United States Patent

[11] **3,549,849**

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[54] **MICROWAVE HEATING APPARATUS AND ENERGY DISTRIBUTION MEANS THEREFOR**
2 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **219/10.55**
[51] **Int. Cl.** **H05b 9/06**
[50] **Field of Search** 219/10.55

[56] **References Cited**

UNITED STATES PATENTS

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2,909,635	10/1959	Haagensen	219/10.55
3,320,396	5/1967	Boehm	219/10.55
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ABSTRACT: There is shown a waveguide tee having an output probe extending from each arm thereof into an oven cavity and connected to a respective antenna element in the cavity. Microwave energy injected into and propagated through the leg of the tee divides between the arms. A rotor carries an offset metal pin which extends into one arm of the tee, and an external drive is provided for the rotor. Rotation of the rotor causes the pin to move in a circle to effect phase and frequency shift of the generated energy, and interaction between the two arms causes the energy change to shift back and forth therein, and thereby effects corresponding shifts in energy radiated from the antenna elements into the cavity. This results in such mode shifting of energy in the cavity as to establish a substantially uniform microwave heating effect for foodstuffs placed in the cavity. The antenna elements are also adapted to be heated by current for effecting conventional thermal heating of the foodstuffs.

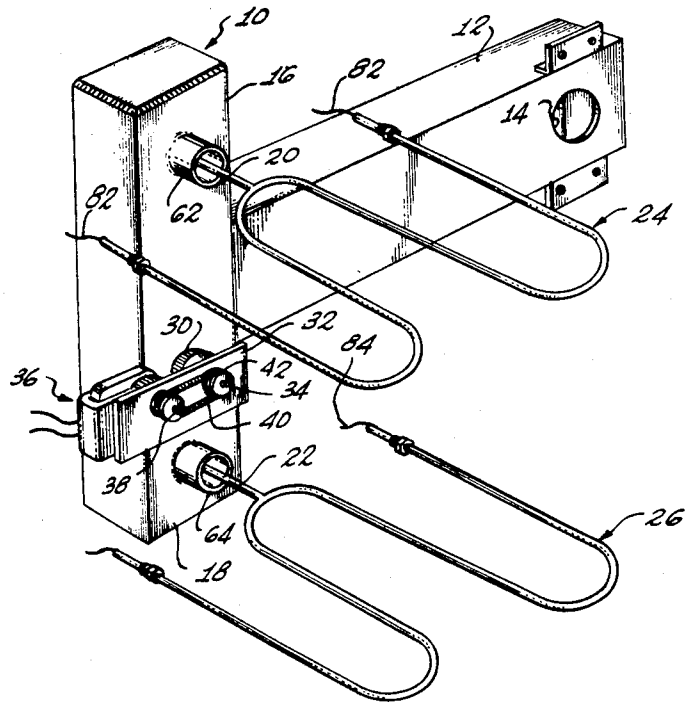
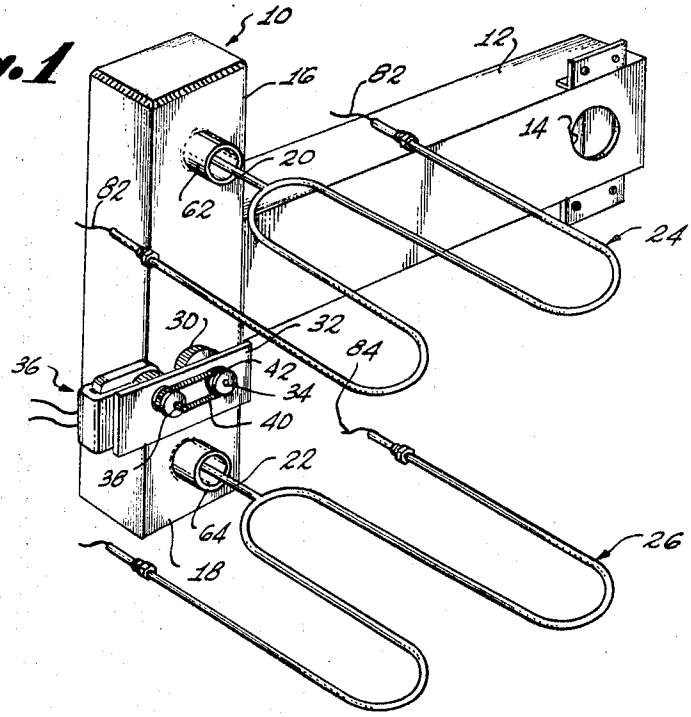


Fig. 1



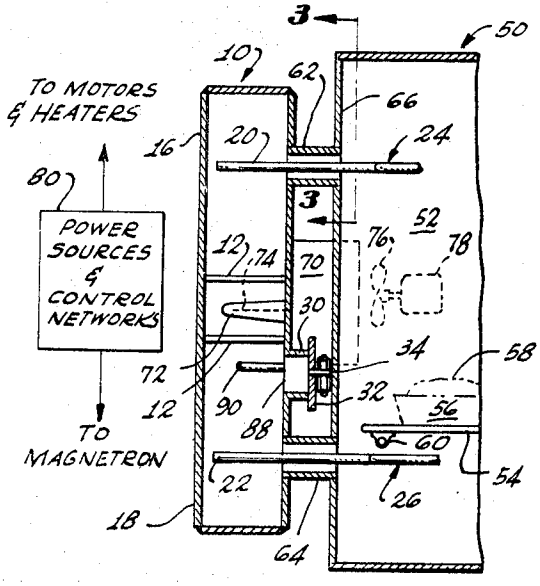


Fig. 2

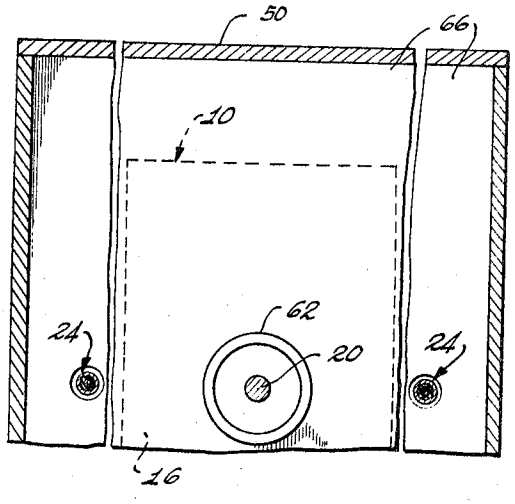


Fig. 3

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MICROWAVE HEATING APPARATUS AND ENERGY DISTRIBUTION MEANS THEREFOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to microwave heating apparatus, and more particularly to microwave cooking ovens and improved energy distribution means therefor.

2. Description of the Prior Art

Heretofore, it has been known to place a metal member inside an oven cavity, and to rotate it so as to "stir" the energy. It was early discovered that such a stirring member had to be shielded to prevent its being coated with materials given off by foodstuffs being cooked in the cavity. The buildup of substances coating the stirring member became particularly rapid when thermal heating elements in the oven were heated to provide the foodstuffs with desired surface appearances. To avoid such material buildup and the maintenance problems it entailed, it became the practice to form the cavity into two compartments, with the stirring member located in one compartment and separated from that in which the foodstuffs are placed. This is accomplished by means of a microwave-transparent plate, e.g., glass, disposed between the stirring member and the rest of the cavity.

This arrangement is undesirable because the plate has a markedly different coefficient of expansion than the metal it contacts, and is undesirably stressed and weakened at high temperatures created in thermal heating, e.g., broiling. The plate also becomes coated with materials driven off foodstuffs being cooked, which means that where the housewife uses the oven many times between cleanings, microwave cooking is frequently being done under conditions in which identical foodstuffs on different days require different time periods to cook them to the same extent.

SUMMARY OF THE INVENTION

This invention embraces a pair of antenna elements in a microwave oven cavity, such elements being coupled to branched arms of a waveguide feed, and a movable metal element in the feed positioned and operated to effect frequency shift of energy in the feed and interaction between the branched arms to cause mode shifting of energy radiated into the cavity by the antennas. This manner of effecting mode shifting is different in operation than, and eliminates the problems created in the use of, conventional mode stirring members.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view of a waveguide feed **10** with energy distribution means in accordance with this invention, showing antenna elements coupled to branching arms and a rotor for rotating a metal pin in one of the arms;

FIG. 2 is a fragmentary sectional view of a microwave oven with the waveguide feed and energy distribution means of FIG. 1; and

FIG. 3 is a fragmentary sectional view taken along the line 3–3 of FIG. 2.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring to FIG. 1, there is shown a waveguide feed **10** in the form of a tee, wherein the leg **12** is provided with an opening **14** through which to inject microwave energy into the feed. Output probes **20**, **22** extend from the respective arms adjacent the ends thereof, and are connected to the centers of respective heater elements **24**, **26**.

Mounted in one of the arms **18** is a sleeve **30**, the outer end of which is secured to a plate **32**. The sleeve **30** forms a sleeve bearing for a rotor having a central shaft **34** journaled in the plate **32**. The plate **32** also supports a motor **36** having a shaft **38** journaled in the plate. The motor shaft **38** drives the rotor shaft **34** via coupling means indicated at **40**, **42**, **44**, or any suitable drive means such as gears, a flexible shaft or the like.

Referring to FIGS. 2 and 3 along with FIG. 1, the above-described arrangement of elements is shown as part of a microwave oven assembly **50**. Mounted in the oven cavity **52** is a rack **54** for supporting a container **56** of foodstuff **58** to be cooked. The rack **54** is mounted on supports **60** that are secured to the sidewalls of the cavity.

The probes **20**, **22** extend from the arms **16**, **18** through tubular elements **62**, **64**. Each of the tubular elements **62**, **64** is secured at one end in its waveguide arm, and at its other end in the back wall **66** of the cavity **52**. The probes are suitably fastened, as by means of transverse straps (not shown) engaging the probes and secured at their ends in the sides of the arms. The ends of the heaters **24**, **26** extend through the back wall **66**.

As illustrated in FIG. 2, a magnetron structure **70** is mounted on the waveguide leg **12** with its probe shield **72** extending into the opening **14** (FIG. 1). The magnetron output probe is indicated by dotted lines **74**. Cooling means for the magnetron structure **70** is shown by a fan **76** and a motor **78** therefor.

Power sources and control networks for the magnetron and the motors **36**, **78**, and including switches controlled by the door (not shown), are illustrated at **80**. Such power sources and control networks are known, and may be as disclosed in U.S. Pat. No. 3,320,396, for "Electronic Oven," issued May 16, 1967, and assigned to the same assignee as the present application. It will be noted that a power connection is indicated to the heaters as well as the motors. In this regard, the heaters **24**, **26** preferably are of the dual-purpose type disclosed in the aforesaid patent, i.e., they serve as antennas to radiate microwave energy into the oven cavity, and they can also be heated by line current for thermally cooking foodstuffs placed in the cavity. For thermal heating, respective pairs of leads **82**, **84** are shown connected in FIG. 1 to their ends. The control networks function to effect selective microwave and thermal heating of foodstuffs in the cavity, and to effect operation of the motors **36**, **78** throughout operation of the magnetron **70**.

Referring to FIG. 2, the rotor previously mentioned is shown at **88** and is rotatable in the sleeve **30**. The rotor **88** carries an offset metal pin **90** extending into the waveguide arm **18**, whereby rotation of the rotor effects movement of the pin **90** in a circular path. The diameter of this path is such that the pin effectively scans the waveguide a distance of substantially a quarter of a wavelength of the propagated energy and preferably between minimum and maximum points with respect to standing waves. As will be appreciated, the pin throughout each revolution causes energy reflection to the magnetron to vary. In this connection the magnetron is initially adjusted under no-load conditions, and with the pin **90** in the position in which it has the least effect on the tube.

It should be noted that what happens to the energy during rotation of the pin **90** is too complex to permit accurate definition or explanation. However, it is clear that the rotating pin causes energy to shift back and forth in the arm **18**, and that energy interaction between the arms **16**, **18** causes correlative energy shifting in the arm **16**. Such shifting results in a frequency drift on either side of the tube's center frequency.

Still further, the position of the rotor **88** is preferably chosen so that scanning is done in the highest efficiency operating region of the magnetron, and wherein its frequency drift, i.e., the direct pulling factor, is high. In one example, wherein the magnetron is operated at a frequency of 2,450 mc., a frequency drift of ±10 mc. occurs during each revolution of the pin **90**. While the percentage of such frequency drift is quite small, the amount is quite pronounced in its effect on the mode pattern of the energy radiated into the cavity from the heaters **24**, **26**. It has been found that this effect results in pronounced mode shifting and establishes uniform distribution of microwave energy throughout the cavity.

For a given waveguide feed, the degree of mode shifting can be adjustable if desired. For example, pins of different lengths and/or sizes may be adapted to be threaded into the rotor **88**. Further, my invention embraces means for effecting either uniform or nonuniform movement of the pin.

My invention also embraces various other modifications of the illustrated energy distribution means. For example, other metal elements than pins may be used, e.g., curved and flat plates, screens and the like. Means may be employed for moving such an element in other than a circular path, e.g., back and forth longitudinally. Such movable elements may be located in both arms and operated simultaneously.

In addition to the distinctive manner in which I achieve energy distribution, it should be noted that with the movable elements located well within the waveguide feed, they are protected from direct exposure to materials within the cavity. It is further desired to prevent moisture and materials from entering the waveguide feed. To this end, the top wall of the cavity is shown with openings **96** through which to permit such moisture and materials to leave the cavity.

If desired, the inner ends of the tubular elements **62, 64** may be closed, as with nonmetallic disc collars (not shown) around the probes **20, 22** and covering the openings in the tubular elements. Alternatively, the inner ends of the tubular elements may be left open, and the fan **76** utilized to establish sufficient air pressure in the waveguide feed to prevent moisture or materials from entering the tubular elements. This involves making openings in the leg **12** through which the fan directs air into the feed, e.g., as disclosed in my application, "Microwave Heating Apparatus," Serial No. 595,995, filed Nov. 21, 1966, now U.S. Pat. No. 3,440,386 and assigned to the same assignee as the present application.

I claim:

1. The combination, for a microwave oven cavity, of:

a length of waveguide;

means for injecting microwave energy into said waveguide intermediate its ends to be divided and propagated to the ends thereof including a waveguide section extending from said length of waveguide,

said length of waveguide being straight and forming with said section a waveguide feed wherein the portions of said length of waveguide extending from said section form branching arms for the feed, said section being adapted to receive the output of a magnetron,

said waveguide section extending to the center portion of said length of waveguide,

said length of waveguide and said section being straight, whereby said section and length of waveguide form a waveguide tee;

respective means adjacent the ends of said waveguide for directing microwave energy into the cavity, including output probes of sufficient length extending from the waveguide into the cavity;

an antenna element extending from the outer end of each probe;

a movable metallic element extending into one of said arms;

means for moving said element in a predetermined path such that it traverses a longitudinal distance of the waveguide that is substantially a quarter of a wavelength of the microwave energy therein.

2. The combination of claim **1** wherein said movable element is an offset pin on a rotor, said rotor having an external shaft, whereby rotation of the rotor by said moving means causes said pin to move in a circular path.