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R. V. SMITH

2,813,185

HEATING DEVICES

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FIG. 1

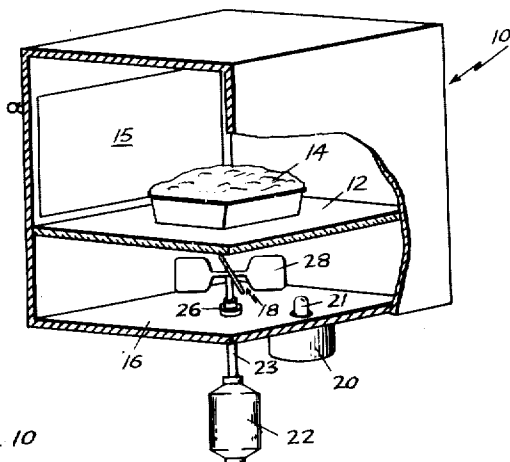


FIG. 2

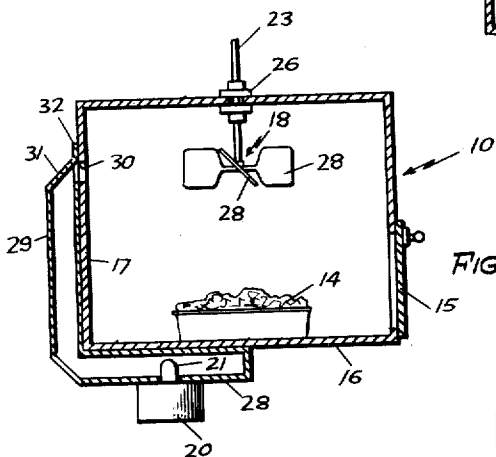


FIG. 3

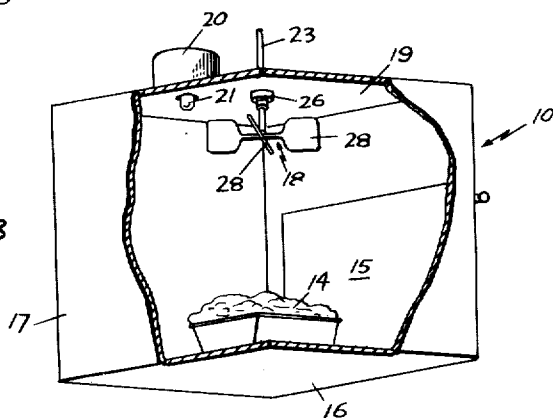
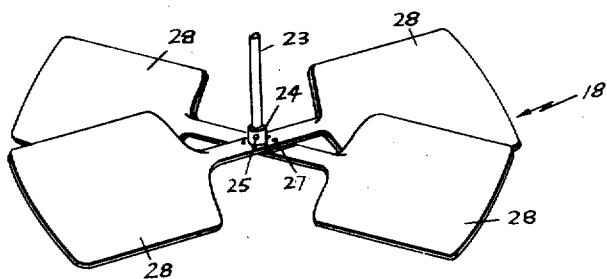


FIG. 4



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2,813,185

HEATING DEVICES

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5 Claims. (Cl. 219—10.55)

This invention relates to a heating device and more particularly to a high frequency oven containing a fan for obtaining an improved heating pattern in the vicinity of the oven load.

Heating devices for supplying energy of relatively short wave length to an object to be heated or cooked are well known in the art. Because of the high frequency used in such devices, the heat generated in the load is intense and evenly distributed throughout the mass, resulting in a heating process which is not only rapid but uniform.

In previous analysis of high frequency ovens, the oven has been considered to be a resonant cavity of high Q and a movable device is incorporated in the oven to excite many modes. This analysis is reasonably accurate when dealing with lightly loaded ovens. It has been found, however, that foods in general represent large heating loads and that the phenomenon of excitation of a large number of modes in a heavily loaded resonant cavity whose Q is low is secondary to the phenomenon of reflection of energy within said ovens.

In addition, many existing mode-changing devices have been dynamically unbalanced, resulting not only in unsatisfactory mechanical operation but in an asymmetrical heating pattern.

In accordance with this invention, a propeller-type fan having a plurality of radially disposed and symmetrically arranged blades is mounted within the oven in such a position as to intercept a substantial portion of the energy radiated from the high frequency source and to deflect the energy thus impinging upon the fan blades in the direction of the oven load. This fan, in its preferred form, differs from the conventional fan used for air-conditioning in that the various blades are not all inclined in the same direction and the fan is incapable of pumping fluids. The pitch angle of the blades will depend upon the relative position of the fan with respect to the source and the load. As the fan is rotated within the oven, energy from the source impinges successively upon the various fan blades and eventually is reflected toward the food to be cooked, or the material to be heated, as the case may be. The distribution of R. F. energy to the load obtained with the oven of the present invention has been found to be substantially uniform even with large heating loads.

The fan used in the subject invention also serves to excite several modes, particularly when unusually light loads are involved, in addition to properly directing energy from source to load. By periodically changing the field distribution or mode pattern inside the oven, the total heat available in all portions of the oven is made more nearly uniform. Although this effect is not too pronounced in heavily loaded ovens, it is nevertheless present and becomes important whenever oven operation at light loads is desired.

Referring now to the drawings:

Fig. 1 is a view showing a first embodiment of a high frequency oven according to the invention;

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Fig. 2 is a sectional view of a second embodiment of high frequency oven;

Fig. 3 is a perspective view of still another modification of the subject invention; and

Fig. 4 is a pictorial view of the fan used in the ovens of Figs. 1 to 3.

Referring to Fig. 1, a hollow rectangular metallic enclosure or cavity 10 having mutually perpendicular top, side and bottom walls serves as the oven of the heating device. The dimensions of the enclosure are preferably, although not necessarily, large compared with the wave length of the exciting source at the operating frequency. A shelf 12 made of a material transparent to high frequency energy is adapted to support the heating load 14, such as an article of food to be cooked. In order to allow for insertion or removal of food from the oven, an aperture closed by a hinged metal door 15 is provided in one wall of the oven. This door may extend to the bottom of the oven, if desired, in order to facilitate inspection or maintenance of the fan and high frequency source.

Fan 18, shown in detail in Fig. 4, is mounted about a vertical axis of revolution at or near the geometrical center of bottom wall 16 of the oven. By mounting the fan near the center of the oven wall, symmetry of R. F. distribution of energy within the oven is more readily obtained. Fan 18 is rotated by a prime mover 22, such as a fractional horse power motor, whose shaft 23 is affixed to the hub 24 of the fan by a set screw 25. The prime mover 22 is positioned externally of the oven in order to prevent destruction of the motor caused by intense R. F. fields. Shaft 23 is mounted in bearing 26 affixed to the bottom wall 16 of the oven. Fan 18 includes a plurality of blades 28 radially disposed about hub 24. The individual blades 28 of fan 18 may be fastened together, as by rivets 27, while the hub 24 may be welded or otherwise attached to the fan blades. Any method of constructing fan 18 is within the scope of the invention; for example, the fan may be cast in one piece and machined smooth. As clearly shown in Fig. 4, all the fan blades 28 are inclined in the same direction.

A source of high frequency energy, such as a magnetron 20, is mounted in the bottom wall 16 of the oven. This magnetron may, for example, have a dome-shaped portion 21 which functions as an electromagnetic radiator of energy conducted thereto from the magnetron cavity resonators. Such magnetrons, as well as other types of magnetrons which are also adaptable for use with oven 10, are well known in the art and need not be described in detail. Other means of coupling energy into oven 10 may be used, such as the means illustrated in Fig. 2. Magnetron 20 in Fig. 1 is located below fan 18 and preferably along one center line of wall 16. Magnetron probe 21 should be positioned as near the center of the oven as possible to obtain the most symmetrical energy pattern possible. Various oven configurations necessitate a compromise between packaging and symmetrical heating patterns. Although it is generally desirable to operate at frequencies in the microwave region of the frequency spectrum, this invention is equally applicable to sources of R. F. energy of frequency above or below the microwave region.

A considerable portion of the energy radiated from the magnetron impinges upon the upper side of fan blades 28 and is generally reflected upward therefrom so as to strike the food mass 14 to be cooked. In practice, it has been found that the pitch angle of the blades should be in the vicinity of 45 degrees for the oven shown in Fig. 1. The pitch angle will depend upon the relative position of the magnetron radiating probe with respect to the fan, for a given radiation pattern. If the maximum amount of energy is directed toward

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the fan at an angle of 60 degrees with respect to the vertical axis of rotation of the fan, for example, and the energy reflected from the fan is to be directed vertically upward, that is, at an angle of zero degrees with respect to the vertical axis of rotation, well-known quasi-optical principles dictate theoretically that the blade reflecting surface be positioned at an angle of 30 degrees with respect to said vertical axis. The pitch angle arrived at in practice may vary somewhat from that theoretically calculated, however, owing to the fact that energy is not radiated solely in one direction and to the fact that some of the energy is reflected directly from the oven walls or from the under surfaces of the fan blades. In the ovens, shown in Figs. 1 to 3, the pitch angle of the blades has varied from about 30 degrees to 60 degrees.

As the fan rotates, energy is reflected from successive blades. Because of the particular construction of the fan exemplified in Fig. 4 and the symmetrical mounting with respect to the bottom wall of the oven, the R. F. energy distribution in the vicinity of the oven load 14 is cyclically repetitive and the energy absorbed by the load is distributed substantially uniformly throughout the load. The number of blades used is limited in accordance with the physical size of the fan blades necessary to intercept a sufficient amount of energy from the source. The size of the fan blades will depend to a large extent upon the oven dimensions.

A modification of the oven of Fig. 1 is shown in Fig. 2 in which the energy is fed into the upper portion of said oven through a side wall 17. Energy from magnetron 20 is coupled into a wave guide 28 which may, for the sake of economy of space, be mounted against the bottom and side walls 16 and 17, respectively, of the oven, as shown in Fig. 2. Wave guide 28, which includes a conventional right angle bend, is tapered at the end adjacent the oven to form a flared electromagnetic horn 29, whose mouth or aperture is coextensive with an aperture 30 in oven wall 17. This arrangement is illustrated and described in greater detail in an application for United States Letters Patent, Serial No. 265,134 of Judd Blass, filed January 5, 1952. The horn 29 terminates in an inclined plate 31 which reflects the energy directly into the oven substantially in a horizontal plane. The angle of this plate should be in the vicinity of forty-five degrees for minimum reflection of energy back from the oven into the wave guide and magnetron. Inclined plate 31 has a flange portion 32 which permits connection, as by welding, to the wall 17 of the oven. The food mass or other heating load 14 is positioned in the bottom of the oven and access thereto is provided by means of a door 15. Fan 18 is mounted at the top of the oven and is driven by a motor whose shaft passes through the bushing 26 in the top wall 19. In order to reflect the energy arriving at aperture 30 downward to the food mass 14, fan blades 28 are positioned at an angle of forty-five degrees with respect to the plane of rotation of the fan, as shown in Fig. 2. With a pitch angle of forty-five degrees the angles of incidence and reflection of energy are forty-five degrees and a majority of the energy impinging upon the under sides of blades 28 is directed toward the bottom of the oven in the region occupied by load 14.

In Fig. 3, magnetron 20 and fan 18 are both mounted at the top of the oven with the fan disposed between the magnetron and the load at the bottom of the oven. The fan is centrally positioned with respect to the top wall while the magnetron probe 21 is disposed between the fan and a side wall 17. The energy radiated from the magnetron is reflected downward from the fan blade. The operation of the fan in the oven of Fig. 3 is similar to that of Fig. 1; the ovens of Figs. 1 and 3 differ essentially only in that the relative position of the magnetron and the load is reversed.

This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled

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in the art. For example, this invention is not limited to an enclosure having mutually perpendicular walls, but may include an enclosure of any reasonable size or configuration. It is, accordingly, desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. A microwave oven comprising a metallic enclosure, means for supplying high-frequency electromagnetic energy to said enclosure, a heating load contained within said enclosure, a prime mover, a fan mounted within said enclosure and rotated about an axis by said prime mover, said fan including a plurality of blades some of which are inclined in one direction with respect to a plane normal to said axis and others of which are inclined in the opposite direction with respect to said plane and positioned to intercept a portion of said energy, means responsive to rotation of said blades for reflecting a substantial portion of the energy incident on said blades toward said load.

2. A microwave oven comprising a metallic enclosure, means for supplying high-frequency electromagnetic energy to said enclosure, a heating load contained within said enclosure, a prime mover, a fan mounted within said enclosure and rotated about an axis by said prime mover, said fan including a plurality of blades, said oppositely disposed blades of a given pair being inclined in one direction with respect to a plane normal to said axis and the blades of the pair adjacent said given pair being inclined in the opposite direction with respect to said plane, and positioned to intercept a portion of said energy, means responsive to rotation of said blades for periodically changing the mode pattern within said enclosure and for reflecting a substantial portion of the energy incident on said blades toward said load.

3. A microwave oven comprising a metallic enclosure, means for supplying high frequency electromagnetic energy to said enclosure, a heating load contained within said enclosure, a rotatable fan positioned within said enclosure and adapted to intercept a substantial portion of said energy and to reflect a portion of the energy incident thereon toward said load, said fan including a first set of blades and a second set of blades, the blades of said first set presenting a surface inclined at an angle to a substantial portion of said energy, said second set of blades presenting a surface of reversed inclination to that of the blades of said first set to a substantial portion of said energy, means for imparting continuous rotary motion to said fan for producing a cyclically repetitive distribution of energy which is substantially uniform in the region of said enclosure occupied by said load.

4. A microwave oven comprising a metallic enclosure, means for supplying high frequency electromagnetic energy to said enclosure, a heating load contained within said enclosure, a rotatable fan positioned within said enclosure and including a plurality of blades some of which are inclined in one direction with respect to a plane normal to said axis and others of which are inclined in the opposite direction with respect to said plane, said blades each adapted to periodically intercept a substantial portion of said energy and to reflect a portion of the energy incident thereon toward said load, said fan including a first set of blades and a second set of blades, the blades of said first set presenting a surface inclined at an angle to a substantial portion of said energy, said second set of blades presenting a surface of reversed inclination to that of the blades of said first set to a substantial portion of said energy, means for imparting continuous rotary motion to said fan for producing a cyclically repetitive distribution of energy which is substantially uniform in the region of said enclosure occupied by said load.

5. A microwave oven comprising a metallic enclosure, means for supplying high frequency electromagnetic energy to said enclosure, a heating load contained with-

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in said enclosure, a rotatable fan positioned within said enclosed and including a plurality of radially disposed blades each having the same pitch angle, some of said blades being inclined in the opposite direction to that of the others of said blades, said blades each adapted to periodically intercept a substantial portion of said energy and to reflect a portion of the energy incident thereon toward said load, said fan including a first set of blades and a second set of blades, the blades of said first set presenting a surface inclined at an angle to a substantial portion of said energy, said second set of blades presenting a surface of reversed inclination to that of the blades of said first set to a substantial portion of said energy, and means for imparting continuous rotary motion to said fan for producing a cyclically repetitive distribution of energy which is substantially uniform in the region of said enclosure occupied by said load.

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