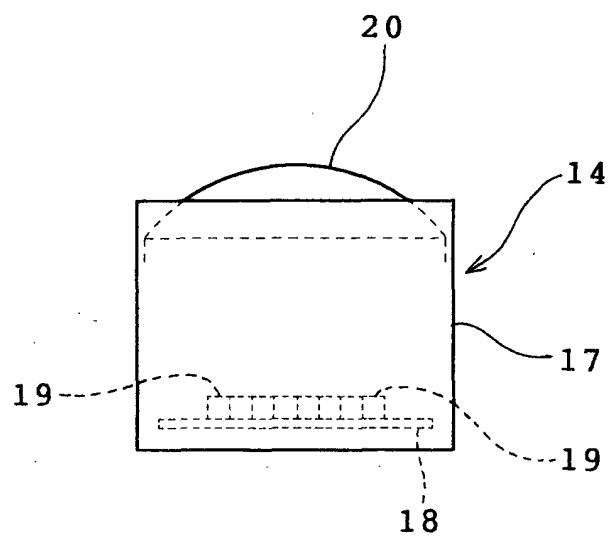


FIG. 6

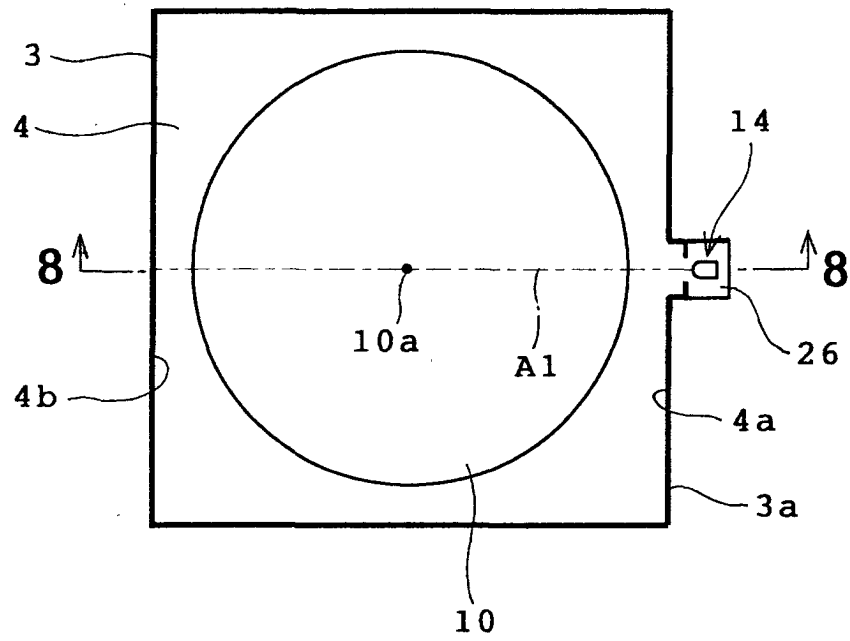


FIG. 7

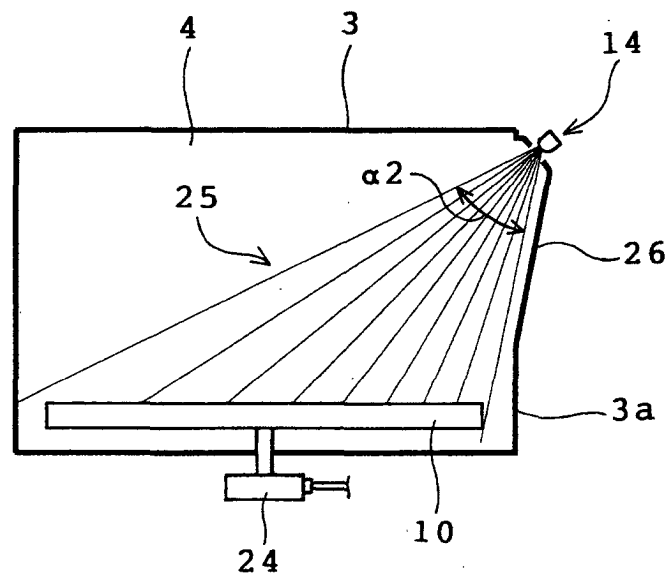


FIG. 8

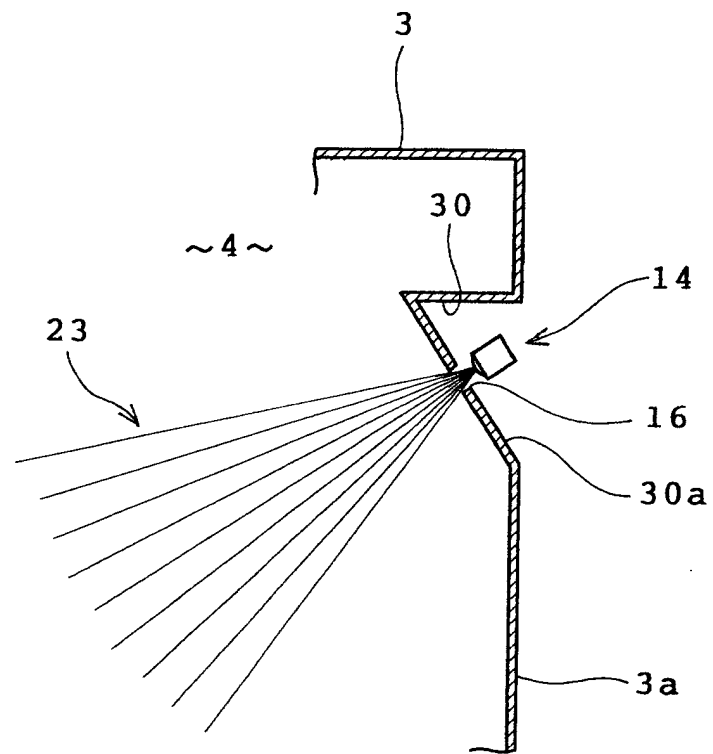


FIG. 9

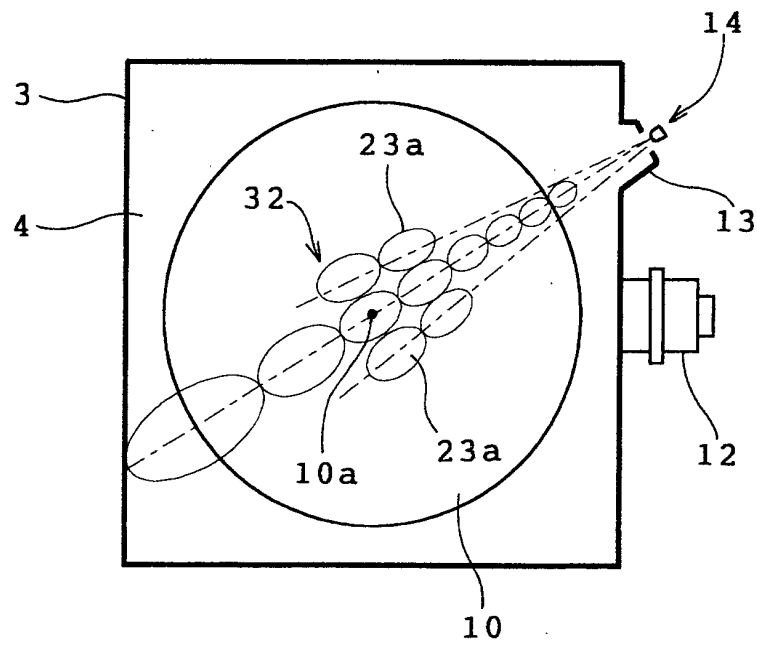


FIG. 10

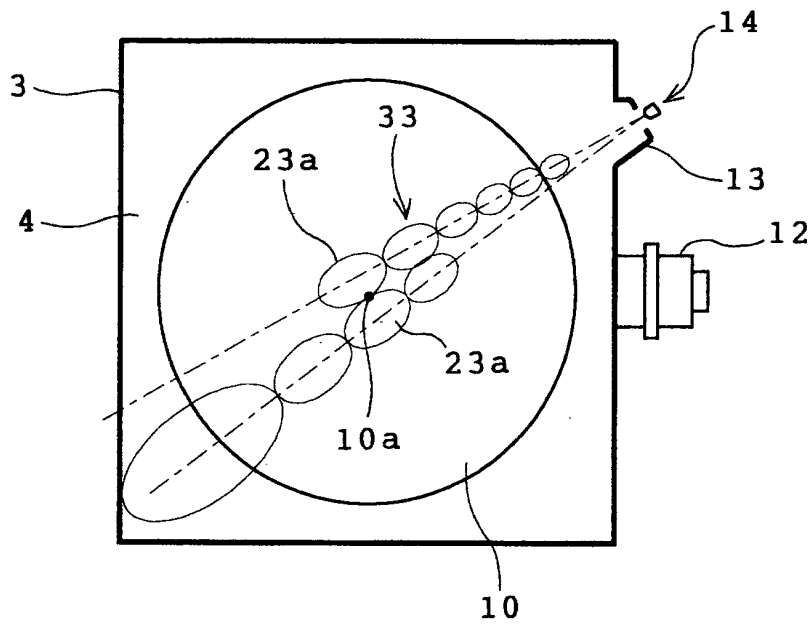


FIG. 11

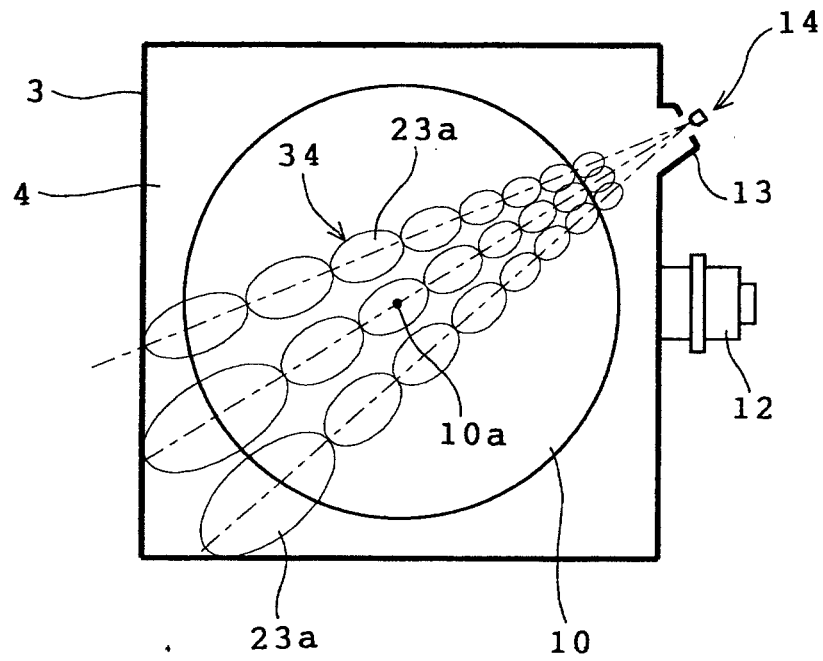


FIG. 12

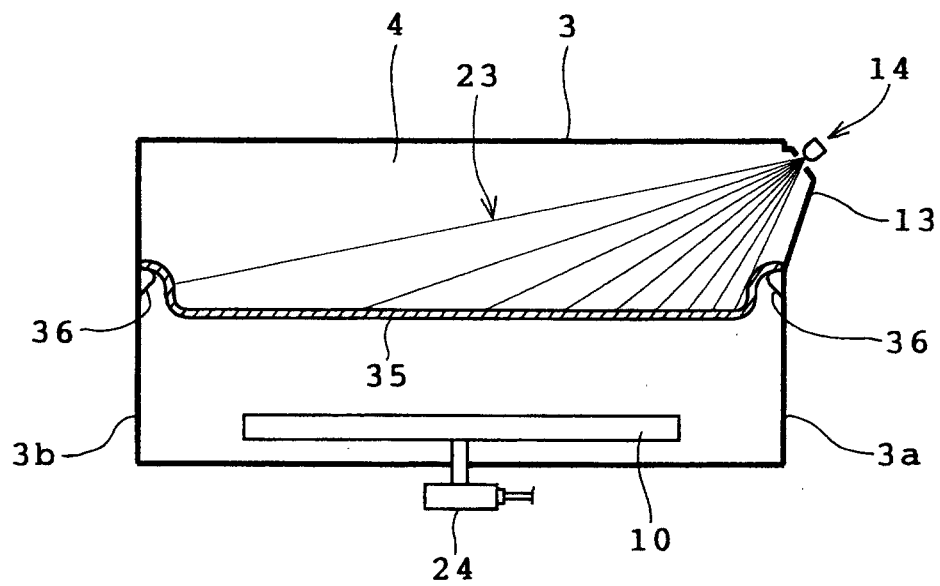


FIG. 13

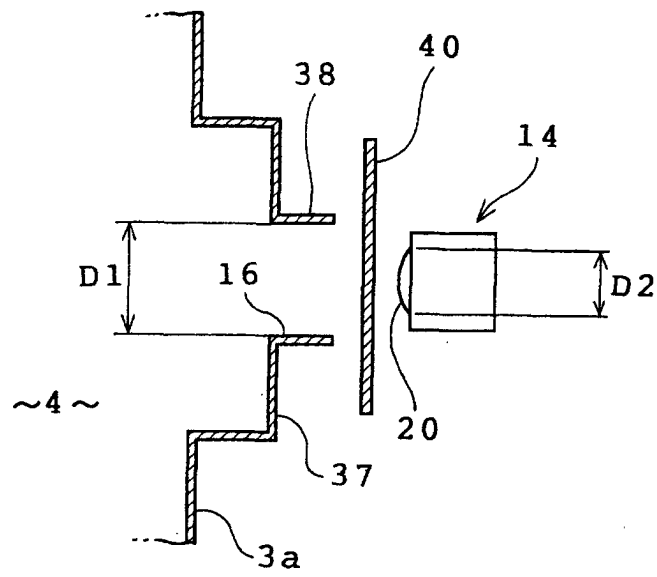


FIG. 14

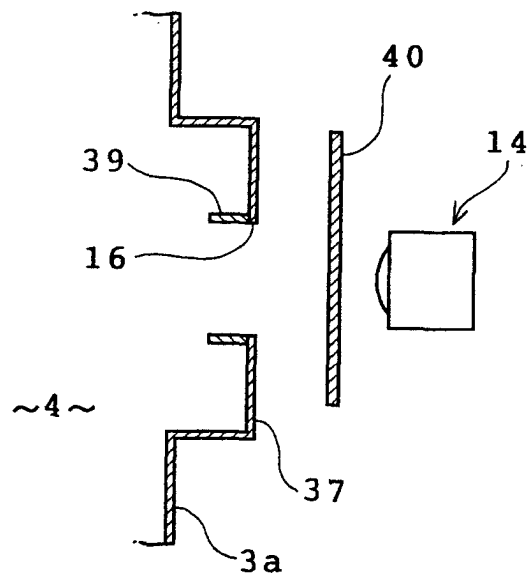


FIG. 15

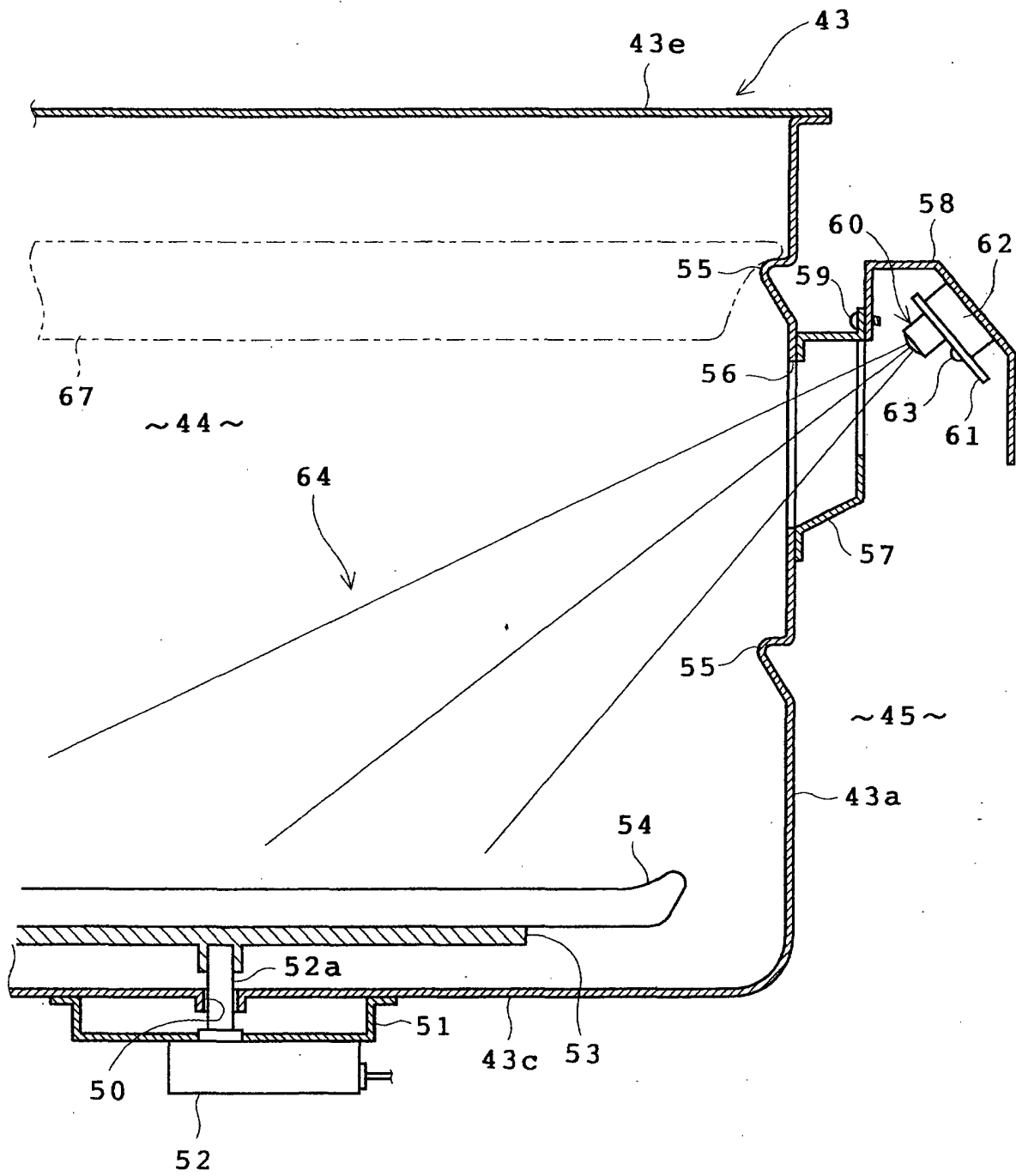


FIG. 16

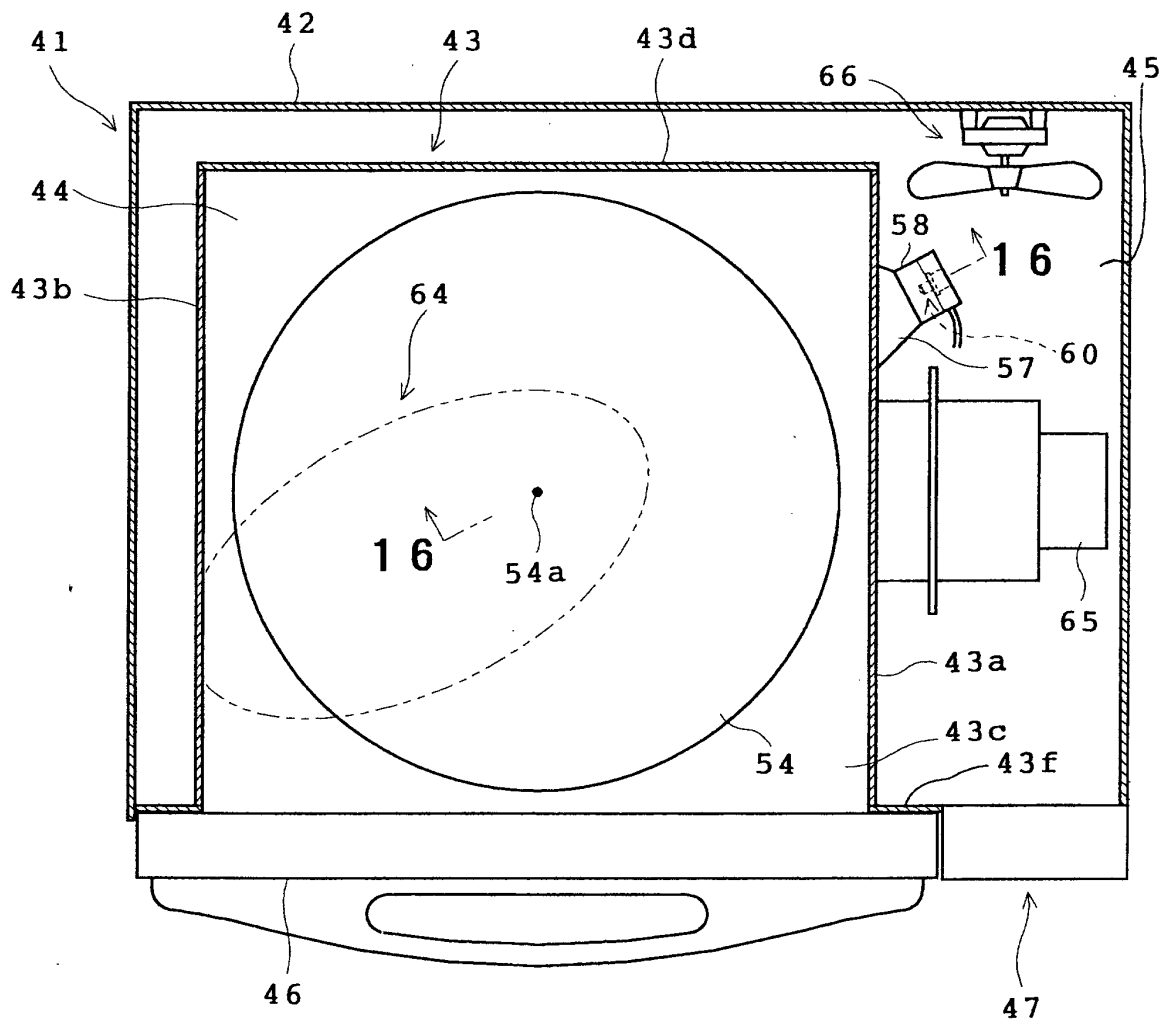


FIG. 17

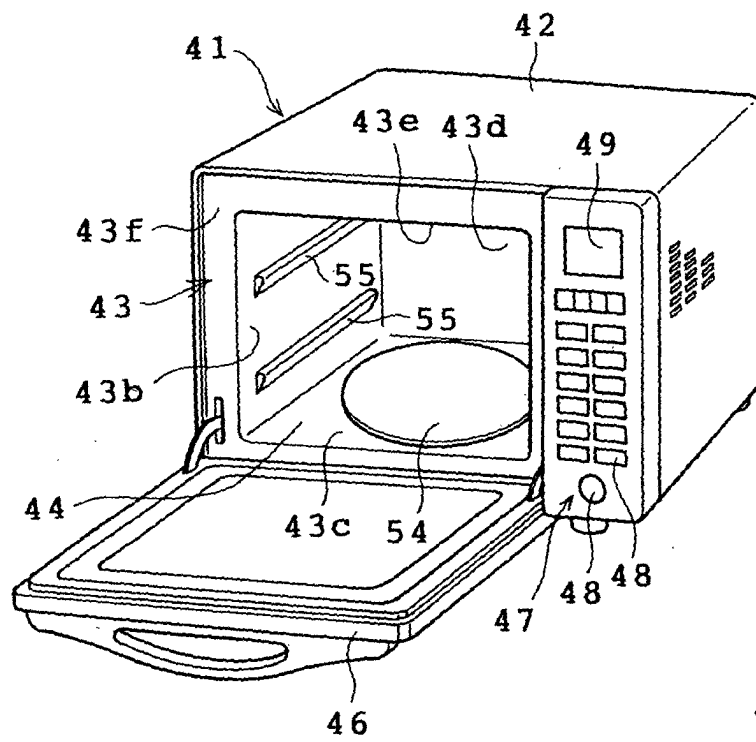


FIG. 18