March 22, 1955 J. BLASS ET AL 2,704,802

MICROWAVE OVENS

Filed May 22, 1952

FIG. 1

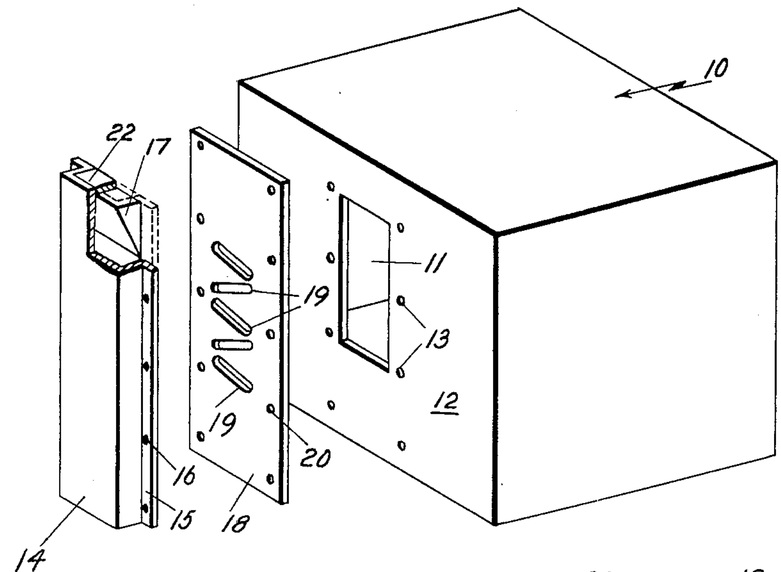
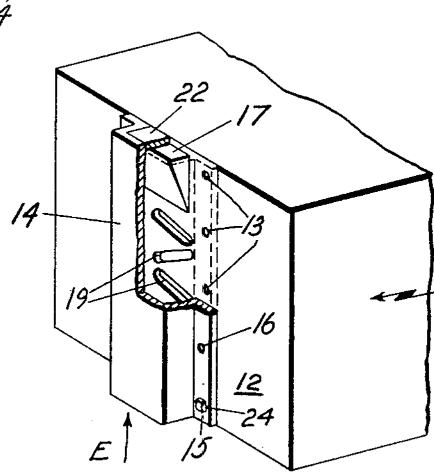
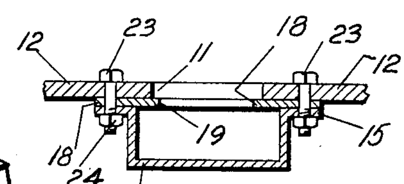


FIG. 4





14 FIG. 2

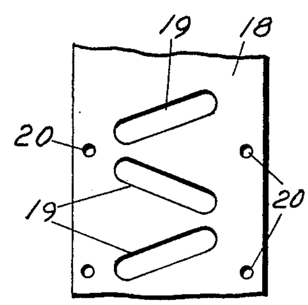


FIG. 3

FIG. 6

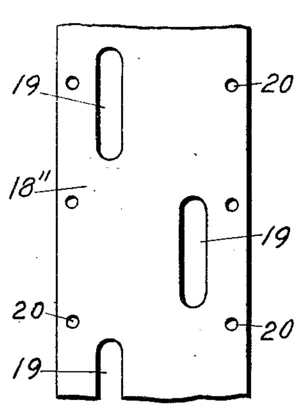
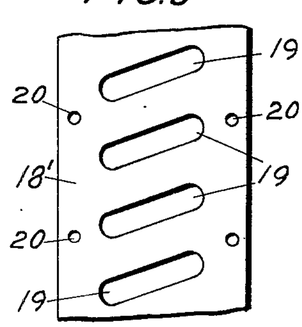


FIG. 5



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MICROWAVE OVENS

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6 Claims. (Cl. 219—10.55)

This invention relates to a microwave oven and, more particularly, relates to a broadside transition for coupling microwave energy from a wave guide into an oven whose dimensions are large compared with the wave length of said energy.

In accordance with this invention, the transition may comprise a section of wave guides several wave lengths long in which an array of resonant or substantially resonant slots are cut. One end of this wave guide section is connected to a source of microwave energy, such as a magnetron, while the other end of the wave guide is terminated in a dissipative load. The wave guide wall in which the slots are cut is positioned in energy-coupling relationship with the interior of said oven, and a large portion of the energy traveling along the wave guide from the microwave source is radiated from the slots into the oven in the form of a beam whose polarization may be either horizontal, vertical or elliptical, depending upon the orientation of the slots and whose direction of radiation is dependent upon the width and spacing of the slots. A variation in the slot orientation, size and spacing may be readily accomplished by constructing the guide in two pieces, one of which is a rectangular channel and the other a plate in which the radiating slots are cut; the channel and plate are bolted together over a window in said oven wall. By replacing the slotted plate with another plate having a different slot configuration, a different distribution of energy may be produced within the oven.

Alternatively, the oven wall itself may be slotted and the rectangular channel mounted on said oven wall over said slotted portion of said oven wall so that the latter forms the fourth side of the wave guide. This alternative arrangement, while simpler of construction than the first arrangement using a wave guide comprising a channel and an interchangeable plate, cannot be varied readily.

A dissipative load or termination at the end of the wave guide remote from the energy source provides a considerable amount of no-load or light-load protection for the magnetron. When the oven is heavily loaded by articles to be cooked or heated, assuming, of course, that the directivity of energy radiated into the oven is such that a reasonable number of reflections from the oven walls occur, the microwave energy coming from the magnetron is largely dissipated in the oven load and only a relatively small part of the energy reaches the dissipative termination or the source. When the oven is lightly loaded, however, more of the energy is absorbed by the lossy termination. At no-load, most of the energy not absorbed by reflections from the oven walls is absorbed in said termination. Thus, the magnetron is more properly terminated under all conditions of oven load.

In the drawing:

Fig. 1 is an exploded view showing a first embodiment of the invention;

Fig. 2 is a small section view showing the details of a portion of the device of Fig. 1;

Fig. 3 is a fragmentary plan view of a slotted plate used in the device of Fig. 1;

Fig. 4 is an isometric view, partly broken away, showing a second embodiment of the invention; and

Figs. 5 and 6 are fragmentary plan views showing alternative forms of slotted plates such as used in the embodiment shown in Fig. 1.

Referring now to Figs. 1 to 3, a rectangular microwave oven 10 is shown having mutually perpendicular sides or walls defining a substantially enclosed cavity adapted to be energized by a source of microwave energy whose wave length is short compared with the dimensions of said oven. A rectangular window 11 is cut in one of the oven walls, such as rear wall 12. The front wall opposite wall 12 (not shown) contains a door (not shown) for insertion of the food to be cooked. Adjacent window 11 is a plurality of holes 13 whose purpose will be subsequently explained. A rectangular channel 14, which may be made of sheet metal having electrical conducting properties, includes a pair of flanged portions 15 bent at right angles to the side portions of the channel member. Each flanged portion has a vertical row of holes 16 therein which are spaced apart the same distance as the corresponding row of holes 13 in the oven wall 12; the lateral spacing between the two rows of holes in channel 14 is equal to that between the rows of holes in oven wall 12 so that the holes in channel 14 and oven wall 12 are in alignment. A dissipative load or termination 17 is positioned at the top end of channel member 14 for reasons to be explained later. This top end of the guide is preferably closed, as by a metallic insert 22 brazed to channel 14.

A metal plate 18, which may be of the same stock as channel 14, contains a number of spaced resonant or substantially resonant slots 19 which are approximately a half wave length long at the operating frequency. Alternate slots have opposite slopes, as clearly shown in Fig. 3, the longitudinal axis of each slot being approximately twenty degrees from the transverse axis at the plate. A number of holes 20 are formed in plate 18, which are in alignment with those in flanged channel 14 and wall 12 of oven 10.

The channel 14 and plate 18 are fastened to oven wall 12 by means of bolts 23 and cooperating nuts 24, as shown in Fig. 2. The bolts are passed through corresponding holes 16, 20 and 13 in channel 14, plate 18 and oven wall 12, respectively.

Rectangular channel 14 thus forms one wide wall and the two narrow walls of a rectangular wave guide while slotted plate 18 mounted against channel 14 between the channel and the oven wall serves as the other wide wall of the wave guide. The energy fed into the bottom end of the wave guide from the microwave source (not shown) is coupled through slots 19 in the plate portion 18 of the wave guide and enters oven 10 through the window 11.

Figs. 5 and 6 illustrate portions of alternative guide plates 18′ and 18″, respectively, which may be used instead of plate 18 in the device of Fig. 1.

The polarization and direction of the beam radiated from the wave guide into the oven are dependent upon such factors as the orientation, size, shape and spacing of the slots 19 in the guide plate 18.

The configuration of the individual slots may vary, provided the length of the slot is substantially greater than the width. Preferably, the slots are substantially rectangular with either straight ends or with rounded ends, as shown in the drawing. The length of the slots may be approximately half the wave length in free space of the energy being radiated therethrough. The exact length of the slots for resonance, although dependent primarily on wave length, is also somewhat dependent upon wave guide dimensions so that the exact length of the slot for resonance must be determined for the particular wave guide and frequency used. The width of the slot will depend on the amount of peak power which is to pass through the slot, the width being greater as more power is required.

The longitudinal spacing of the slots will partially determine the direction of the radiation relative to the axis of the wave guide.

The polarization of the radiated beam is largely dependent upon the orientation of the slots 19. For example, for propagation of a TE mode, the slots in plate 18″ of Fig. 6 would cause horizontally polarized waves to be produced.

Since plate 18 usually extends above and below the top and bottom walls of the oven, respectively, in order to accommodate dissipative termination 17 and suitable coupling means to the source of energy, respectively, additional holes 16 and 20 must be positioned in the upper and lower portions of the channel **14** and plate **18** to fasten these two members firmly together at the ends.

The distribution of energy in microwave oven **10** may be readily altered, inasmuch as it is quite easy to remove plate **18** and replace it by another plate, such as plate **18'** in Fig. 5. Plate **18** is removed by loosening and removing nuts **24** and removing both channel **14** and plate **18** from bolts **23**. The new plate, such as plates **18'** or **18''**, and channel **14** are positioned over bolts **23**, in that order, and nuts **24** tightened as before.

By proper orientation of the beam, the energy in the cavity undergoes many reflections from the walls of the oven thus minimizing the amount of energy escaping from the oven for a given oven load. Whenever the oven contains a normal complement of food, a considerable portion of the reflected energy is absorbed and very little of the energy can return to the magnetron with undesirable effects on the latter. If, however, there is either no food or a very small amount of food within said oven, the tendency for reflection of energy back toward the wave guide in the direction of the magnetron is increased. To provide considerable protection to the magnetron at either no-load or light-load, dissipative termination **17** is provided, as shown in Fig. 1, to absorb a considerable portion of this energy tending to return toward the magnetron. Termination **17** may be any conventional type microwave non-reflective termination, such as a tapered block of dielectric material, presenting a sloping face to incident waves and adapted to be retained in position by a suitable cement or adhesive on the outer surface thereof. The taper should be as long as necessary to minimize wave reflections. A suitable cooling means (not shown) may be positioned in the vicinity of the load **17**, if desired.

A second embodiment of the invention is shown in Fig. 4, like reference numerals representing elements which are identical to those shown in Fig. 1. The flanged portion **15** of rectangular channel **14** is bolted directly to the wall **12** of oven **10** by bolts **23**, as shown in Fig. 4. A portion of the oven wall **12** is slotted in the same manner as plate **18** in Fig. 1 and functions instead of plate **18** in Fig. 1, as the fourth side of the wave guide. Energy is fed into the bottom end of the wave guide in the direction shown by arrow E. At the other end of the wave guide, a dissipative load **17** is positioned just as in Fig. 1. Variations in the energy distribution within oven **10** may be accomplished by cutting the slots in wall **12** of oven **10** in a different manner, such as shown in Figs. 5 and 6.

The operation of a device of Fig. 4 is identical to that of Fig. 1. The arrangement of Fig. 4 is simpler in construction than that of Fig. 1 but is less amenable to variation.

This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled in the art. For instance, the configuration or arrangement of the slots within the broadside transition need not be limited to those shown in Figs. 1–6, since many other arrangements may be used, depending upon the polarization and direction of radiation desired. 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 substantially closed cavity, a source of microwave energy whose wave length is short compared with the dimensions of said cavity, an electrically-conductive channel, a plate containing a plurality of spaced energy-radiating slots therein and cooperating with said channel to form a closed wave guide receptive of energy from said source, said cavity having an aperture located in one wall which is transparent to microwave energy, said wave guide being mounted on said one wall over said aperture and arranged to transfer energy from said wave guide into said cavity through said slots and aperture.

2. A microwave oven comprising a substantially closed cavity, a source of microwave energy whose wave length is short compared with the dimensions of said cavity, an electrically-conductive channel, a plate containing a plurality of spaced energy-radiating slots therein and cooperating with said channel to form a closed wave guide receptive of energy from said source, said cavity having an aperture located in one wall which is transparent to microwave energy, said wave guide being mounted on said one wall over said opening and arranged to transfer energy from said wave guide into said cavity through said slots, said slots being substantially resonant for the wave length of said source.

3. A microwave oven comprising a substantially closed rectangular cavity having mutually perpendicular top, side and end surfaces, a source of microwave energy of wave length short compared with the dimensions of said cavity, an electrically-conductive channel, a plate containing a plurality of spaced energy-radiating slots therein adapted to be readily inserted in cooperative relationship with said channel to form a closed wave guide receptive of energy from said source, said cavity having an aperture in one surface thereof, said wave guide being aligned with said aperture and mounted against said one surface and adapted to transfer energy from said wave guide into said cavity through said slots.

4. A microwave oven comprising a substantially closed rectangular cavity having mutually perpendicular top, side and end surfaces, a source of microwave energy of wave length short compared with the dimensions of said cavity, an electrically-conductive channel, a flat plate containing a plurality of spaced elongated energy-radiating slots therein and cooperating with said channel to form a closed wave guide receptive of energy from said source, said slots being substantially resonant for the wave length of said source, said cavity having an aperture in one surface thereof, said wave guide being aligned with said aperture and mounted against said one surface and adapted to transfer energy from said wave guide into said cavity through said slots, and an energy dissipative termination positioned at the end of said wave guide remote from said source.

5. A microwave oven comprising a substantially closed cavity, a source of microwave energy whose wave length is short compared with the dimensions of said cavity, a rectangular electrically-conductive channel mounted on a portion of one wall of said cavity, said portion of said one wall and said rectangular channel together forming a wave guide receptive of energy from said source, a plurality of spaced energy-radiating slots substantially resonant for the wave length of said source located in said portion of said one wall and adapted to direct energy from said wave guide into said cavity so as to provide an appreciable number of reflections of said energy from said oven walls, and an energy dissipative termination positioned at the end of said wave guide remote from said source.

6. A microwave oven comprising a substantially closed cavity, a source of microwave energy of wave length short compared with the dimensions of said cavity, an electrically conductive channel, a plate containing a plurality of spaced elongated energy-radiating slots therein and cooperating with said channel to form a closed wave guide receptive of energy from said source, said slots being substantially resonant for the wave length of said source, said cavity having an aperture in one surface thereof, said wave guide being aligned with said aperture and mounted against said one surface and adapted to transfer energy from said wave guide into said cavity through said slots, and an energy dissipative termination positioned at the end of said wave guide remote from said source.

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