March 14, 1950 W. M. HALL ET AL 2,500,676

HEATING APPARATUS

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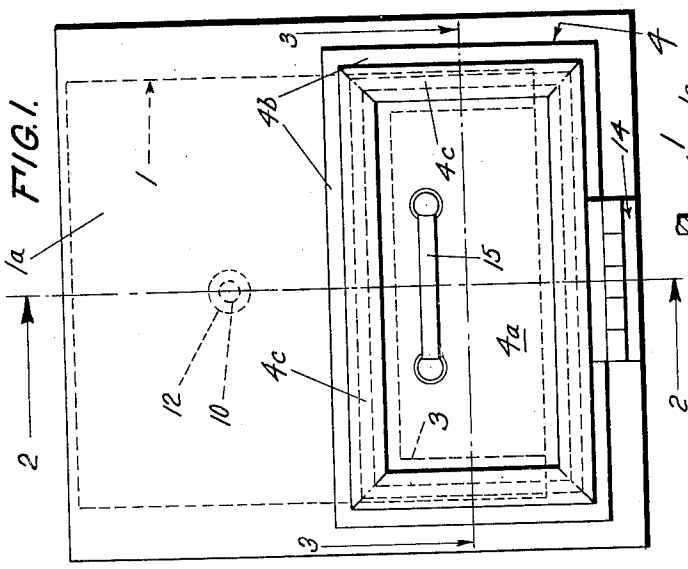


FIG. 1.

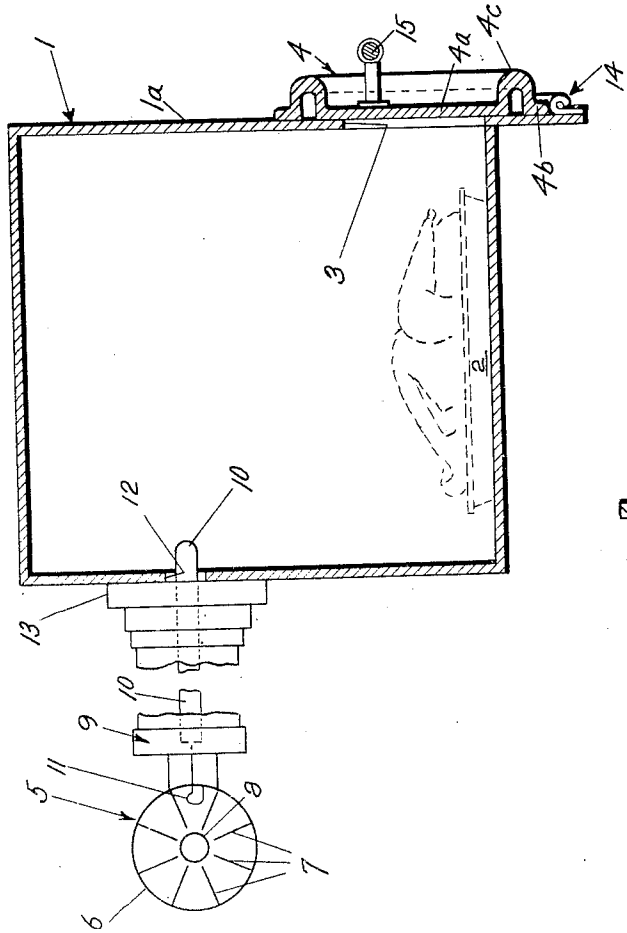


FIG. 2.

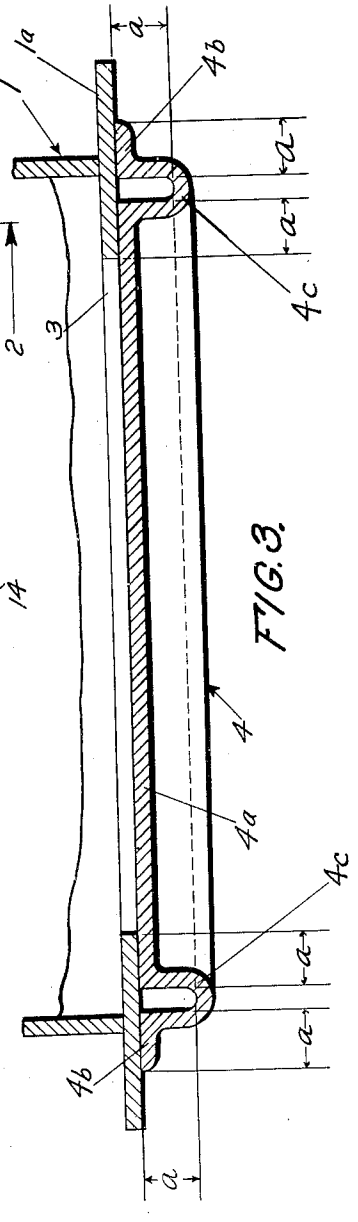


FIG. 3.

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HEATING APPARATUS

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8 Claims. (Cl. 219—47)

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This invention relates to heating apparatus, and more particularly to an oven-type microwave heating device.

An object of this invention is to provide an improved door structure for microwave heaters of the oven type.

Another object is to provide a convenient means of access to metallic enclosures or cavities which are adapted to be supplied with microwave energy, which means of access will not affect or interfere with the wave characteristics of the cavity.

A further object is to provide a means of access to a metallic radio-frequency cavity, which will not permit any appreciable escape or leakage of microwave energy from the interior of the cavity.

The foregoing and other objects of the invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein:

Fig. 1 is a front view of an oven according to this invention;

Fig. 2 is a vertical section taken along line 2—2 of Fig. 1; and

Fig. 3 is a partial horizontal section, on an enlarged scale, taken along line 3—3 of Fig. 1.

In oven-type microwave cooking devices, the problem arises of providing adequate shielding of the door opening to prevent escape of radio-frequency energy. As the field intensity inside the oven is very high, this may be an important problem, both to minimize radio-frequency interference and to prevent radio-frequency burns if a person happens to come into contact with the edge of the door. Any feasible type of spring finger contact, between the door and the oven, which would provide adequate contact, would be extremely difficult to keep clean. Similar problems would be presented by a conventional type of radio-frequency choke structure.

It has been found that a planar contact type closure, of such size that the metallic contact area between the door and the oven is approximately a quarter-wavelength long, is very effective, giving substantially complete shielding yet being free from sparking. Such a closure is within the scope of this invention.

An improved closure contact structure has been devised, however, which gives better shielding than the single quarter-wavelength overlapping, does not require a particularly good contact surface, and has an easy surface to keep clean. This improved contact structure, which will be described in a more detailed manner below, might

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be termed a two-stage choke, and consists of two metallic contact surfaces or areas each approximately a quarter-wavelength long, separated by a groove approximately a quarter-wavelength deep, said contact surfaces and groove being integral with the closure.

Now referring to the drawing, a hollow rectangular prismoidal enclosure or cavity 1 is made of a suitable metal and has rather thin walls as shown; enclosure 1 is adapted to serve as the oven of the cooking apparatus. Oven 1 is adapted to have a container 2 of food placed therein, said container resting on the bottom wall of the oven while the food therein is being cooked. In order to allow access to the interior of the oven for placing the food therein and for removing the food therefrom, a rectangular aperture 3 is provided in the front wall of the oven 1 near the lower end of said wall, this aperture being closable by means of a pivotally-supported metal door 4, to be described more in detail hereinafter. When door 4 is closed, the enclosure 1 is entirely closed, except for the opening 12 for the exciting means to be described hereinafter.

Numeral 5 generally designates an electron-discharge device of the magnetron type, which includes, for example, an evacuated envelope 6, made of highly conductive material, such as copper, and provided with a plurality of inwardly-directed, radially-disposed anode vanes 7. The arrangement is such that each pair of adjacent anode vanes 7 forms, together with that portion of the envelope lying therebetween, a cavity resonator whose natural frequency is, as is well known to those skilled in the art, a function of the geometry of the physical elements making up the same. For the purposes of the present invention it is desirable that the dimensions of each such cavity resonator be such that the wavelength of the electrical oscillations adapted to be generated therein has a predetermined value, for example, of the order of ten centimeters. Wavelengths of this order lie in the microwave region of the frequency spectrum. However, this invention is equally applicable to radio-frequency energy of longer or shorter wavelengths, such wavelengths lying within or without the microwave region.

Centrally located in envelope 6 is a highly electron-emissive cathode member 8, for example, of the well-known alkaline-earth metal oxide type, said cathode member being provided with conventional means (not shown) for raising the temperature thereof to a level sufficient for thermionic emission.

The electron-discharge device 5 is completed by magnetic means (not shown) for establishing a magnetic field in a direction transversely of the electron path between the cathode and anode members thereof.

Magnetron 5 is energized from any suitable source (not shown) and when so energized delivers microwave energy or high-frequency electromagnetic waves to a coaxial transmission line 9 the inner conductor 10 of which is coupled to oscillator 5 by a loop 11 and the outer conductor of which is connected to envelope 6. The inner conductor 10 of line 9 extends directly into the interior of oven 1 through a suitable opening 12 provided in the rear wall thereof, while the outer conductor of said line is connected to the rear wall of the oven 1 by a suitable fastening means 13. Opening 12 is preferably centered with respect to the vertical side walls of the oven, as shown in Fig. 1, and is preferably somewhat above the horizontal midplane of the oven, as shown in Figs. 1 and 2.

The front wall 1*a* of the oven, as shown in Figs. 1 and 3, extends an appreciable distance beyond the oven 1 at the sides and bottom thereof, to provide side and bottom outwardly-projecting flanges at the front of the oven. A hinge structure 14, fixed to the bottom flange of the oven, pivotally supports door 4 on the oven. Door 4 is substantially rectangular in configuration and has a planar or flat central portion 4*a*, a flat peripheral or outer flange portion 4*b*, and an inwardly-opening outwardly-extending rib portion 4*c* between portions 4*a* and 4*b*. Portions 4*a*, 4*b*, and 4*c* are all substantially rectangular in configuration. The internal depth *a* of the inwardly-opening groove which forms rib portion 4*c*, measured from the inner surface of the door, has a value such that it is approximately equal to one-fourth of the wavelength of the waves generated by oscillator 5, and this internal depth is constant throughout all four sides of the rib portion. The total area of the inner face of door 4 is substantially larger than the area of rectangular aperture 3, and door 4 is so positioned that the center of the door's inner face area coincides with the center of aperture 3.

The central portion 4*a* of door 4 has an area somewhat larger than rectangular aperture 3, as shown in Fig. 1, and the distance, on all four sides of aperture 3, from the edge of said aperture to the nearest or inner edge of the corresponding groove forming rib portion 4*c*, is made equal to *a* and is therefore approximately one-quarter wavelength of the waves generated by oscillator 5. This aforesaid distance is of course measured when the door is in place on oven 1.

The distance, on all four sides of door 4, from the extreme outer edge of flange portion 4*b* to the nearest or outer edge of the corresponding groove forming rib portion 4*c*, is also made equal to *a* and is therefore also approximately one-quarter wavelength.

The inner planar surface of the door 4 is made reasonably smooth or uniform, and in the closed position of the door, which is the only position thereof illustrated in the drawing, the inner planar surface of said door is in firm metallic contact with the front wall 1*a* of enclosure 1 in a region thereof adjacent to and immediately surrounding all sides of aperture 3, as is apparent from Figs. 2 and 3. The side and bottom outwardly-projecting flanges of wall 1*a* assist in achieving such contact.

Since the distances *a* are all equal to a quarter-wavelength, two surfaces or areas of contact between the door and the oven are provided, these surfaces or areas each being approximately a quarter-wavelength long (or wide), said contact surfaces being separated by a groove in portion 4*c* which is approximately a quarter-wavelength deep. One of these areas extends between the edge of aperture 3 and the inner edge of the groove in door portion 4*c*, and the other of these contact areas extends between the outer edge of said groove and the outer edge of door portion 4*b*. The above-described closure contact structure may for convenience be termed a two-stage choke with a groove between the two stages.

A handle 15 is attached to door 4 to enable manual opening and closing thereof.

It is desirable to prevent leakage of microwave energy from the interior of cavity or enclosure 1, when door 4 is closed and oscillator 5 is energized to produce high-frequency electromagnetic waves or microwave energy. Microwave energy is fed by coaxial line 9 and exciting probe or rod 10, from magnetron oscillator 5 to the interior of oven or cavity 1. Leakage of microwave energy from the interior of cavity 1 would ordinarily take place through aperture 3, unless the door structure were devised to substantially prevent such leakage. In this invention, the structure of door 4, and its contact with enclosure 1, are designed to shield the aperture 3 to prevent escape of radio-frequency energy therethrough.

Due to the fact that the inner planar surface of the door is only reasonably smooth or uniform, good but not perfect contact between the door and the outer surface of the enclosure is provided throughout the innermost or first contact surface or area. Therefore, this contact area acts as a quarter-wavelength choke with a minute amount of insulation, presenting a high impedance at the edges of the aperture 3 and preventing any appreciable leakage of microwave energy through or over the edges of said aperture to the exterior of cavity 1.

The groove in door portion 4*c*, which groove is a quarter-wavelength deep, provides a discontinuity at the edge or end of the first contact area, above referred to. Adjoining or surrounding the groove at its outer edge is a second contact area, as above described. This second area is also approximately a quarter-wavelength long and functions as a quarter-wave choke as does the first contact area, so that said second area functions as the second stage of the two-stage choke. The two contact areas or quarter-wave chokes are effectively separated by the discontinuity provided by the groove, and effectively function in combination as a two-stage radio-frequency choke the two stages of which are in series with each other.

It has been found that such a two-stage choke provides exceptionally complete shielding, does not require particularly good contact surfaces, and has an easy surface to keep clean. If there is metallic contact between the door and the enclosure, the radio-frequency choke functions as desired, but if there is no contact the structure functions as a low-impedance quarter-wave choke.

As stated above, a contact type closure, in which the contact is approximately a quarter-wavelength long, has been found to be very effective also. In this case, the structure functions as a single quarter-wave choke, presenting a high impedance at the edges of the aperture, giving

very complete shielding yet being free from sparking.

Of course, it is to be understood that this invention is not limited to the particular details as described above, as many equivalents will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of this invention within the art.

What is claimed is:

1. High-frequency apparatus, comprising a metallic enclosure, means for supplying high-frequency electromagnetic waves of a predetermined wavelength to the interior of said enclosure, said enclosure having an access aperture therein, and a metallic door for closing said aperture, said door, upon closure thereof, being in direct metallic contact with said enclosure outside of said aperture over a planar contact area whose width is substantially one-quarter of said wavelength.

2. High-frequency apparatus, comprising a metallic enclosure, means for supplying high-frequency electromagnetic waves of a predetermined wavelength to the interior of said enclosure, said enclosure having an access aperture therein, and a metallic door for closing said aperture, said door being mounted to allow arcuate motion thereof and upon closure being constructed to be in direct metallic contact with said enclosure over a contact area entirely surrounding said aperture, said area having a width substantially one-quarter of said wavelength.

3. High-frequency apparatus, comprising a metallic enclosure, means for supplying high-frequency electromagnetic waves of a predetermined wavelength to the interior of said enclosure, said enclosure having an access aperture therein, and a metallic door for closing said aperture, said door, upon closure thereof, being in direct metallic contact with said enclosure outside of said aperture over a plurality of spaced contact areas whose widths are each substantially one-quarter of said wavelength, and the distance between said areas being substantially less than a quarter wave length.

4. High-frequency apparatus, comprising a metallic enclosure, means for supplying high-frequency electromagnetic waves of a predetermined wavelength to the interior of said enclosure, said enclosure having an access aperture therein, and a metallic door for closing said aperture, said door, upon closure thereof, being in direct metallic contact with said enclosure over a pair of spaced planar contact areas each entirely surrounding said aperture, each of said areas having a width substantially one-quarter of said wavelength.

5. High-frequency apparatus, comprising a metallic enclosure, means for supplying high-frequency electromagnetic waves of a predetermined wavelength to the interior of said enclosure, said enclosure having an access aperture therein, and a metallic door for closing said aperture, said door, upon closure thereof, being in direct metallic contact with said enclosure outside of said aperture over a pair of spaced contact areas whose widths are each substantially one-quarter of said wavelength, said areas being spaced from each other by a groove whose depth is substantially one-quarter of said wavelength.

6. High-frequency apparatus, comprising a metallic enclosure, means for supplying high-frequency electromagnetic waves of a predetermined wavelength to the interior of said enclosure, said enclosure having an access aperture therein, and a metallic door for closing said aperture, said door, upon closure thereof, being in direct metallic contact with said enclosure outside of said aperture over a pair of spaced planar contact areas whose widths are each substantially one-quarter of said wavelength, said areas being spaced from each other by a groove in said door whose depth is substantially one-quarter of said wavelength.

7. Heating apparatus including an oven, comprising a metallic enclosure, means for supplying high-frequency electromagnetic waves of a predetermined wavelength to the interior of said enclosure, said enclosure having an access aperture therein, and a metallic door for closing said aperture, said door, upon closure thereof, being in direct metallic contact with said enclosure over a pair of spaced contact areas each entirely surrounding said aperture, each of said areas having a width substantially one-quarter of said wavelength, said areas being spaced from each other throughout their extents by a groove whose depth is substantially one-quarter of said wavelength.

8. High-frequency apparatus, comprising a metallic enclosure, means for supplying high-frequency electromagnetic waves of a predetermined wavelength to the interior of said enclosure, said enclosure having an access aperture therein, and a metallic door for closing said aperture, said door, upon closure thereof, being in direct metallic contact with said enclosure over a pair of spaced planar contact areas each entirely surrounding said aperture, each of said areas having a width substantially one-quarter of said wavelength, said areas being spaced from each other throughout their extents by a groove in said door whose depth is substantially one-quarter of said wavelength, and whose width is substantially less than a quarter wave length.

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