

[54] **PARTITION AND FRONT WALL FORMING
CHOKE STRUCTURE FOR A MICROWAVE
OVEN**

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abandoned.

[30] **Foreign Application Priority Data**

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[51] **Int. Cl.** **H05b 9/06**

[58] **Field of Search**..... 219/10.55; 333/70 S, 73 R,
333/73 C, 73 W

[56] **References Cited**

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[57] **ABSTRACT**

An electromagnetic-wave seal in a high-frequency heating equipment, comprising a first electromagnetic-wave labyrinth which has its terminal short-circuited either to a front port of a heating chamber or to a door and which is approximately equal in total length to an integral times a half-wavelength of the fundamental wavelength, and a second electromagnetic-wave labyrinth which has its terminal short-circuited to the vicinity of an inlet of said first electromagnetic-wave labyrinth and which is approximately equal in total length to an odd number times the quarter-wavelength of the fundamental wavelength, thereby efficiently preventing leakage of electromagnetic-waves.

6 Claims, 17 Drawing Figures

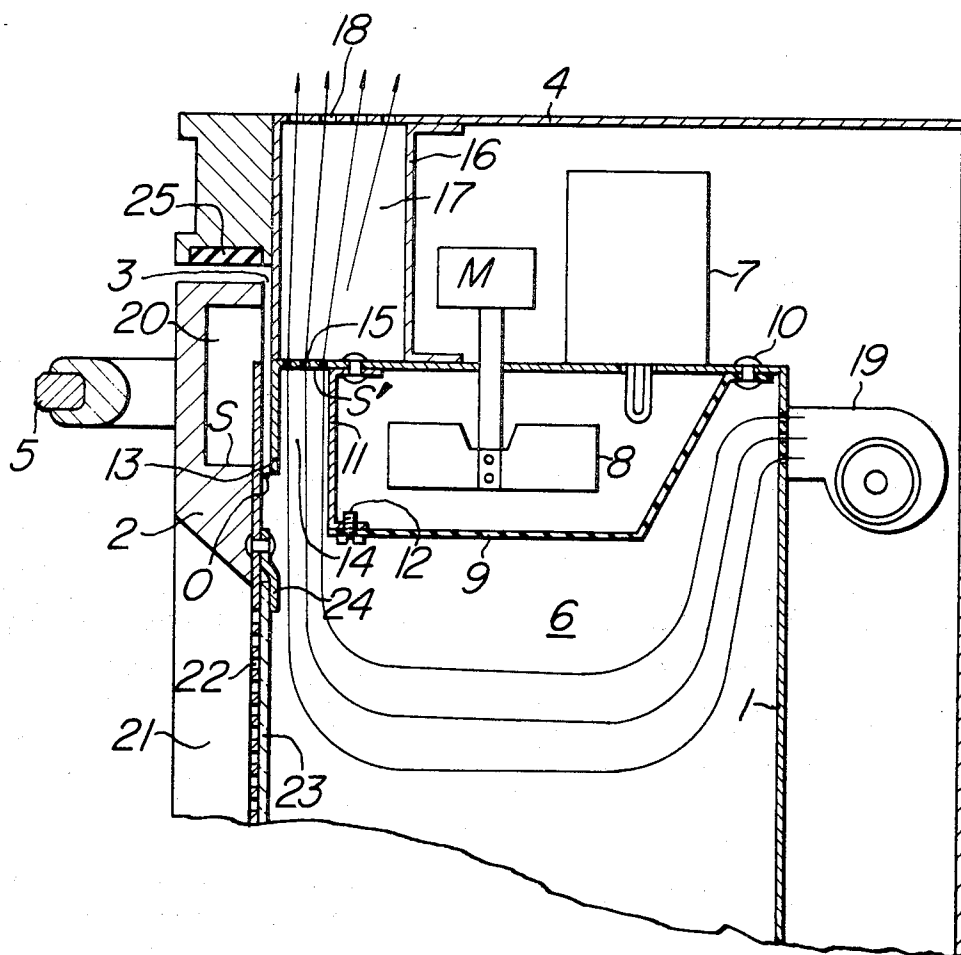


FIG. 1

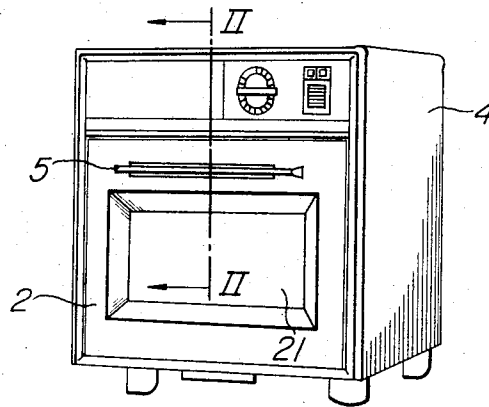
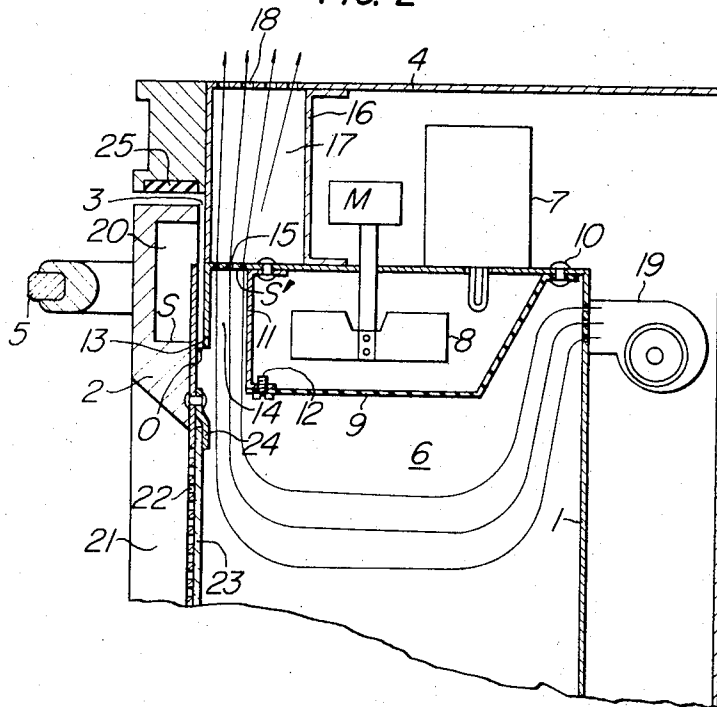


FIG. 2



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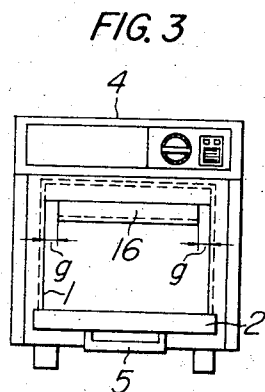
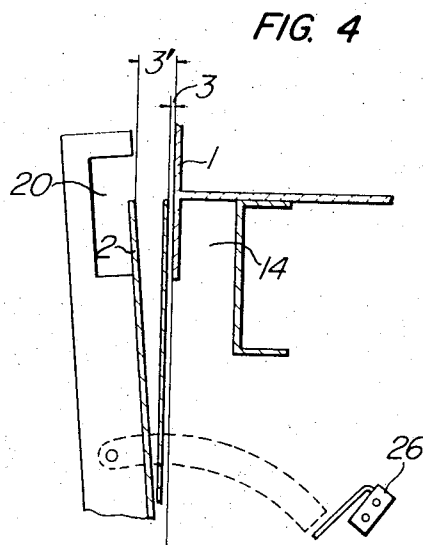
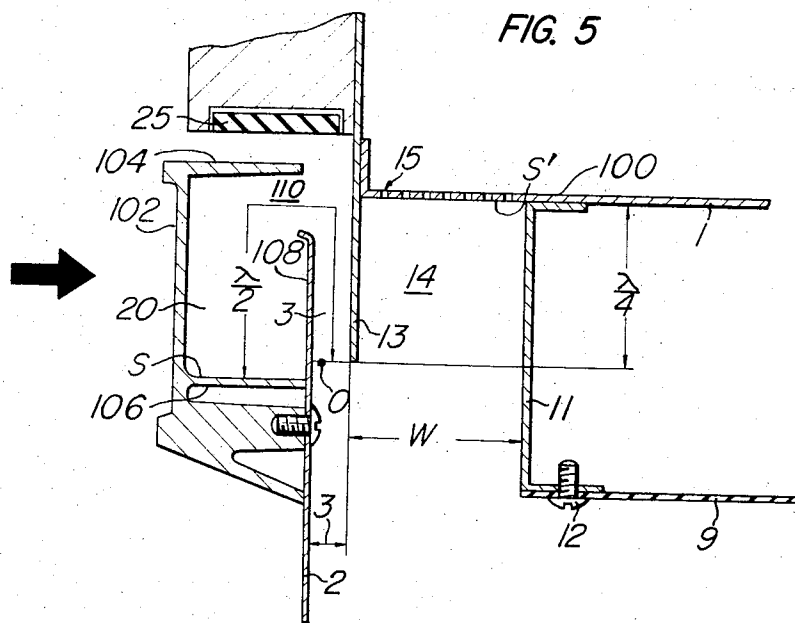


FIG. 6

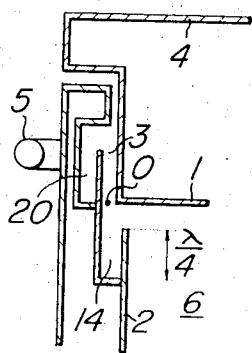


FIG. 7

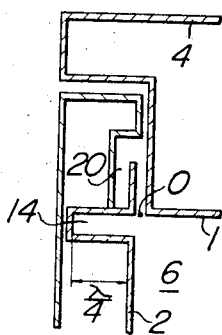


FIG. 8

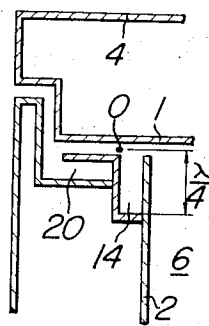
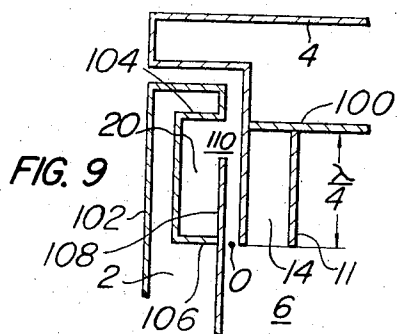


FIG. 10

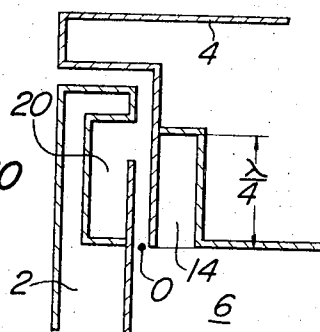
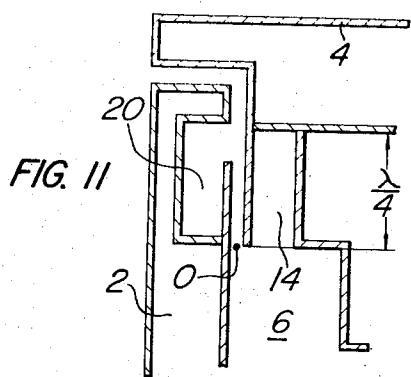
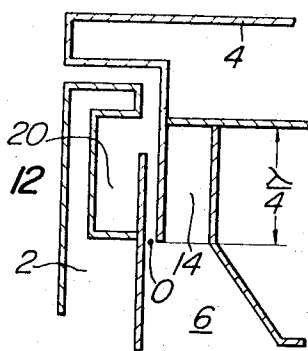


FIG. 12



PARTITION AND FRONT WALL FORMING CHOKE STRUCTURE FOR A MICROWAVE OVEN

This is a continuation, of application Ser. No. 119,628, filed Mar. 1, 1971, now abandoned.

This invention relates to a high-frequency heating equipment, and more particularly to an electromagnetic-wave seal in the high-frequency heating equipment.

The principal object of this invention is to provide a high-frequency heating equipment which comprises a first electromagnetic-wave labyrinth having its terminal short-circuited to either a front port of a heating chamber or a door of the equipment and being approximately equal in total length to an integral times half-wavelength, and a second electromagnetic-wave labyrinth having its terminal short-circuited to the vicinity of an inlet of the first electromagnetic-wave labyrinth and being approximately equal in total length to an odd number times a quarter-wavelength, thereby efficiently preventing leakage of electromagnetic-waves and eliminating adverse effects to the human body and interference to communication.

Another object of this invention is to provide an inexpensive electromagnetic-wave seal which may prevent the leakage of electromagnetic-waves when opening the door, merely by locating the second electromagnetic-wave labyrinth at the upper part of the front of the heating chamber.

Still another object of this invention is to provide an electromagnetic-wave seal in which a partition wall defining the second electromagnetic-wave labyrinth is also used as fittings for a dielectric plate provided so as to cover a stirrer and the antenna section of a magnetron, thereby making the seal inexpensive.

A further object of this invention is to provide a high-frequency heating equipment wherein the partition wall defining the second electromagnetic-wave labyrinth and the dielectric plate form an air guide plate and an air passage, a plurality of air holes are formed at the top of the air passage, and a plurality of air holes are also formed in an outer housing to which the first-mentioned air holes are opposed, whereby vapor produced in the heating chamber is efficiently exhausted to the exterior by utilizing the second labyrinth, and therewith, a transparent body of glass or the like being provided at a peep window is prevented from becoming dim.

A still further object of this invention is to make the first and second labyrinths smaller in size by packing into them a filler made of a dielectric material of low high-frequency loss.

A yet further object of this invention is to efficiently and positively prevent leakage of electromagnetic waves by combining the first labyrinth, the second one and an electromagnetic-wave absorbing member.

This invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of the whole of a high-frequency heating equipment;

FIG. 2 is an enlarged sectional view taken along a line II—II in FIG. 1;

FIG. 3 is a front view showing the state of the equipment in which a door is opened;

FIG. 4 is a sectional view for explaining the operation of opening and closing the door of the equipment;

FIG. 5 is an enlarged sectional view of an electromagnetic-wave sealing section essential to the equipment;

FIGS. 6 to 14 are sectional views which illustrate embodiments of the electromagnetic-wave sealing section, respectively;

FIGS. 15 and 16 are diagrams for explaining the principle for sealing electromagnetic waves in the equipment; and

FIG. 17 is a sectional view of a conventional choke-sealing section.

Referring first to FIG. 17, a prior art choke-sealing section will be briefly described. Heretofore it has been common practice that, as shown by hatching in the figure, a labyrinth C for electromagnetic waves which has a length of approximately one-half of the wavelength of high-frequency energy filled within a housing 1 is formed at the junction between the housing 1 and a door 2, whereby the amount of electromagnetic waves leaking through the gap 3 between the housing 1 and the door 2 is reduced to 10 mW/cm² or so at the output of high-frequency heating equipment adverse effects of 1 kW. With the progress of study on an impediment to the human body due to electromagnetic waves, however, it has been found that the allowable power level to the human body should be lowered to 1 mW/cm².

A high-frequency heating equipment according to this invention is juxtaposed, in order to accomplish the above-mentioned objects, with a second electromagnetic-wave labyrinth having a total length of approximately one-fourth wavelength in the vicinity of an inlet O of the electromagnetic-wave labyrinth C being approximately one-half wavelength in overall length, without rendering the construction of the door more complicated than in the prior art. Thus, the amount of electromagnetic waves leaking through the gap 3 between the housing 1 and the door 2 is decreased to approximately 0.1 mW/cm². Even if the gap 3 becomes as large as 5 mm on account of, e.g., non-uniformity in the dimensions of mechanism components during mass production or deformation of such components, the amount of the leaking electromagnetic waves may be made smaller than 1 mW/cm² which is the allowable value to the human body. Incidentally, in FIG. 17, reference numeral 5 designates a handle of the door 2, while numeral 6 designates a heating chamber.

Description will now be made of an embodiment illustrated in FIGS. 1 to 5. Numeral 1 designates a housing which defines a heating chamber 6. Numeral 2 represents a door, 3 the space between the housing 1 and the door 2 when the door is closed, 4 an outer housing, and 5 a handle disposed on the front of the door. Numeral 7 represents a magnetron provided on the top of the heating chamber 6, and numeral 8 a stirrer for agitating electromagnetic waves. Shown at 9 is a plate composed of dielectrics which is so arranged as to cover the lower parts of the magnetron 7 as well as the stirrer 8 and through which the electromagnetic waves permeate. One end of the dielectric plate 9 is attached to the top of the heating chamber by means of a screw 10, while the other end is anchored by means of a screw 12 to the lower end of a U-shaped partition wall 11 provided at the upper part of the front of the heating chamber 6, whereby the dielectric plate 9 protects the magnetron 7 and the stirrer 8 from vapor which is produced in the heating chamber 6.

The partition wall 11, which is secured to the top wall 100 of the heating chamber, defines a labyrinth equal in length to one-fourth of the fundamental wavelength of the oscillation from the magnetron 7, between it and a front wall 13 formed at the upper part of the front of the heating chamber 6.

In a wall defining the terminal of the labyrinth 14, a plurality of air vents 15 are provided so as to oppose an exhaust passage 17 defined by the housing 1, the outer housing 4 and the partition wall 16. Gaps g are formed between both ends of the partition wall 16 and side-walls of the heating chamber 6, respectively. Numeral 18 designates a plurality of air vents provided in that portion of the outer housing 4 which opposes the exhaust passage 17, while numeral 19 represents a blower which is disposed at the upper part of the rear of the heating chamber 6. Shown at 20 is a labyrinth which is formed in a manner oppose to that part of the door 2 being held in contact with a front port of the heating chamber 6, and which has the length from its origin O to its terminal S made one-half of the fundamental wavelength (refer to FIG. 5).

A peep window 21 formed at the central part of the door 2 is provided with a punched metal member 22, and with a transparent plate 23 of glass, etc. which is fixed to the rear of the punched metal plate 22 by means of fittings 24. A peripheral edge 25 of the port of the heating chamber 6 consists of an electromagnetic-wave absorbing member disposed in opposition to a peripheral edge of the door 2 and made of ferrite rubber or the like.

Referring particularly to FIG. 5, the outer peripheral portion of door 2 is defined by a forward member 102 and spaced upper and lower members 104 and 106, respectively, which extend substantially perpendicular to forward member 102. An inner member 108 is positioned substantially parallel to and spaced from the forward member 102, and when door 2 is closed, inner member 108 is parallel to and spaced from the front wall 13 of the heating chamber. A gap 110 is formed between the inner member 108 and upper member 104.

With the above construction, air is sent into the heating chamber 6 by the blower 19 during cooking. The air sent is guided by the dielectric plate 9, and flows upwards along the transparent plate 23 as shown by arrows in FIG. 2. Thus, it exhausts vapor within the heating chamber 6 to the exterior via the labyrinth 14, the exhaust holes 15, the exhaust passage 17 and the exhaust holes 18.

According to this embodiment, the labyrinth 14 is defined only at the upper part of the front of the heating chamber 6. When the door 2 is opened in the manner illustrated in FIG. 4, the gap 3' between the front opening of the heating chamber 6 and the door 2 is narrower closer to the hinge (not shown) and the amount of leakage of electromagnetic waves smaller accordingly. For this reason, even when the labyrinth 14 is disposed as in the above embodiment only at the upper part presenting the largest amount of leakage of electromagnetic waves, the leakage of electromagnetic waves may be sufficiently prevented till actuation of a microswitch 26.

Needless to say, when the labyrinth 14 is formed over the entire peripheral edge of the front port of the heating chamber 6, the sealing effect will be more enhanced.

Referring now to FIGS. 15 and 16, description will be made of the principle for sealing electromagnetic waves with both the labyrinths 14 and 20. A circuit shown in FIG. 16 wherein the impedance Z_A of the first electromagnetic-wave labyrinth 20, as viewed from its origin O towards its terminal S , and the impedance Z_B of the second electromagnetic-wave labyrinth 14 as viewed from its origin O' towards its terminal S' are connected in series with a constant-current power source, may be considered as an equivalent circuit for FIG. 15. In this case, a current induced by an electromagnetic field $\vec{E}$ within the housing 1 and thus caused to flow through the walls of the housing 1 corresponds to the current $\vec{I}$ of the constant-current power source. The magnitude of the induced current may be considered to be proportional to the high-frequency output of the heating equipment. Herein, if the total length of the first electromagnetic-wave labyrinth 20 and L of the second labyrinth 14 are selected at approximately one-half wavelength and approximately one-fourth wavelength, respectively, and if the terminals S and S' of the respective labyrinths are short-circuited, then there will be established a relation $Z_A \ll Z_B$, namely, a voltage appearing across $Z_A \ll$ a voltage appearing across Z_B . Considering this in FIG. 15, an electric field appearing across the inlet O' of the second electromagnetic-wave labyrinth 14 is much higher than one appearing across the inlet O of the first electromagnetic-wave labyrinth 20. In other words, electromagnetic waves going towards the corner part of the heating chamber 6 are mostly concentrated into the electromagnetic-wave labyrinth 14, with the result that the amount of electromagnetic waves flowing into the other labyrinth 20 becomes small.

This may also be considered as follows. The pattern of an electromagnetic field within the heating chamber 6 at a part close to the inlet O of the first labyrinth 20 is more heavily influenced by the pattern of an electromagnetic field inside the second electromagnetic-wave labyrinth 14, so that the wall current in the vicinity of the inlet O of the first labyrinth 20 is reduced. This may be easily understood from the fact that the wall current i for the labyrinth 14 decreases with distance from the terminal S' of this labyrinth as is graphically shown in FIG. 15 and that the wall current i becomes the least when the overall length of the labyrinth 14 is equal to one-fourth wavelength.

For the above reason, the amount of electromagnetic waves leaking through a seam of the first electromagnetic-wave labyrinth 20 distant by one-fourth wavelength from the terminal S thereof may be reduced to approximately 1/10 to 1/200 by provision of the second labyrinth 14 for electromagnetic waves. Further, experiments have revealed that this effect may, in general, be enhanced by making the width of the inlet O' of the second labyrinth 14 larger than that of the inlet O of the first labyrinth 20 as is the case in FIG. 15. It is to be understood that a plurality of labyrinths 14 may be provided close to one another. In an electronic range using electromagnetic waves of 2,450 MHz, the width of the inlet O of the first labyrinth 20 is made approximately 0.5 to 3 mm, while that of the inlet O' of the second labyrinth 14 is selected at approximately one-tenth of the wavelength of the electromagnetic waves, i.e., at approximately 10 to 20 mm. It has been experimentally confirmed that the amount of leakage electromagnetic waves may be suppressed to 0.1 mW/cm² or below in

an electronic cooking stove having an output of 1 kW.

The idea of this invention is also applicable to a construction the first and second labyrinths are filled with a dielectric material of small high-frequency loss, whereby the total lengths of the labyrinths are adjusted to the dielectric constant of the filler to make the labyrinths small in size and thus they are made, in substance, one-half or one-fourth wavelength. Furthermore, it is also effective to select the length of the first labyrinth 20 an integral times one-half wavelength and that of the second labyrinth 14 an odd number times one-fourth wavelength.

The sealing effect may be further enhanced by combining the first labyrinth 20 and the second one 14 and finally disposing as sealing means the electromagnetic-wave absorbent member 25 of, for example, ferrite rubber.

It has been successfully confirmed by experiments that the sealing effect is better when the second labyrinth 14 is made wider than the first labyrinth 20, and that particularly it is best when the width of the second labyrinth is set at one-fourth λ (wavelength).

When the first labyrinth 20 and the second one 14 are positioned in parallel as illustrated in FIGS. 2 and 5, the front wall 13 may define the second labyrinth 14 on one side and the gap 3 on the other side. Therefore, the electromagnetic-wave seal of this invention is simple in construction and low in cost.

Illustrated in FIGS. 6 to 14 are modifications of the combination between the first and second labyrinths. In the modification of FIG. 6, the second labyrinth 14 is longitudinally defined on the side of the door 2 opposing the origin O of the first labyrinth 20. In FIG. 7, the second labyrinth 14 is laterally provided on the side of the door 2. In FIG. 8, the first labyrinth 20 and the second one 14 are positioned in the lateral and longitudinal directions, respectively, and both are formed at the upper part of the door 2. According to the modification shown in FIG. 9, the first labyrinth 20 is disposed on the side of the door 2 while the second one 14 is protrusively provided on the side of the heating chamber 6, and both the labyrinths are arranged in parallel to each other. In FIG. 10, the first labyrinth 20 is defined on the side of the door 2 while the second one 14 on the side of the heating chamber 6, both are arranged in parallel to each other, and the second labyrinth 14 is projected above the heating chamber 6. In the modification of FIG. 11, the first labyrinth 20 is formed on the side of the door 2, the second labyrinth 14 is provided on the side of the heating chamber 6 in parallel with the first one, and the lower end of the partition wall defining the second labyrinth 14 is bent in the form of a crank. FIG. 12 shows the modification which is similar to that of FIG. 11 except that the lower end of the partition wall is inclined. In FIG. 13, the first labyrinth 20 is longitudinally provided on the side of the door 2, while the second labyrinth 14 is laterally formed on the side of the housing 1 opposing the opening of the first one 20. Finally, according to the modified embodiment shown in FIG. 14, the first labyrinth 20 is laterally disposed on the side of the door 2, while the second one 14 is longitudinally arranged on the side of the housing 1.

While other combinations between the first labyrinth 20 and the second one 14 than the above embodiments may be thought out, it is a matter of course that they

are included within the scope of this invention.

What is claimed is:

1. High-frequency heating equipment comprising
 - a. a heating chamber having top and front walls, said front wall having an access opening therein,
 - b. means for generating electromagnetic waves and transmitting the generated electromagnetic waves into said heating chamber,
 - c. a partition wall secured to the top wall of said heating chamber and positioned substantially parallel to said front wall, the length of the front wall facing said partition wall being equal approximately to an odd number times one-quarter of the fundamental wavelength of the electromagnetic waves generated by said generating means, and
 - d. a door for closing the access opening in the front wall of said heating chamber, said door having a cavity in the outer peripheral portion thereof defined by a forward member, spaced upper and lower members extending substantially perpendicular to said forward member, and an inner member positioned substantially parallel to and spaced from said forward member and, when said door is closed, substantially parallel to and spaced from the front wall of said heating chamber, a gap being formed between said inner and upper members, the total distance defined by the length of said inner member opposing said front wall added to the length of said inner member between said lower member and said gap being equal approximately to an integer times one-half of the fundamental wavelength of said electromagnetic waves, the space defined by said front wall and inner member and by said cavity comprising a first electromagnetic wave labyrinth and the space defined by said partition, top and front wall comprising a second electromagnetic wave labyrinth.
2. High-frequency heating equipment as defined by claim 1 which further comprises electromagnetic wave stirring means located in the upper part of said heating chamber and a dielectric member covering said electromagnetic stirring means and said means for generating electromagnetic waves, said dielectric member being attached to said partition wall, said partition wall being made of a metallic material.
3. High-frequency heating equipment as defined by claim 1 wherein a plurality of air vents are formed in the top wall of said heating chamber, said second electromagnetic wave labyrinth providing a passage for exhaustion of air.
4. High-frequency heating equipment as defined by claim 1 wherein the distance between said partition and front walls is greater than between the inner member of said door and said front wall when said door is closed.
5. High-frequency heating equipment as defined by claim 4 wherein the distance between said partition and front walls is approximately equal to one-quarter of the fundamental wavelength of the electromagnetic waves generated by said generating means.
6. High-frequency heating equipment as defined by claim 4 wherein a filler made of dielectric material having low high-frequency loss is located within said first and second electromagnetic wave labyrinths.

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