United States Patent

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[54] **HIGH-FREQUENCY HEATING APPARATUS HAVING ELECTROMAGNETIC WAVE AGITATING DEVICE**

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[52] **U.S. Cl.** **219/10.55**

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

[58] **Field of Search** 219/10.55

[56] **References Cited**

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[57] **ABSTRACT**

An agitation device for high-frequency electromagnetic waves in a high-frequency oven has at least one pair of planar rotary blades of metal extending in radially opposite directionsfrom a hub part and fabricated, together with the hub part, from a single strip of sheet metal into a staggered or stepped shape in which the blades respectively lie in mutually different offset planes and present minimum profiles with respect to air resistance during rotation, the blades thereby rotating through mutually different paths and imparting effective field agitation to prevent occurrence of a high-frequency standing wave and to render uniform the distributive state of the high-frequency waves applied to the oven interior.

7 Claims, 3 Drawing Figures

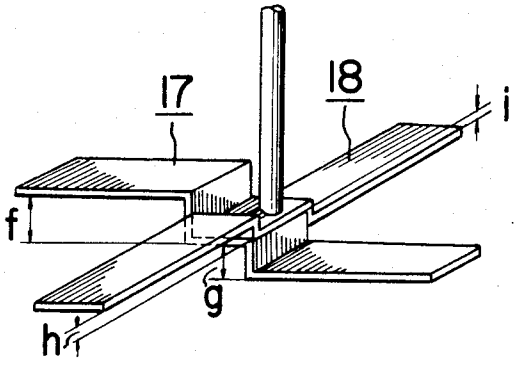


FIG. 1

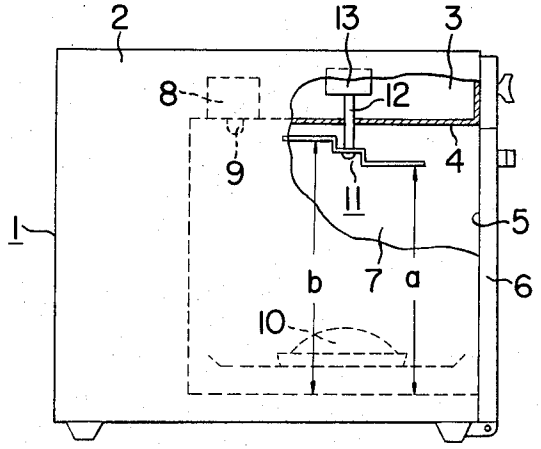


FIG. 2

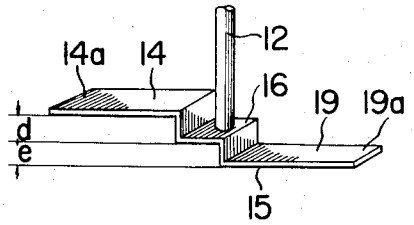
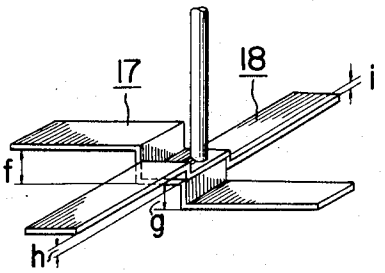


FIG. 3



HIGH-FREQUENCY HEATING APPARATUS HAVING ELECTROMAGNETIC WAVE AGITATING DEVICE

BACKGROUND OF THE INVENTION

This invention relates generally to high-frequency electromagnetic heating and more particularly to devices, such as so-called electronic ovens, in which high-frequency electromagnetic waves are applied to the interior of a heating chamber to heat an object such as an item of food. More specifically, the invention relates to a new and improved agitation device such as stirrer fan or agitator in a heating chamber of this character for agitating the electromagnetic waves therein thereby to prevent the generation of a high-frequency standing wave.

In general, most of the agitation devices provided in the heating chambers of heating devices of this class have blades or vanes of twisted shape. In spite of the difficulty in and high cost of fabrication in providing this twisted shape, the effectiveness of these vanes in producing the objective electrical-field agitation is not satisfactorily high. Furthermore, the twisted shape of the blades gives rise to a stirring of the air within the chamber, which is not the true function of the field agitator.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide, in a high-frequency heating apparatus, an agitation device having high effectiveness in agitation action and having low air drag during operation.

Another object of the invention is to provide an agitation device of the above stated character which is of simple yet strong construction and can be produced at low cost.

According to the present invention, briefly summarized, there is provided a high frequency heating apparatus consisting of a housing structure having an access opening, a heating chamber provided within said housing structure, a generator fixed to the interior of said housing structure for supplying high frequency electromagnetic waves to the interior of heating chamber, a door for closing the access opening, and characterized by an agitation device comprising a motive-power device, a rotatable shaft coupled at one end thereof to the motive-power device to be driven thereby, and a fan structure fixed to the other end of the shaft and having at least two planar rotary blades of metal and of configurations such that the rotational paths thereof are mutually noncoincident and such that minimum air drag is encountered by the fan structure in rotation, said fan structure being disposed within the heating chamber at a position for effectively agitating the high-frequency electromagnetic waves therewithin thereby to prevent the generation therein of a high-frequency standing wave and to render uniform the distributive state of the high-frequency electromagnetic waves.

The nature, principle, and utility of the invention will be more clearly apparent from the following detailed description with respect to preferred embodiments of the invention when read in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 is a side elevation, with a part cut away, showing the essential parts of an electronic oven in which one example an electric-field agitating device according to the invention is installed;

FIG. 2 is a perspective view showing one example of a fan structure having two blades of an agitation device of the invention; and

FIG. 3 is a perspective view showing another example of a fan structure of the invention, which structure has four blades.

DETAILED DESCRIPTION

Referring to FIG. 1, the electronic oven shown therein has an external housing structure 1 comprising an outer case 2 and an inner case 4 with a space 3 interposed therebetween. The outer case 2 is provided at its front wall with access an opening 5 having a door 6 hinged at its lower edge to the lower part of the structure 1. The inner case 4 and the door 6 define a heating chamber, which in this example is a cooking chamber 7. The inner case 4 and door 6, of course, are made of electroconductive materials such as metals.

Through the upper wall or ceiling of the cooling chamber 7, the output part 9 of high-frequency electromagnetic wave generator comprising a magnetron 8 is directed into the chamber to introduce high-frequency waves thereinto to heat an object 10 such as an item of food placed in the chamber.

An agitation device 11 according to the invention as described hereinafter is supported at the upper central part of the cooking chamber 7 by a vertical shaft or driving spindle 12 passing through the ceiling of the chamber and coupled at its upper end to a rotary drive motor 13.

This agitation device 11 is essentially a stirrer fan or fan structure 15 fabricated from a strip of metal sheet into a staggered or stepped shape as shown in FIG. 2 wherein two planar blades 14 and 19 extend radially outward in opposite directions from a central hub part 16 in mutually different offset parallel planes, the blade 14 being offset by a distance d above the plane of the hub part 16 and the blade 19 being offset by distance e below the hub part. The fan structure 15 is fixed at its hub part 16 to the lower extremity of the spindle 12 by any suitable means such as a screw fastening, a welded joint, or a calking joint.

The above mentioned distances d and e are not equal. Because of the stepped shape of the fan structure 15, the distances a and b of the blades 19 and 14 from the bottom or floor of the cooking chamber 7 are also unequal. Another feature of the fan structure 15 is that the blades 14 and 19 are not twisted, and all parts thereof are positioned to present the minimum profile with respect to air resistance during rotation whereby the fan structure incurs minimum air drag during operation.

The electronic oven of the above described organization including the agitator according to the invention operates in the following manner. First, an object to be heated such as an item of food 10 is placed in cooking chamber 7, and door 6 is closed, whereupon the oven is in its operable state. When a switch (not shown) is

closed, magnetron 8 and motor 13 start to operate substantially at the same time, magnetron 8 supplying high-frequency electromagnetic waves into cooking chamber 7, and motor 13 rotating fan structure 15 through driving spindle 12.

Thus, blades 14 and 19 of fan structure 15 rotate smoothly without encountering any appreciable resistance from the air within chamber 7 and thereby agitate the electromagnetic waves therein. As a result, the generation of a high-frequency standing wave is effectively prevented, and, at the same time, the distributive state of the high-frequency waves in chamber 7 is rendered uniform. A feature of the invention is the stepped shape of fan structure 15 whereby it operates with high effectiveness in accomplishing electric-field agitation.

While the fan structure 15 of the agitator 11 in the above described example comprises two blades formed from a single strip of sheet metal, a plurality of such fan structures can be assembled with their hub parts in stacked arrangement to form a multipleblade fan structure. Such a structure is even more effective in accomplishing field agitation.

In one example of such a multiple-blade fan structure as illustrated in FIG. 3, two fan structures 17 and 18, each of stepped shape with offset blades, are combined to form a four-bladed fan structure. The offset distances of the blades from the hub part thereof are all different, so that the blades rotate in respectively different planes. That is, the distances designated by reference characters f, g, h, and i are all different.

The number of blades of the fan structure can, of course, be increased further to produce further effectiveness in field agitation. Furthermore, the offset distances of a single two-blades structure 15 can be made equal.

From the foregoing description, it will be apparent that because of the simple construction of the field agitator according to the present invention, it can be readily fabricated at low cost.

I claim:

1. In a high-frequency heating apparatus having means therein defining a heating chamber wherein objects to be heated are placed; a generator operable to generate high-frequency electromagnetic waves and supply same into said heating chamber; and an agitation device for agitating the high-frequency electromagnetic waves comprising a rotatable shaft extending into said heating chamber, rotary drive means connected to said shaft for rotationally driving same, at least two planar blades having high-frequency energy-reflective surfaces connected to said shaft and extending radially outwardly therefrom in axially spaced-apart relationship with respect to the shaft axis and cooperative together to effectively agitate the high-frequency electromagnetic waves thereby preventing the formation of high-frequency electromagnetic standing waves within said heating chamber in response to rotation of said shaft, and means positioning said planar blades on said shaft in mutually different parallel planes to present the minimum surface profile with respect to air resistance encountered during rotation of said blades thereby minimizing air drag during operation of the agitating device.

2. In the apparatus according to claim 1 wherein said last-mentioned means comprises means positioning each of said planar blades on said shaft for rotation in mutually parallel and distinct planes.

3. In the apparatus according to claim 1; wherein said at least two planar blades comprise a pair of planar blades extending radially outwardly from said shaft in opposite directions; and a hub connecting said pair of planar blades in mutually offset planes to said shaft.

4. In the apparatus according to claim 3; wherein said hub and pair of planar blades are fabricated from a single strip of sheet metal.

5. In the apparatus according to claim 1 wherein said at least two planar blades comprise two pairs of planar blades, each pair of planar blades extending radially outwardly from said shaft in opposite directions; and a hub connecting each pair of oppositely extending planar blades in mutually offset planes to said shaft.

6. In the apparatus according to claim 10; wherein each hub and the planar blades connected thereto are fabricated from a single strip of sheet metal.

7. In the apparatus according to claim 1; wherein said at least two planar blades comprise a plurality of planar blades extending radially outwardly from said shaft in circumferentially spaced-apart relationship; and wherein said means positioning said planar blades on said shaft comprises means positioning said plurality of planar blades for rotation in mutually different horizontal planes.

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