

April 22, 1969

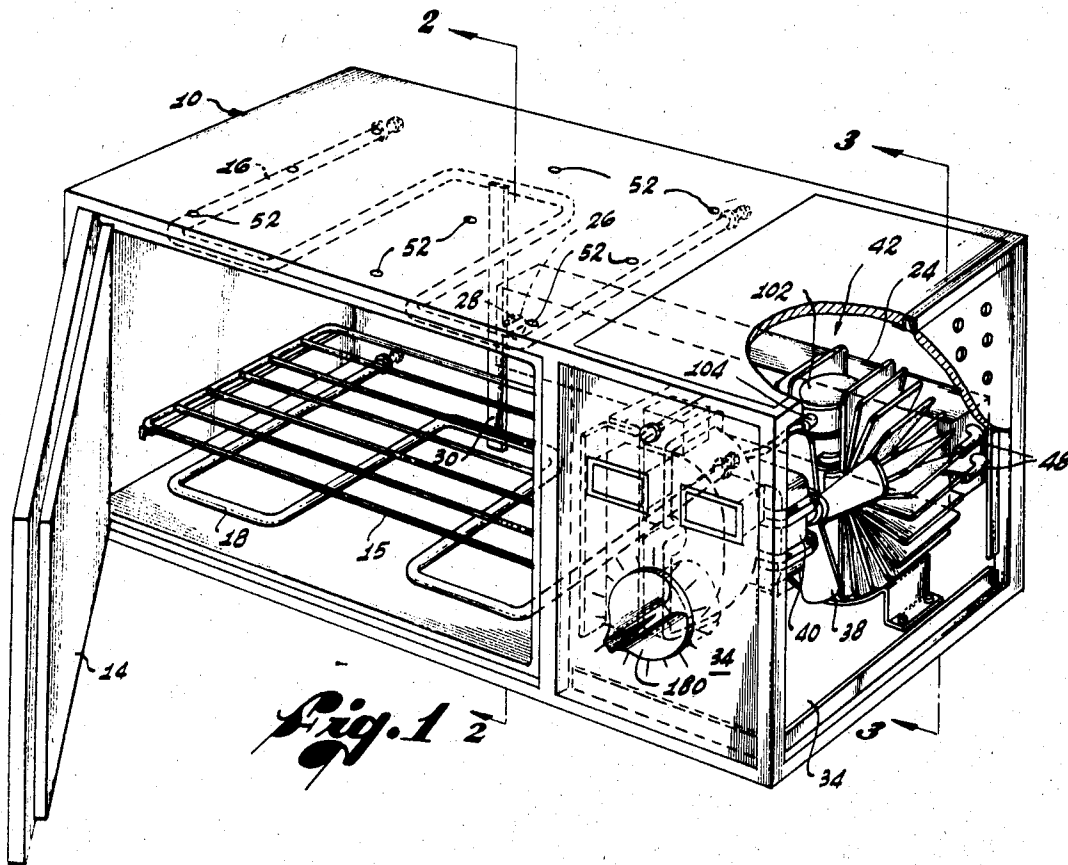
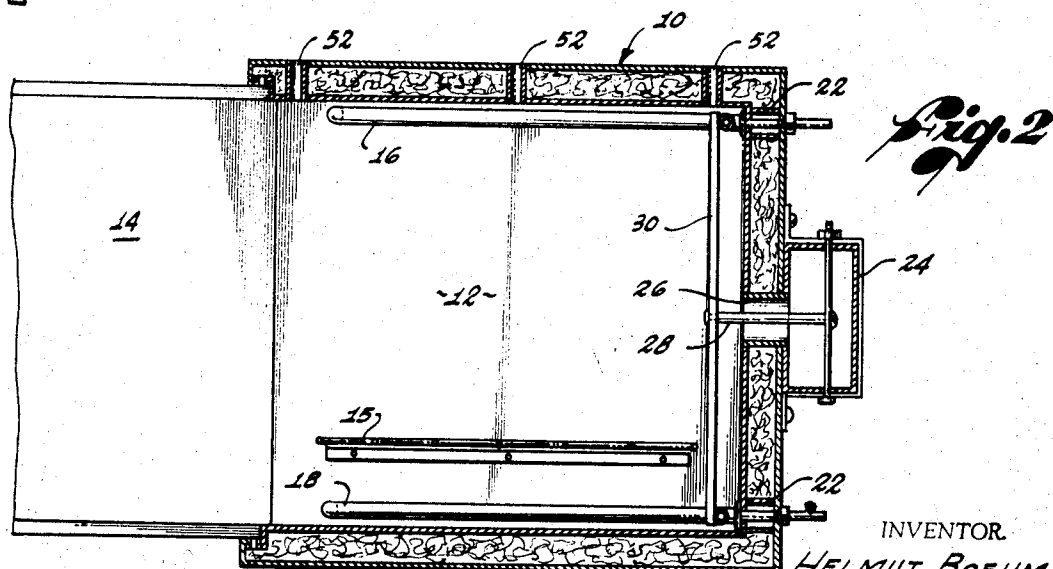
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3,440,386

MICROWAVE HEATING APPARATUS

Filed Nov. 21, 1966

Sheet 1 of 4



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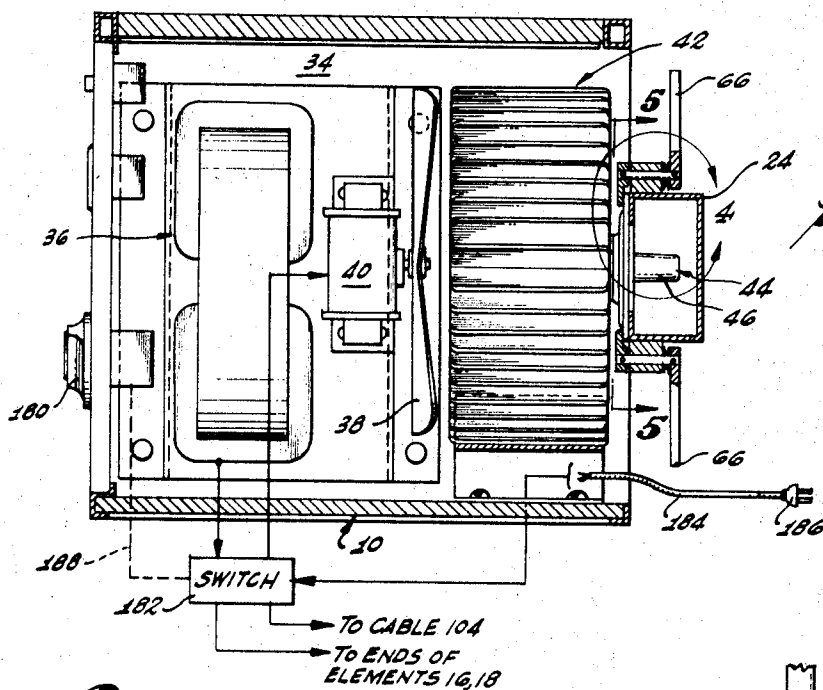


Fig. 3

Fig. 5

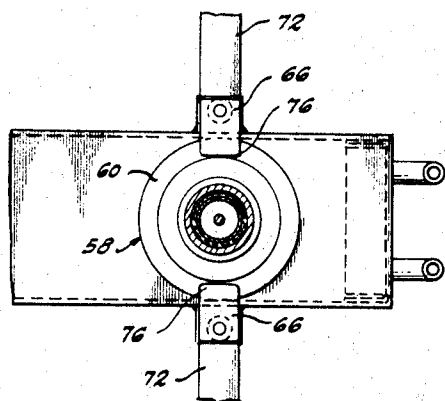
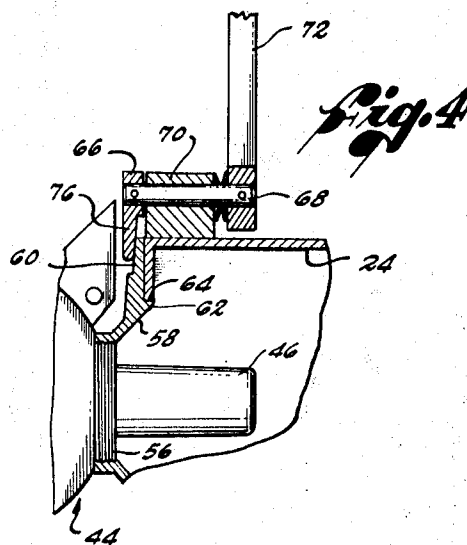


Fig. 4

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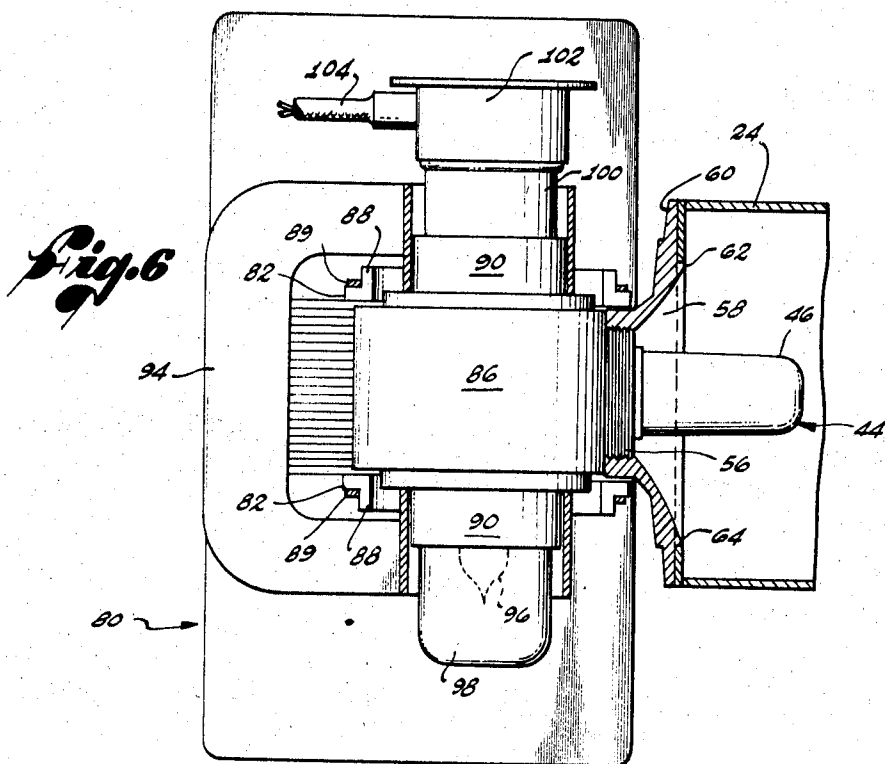
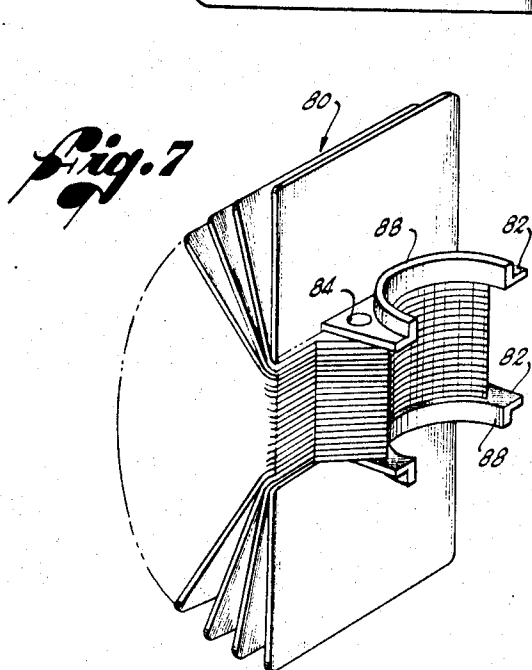
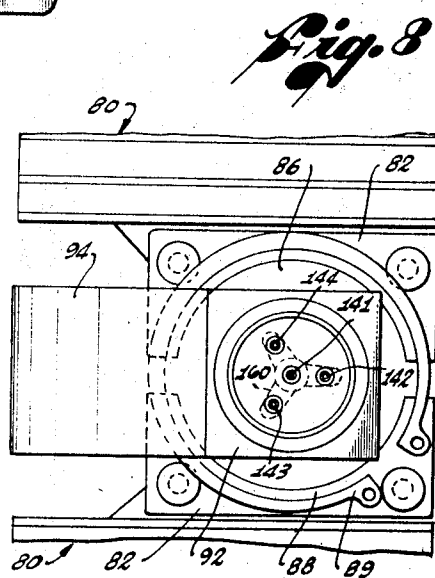
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Sheet 3 of 4



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Sheet 4 of 4

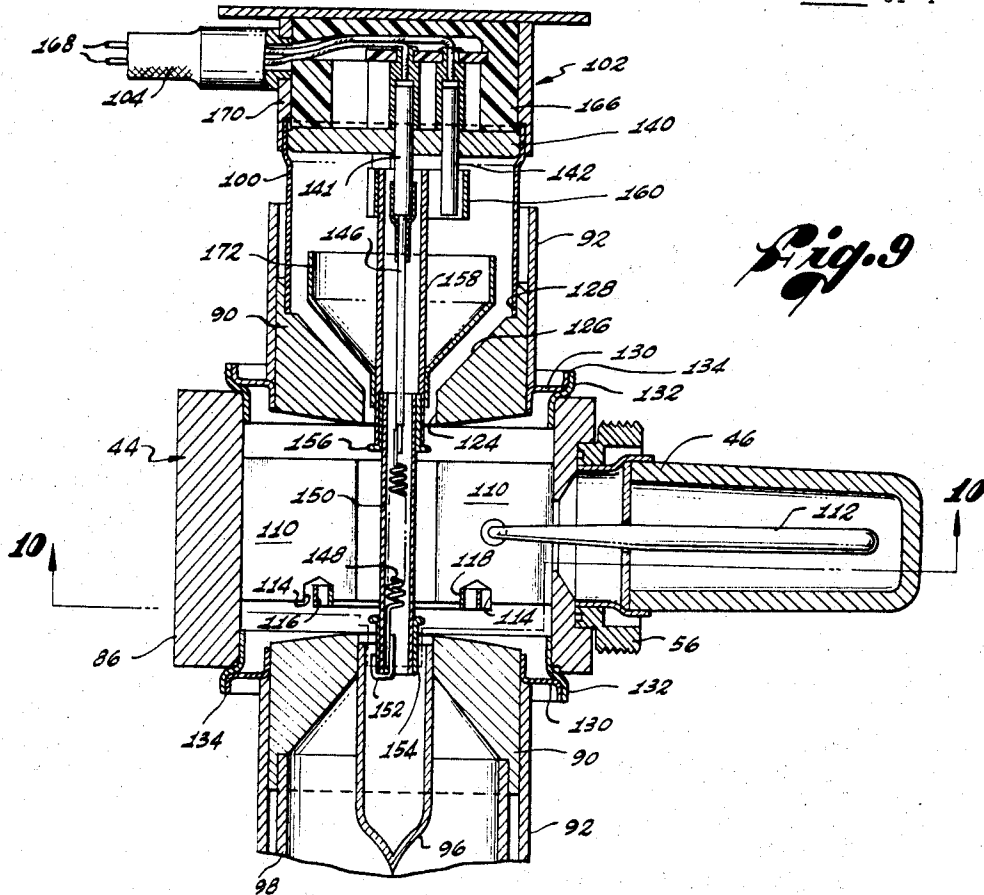


Fig. 9

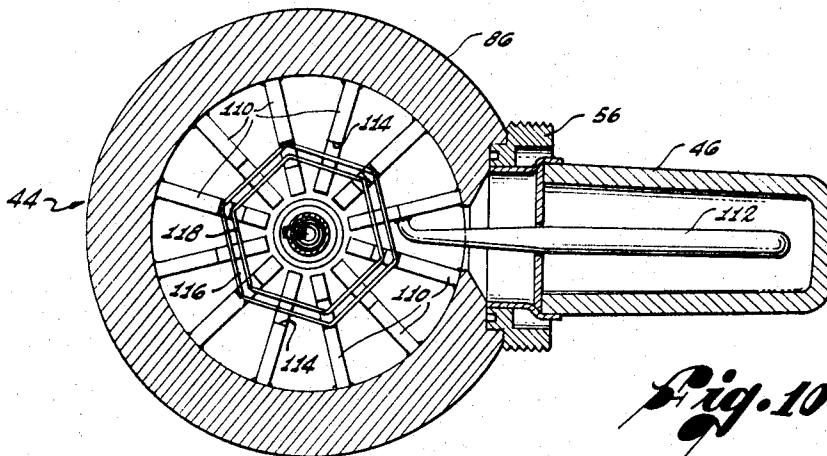


Fig. 10

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3,440,386

MICROWAVE HEATING APPARATUS
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 Filed Nov. 21, 1966, Ser. No. 595,995
 Int. Cl. H05b 9/06

U.S. Cl. 219—10.55

10 Claims

ABSTRACT OF THE DISCLOSURE

A waveguide has one opening into an oven chamber and a second opening for the output probe of a magnetron releasably attached thereto. Antenna elements in the chamber are connected to an output probe from said one opening. Adjacent said second waveguide opening, cooling means operates to cool the magnetron and direct air through the waveguide so as to force vapor in the chamber out of openings in its top wall. The antenna elements can be heated by electric current, and switch means controls connections of a power supply to the magnetron and an electric current source to the elements.

This invention relates to heating apparatus, and more particularly to improved apparatus for heating objects with microwave energy.

The apparatus of my invention will be described for cooking foodstuffs, but will be recognized as suitable for any use involving the application or utilization of microwave energy. More specifically, my invention will be described for cooking apparatus which utilizes a common element in an oven cavity for microwave cooking and/or conventional thermal cooking. Apparatus of this type is disclosed and claimed in my copending application, "Electronic Oven," Ser. No. 376,185, filed June 18, 1964, now Patent No. 3,320,396.

Such apparatus as heretofore known includes a resonant oven cavity with cooking elements therein, a magnetron for generating microwave energy, and waveguide connections for coupling the microwave energy to the elements. The elements function as traveling wave antennas to radiate the microwave energy throughout the cavity to cause foodstuffs placed therein to be cooked as desired. In addition, the elements are adapted to be heated in conventional fashion for thermal cooking. Further, circuit control means are provided for separately or simultaneously applying microwave energy and conventional heating current to the elements. The oven is provided with openings to the exterior, through which air may circulate and vapors from foodstuffs may escape without entering the waveguide system.

The present application is directed to constructions of parts of such apparatus to facilitate great economy and efficiency of manufacture, assembly, operation and maintenance thereof.

It is an object of my invention to provide an improved magnetron structure for use in microwave cooking apparatus.

Another object of my invention is to provide means utilizing the waveguide system of microwave cooking apparatus to prevent entry into such system of vapors from foodstuffs and facilitating escape of vapors from the oven of such apparatus.

Still another object of my invention is to provide means for releasably securing a magnetron structure to a waveguide structure without loss of microwave energy.

A still further object of my invention is to provide structurally cooperative magnetron and cooling fin structures with which to obtain optimum dissipation of heat generated in the magnetron structure.

It is also an object of my invention to provide microwave cooking apparatus which comprises a minimum number of component parts of simple design and rugged construction.

The above and other objects and advantages of my invention will become apparent from the following description taken in conjunction with the accompanying drawings of an illustrative embodiment thereof, in which:

FIGURE 1 is a perspective view of microwave cooking apparatus in accordance with my invention, showing an arrangement for forcing air through the waveguide to enter the cavity and preventing grease and water vapors from entering the waveguide;

FIGURE 2 is a sectional view taken along the lines 2—2 of FIGURE 1, showing the output probe extending from the waveguide into the cavity, and a coupling member extending from the probe to the heater elements;

FIGURE 3 is a sectional view taken along the lines 3—3 of FIGURE 1, showing the magnetron structure releasably locked to the waveguide, with the output probe of the magnetron extending into the waveguide;

FIGURE 4 is an enlarged, fragmentary sectional view of the region 4—4 indicated in FIGURE 3;

FIGURE 5 is a side elevation view, taken along the lines 4—4 of FIGURE 3, showing the lock elements in engagement with the flange portion of the magnetron-waveguide coupler;

FIGURE 6 is a side elevation view of my magnetron structure with its anode nested in one portion of my cooling fin structure;

FIGURE 7 is a perspective view of one of the cooling fin packages which are clamped to the anode body;

FIGURE 8 is a fragmentary end view of the assembled magnetron and cooling fin structure as seen from the connector end;

FIGURE 9 is a longitudinal sectional view of my magnetron structure; and

FIGURE 10 is a sectional view taken along the lines 10—10 of FIGURE 9, showing the arrangement of my unique mode-stabilizing straps.

Referring to FIGURE 1, there is shown a cabinet 10 for microwave cooking apparatus having an oven chamber 12 and a door 14 through which to insert and remove foodstuffs. Foodstuffs are supported on a rack 15 in the chamber. Positioned above and below the rack 15, and adjacent the top and bottom surfaces within the chamber, are elements 16, 18, which are adapted to be excited by and to radiate microwave energy. Additionally, the elements 16, 18 may be connected to a current source and thereby heated so as to raise the temperature of the interior of the oven for cooking foodstuffs thermally in the conventional manner. For radiating microwave energy, the elements are directly coupled to a microwave source, thereby to function as traveling wave antennas for radiating the microwave energy throughout the resonant cavity defined by the oven chamber 12 and the closed door 14, thereby to cook the foodstuff in the cavity solely by microwave energy. Further, the elements 16, 18 may be heated by conventional current and/or excited by microwave energy, thereby to cause the foodstuff to be cooked by a combination of microwave cooking and/or thermal cooking.

Referring to FIGURE 2 along with FIGURE 1, the top, bottom, back and side walls of the chamber 12 are formed of insulated metal walls, which may, in a manner conventional for electric ovens, comprise inner and outer metal walls with insulation 20 between them. The terminals of the elements 16, 18 extend through and are anchored to the inner and outer metal walls at the back of the cabinet 10. If desired, spacer sleeves 22 may be provided intermediate such walls for additional support in securing the terminals in place. However, outer metal

walls and spacers 22 may be eliminated, in which case the insulation 20 is suitably secured to the cavity walls.

In the particular example shown, a waveguide 24 extends along the outer wall at the back of the cabinet 10, and has an opening in which a sleeve 26 is secured. The sleeve 26 forms part of a coaxial line, and is in electrical contact at its inner end with the back wall of the cavity. An output probe 28 extends from the interior of the waveguide 24, through the sleeve 26, and into the interior of the chamber 12, where it is connected to a vertical metal bar 30 that has its upper and lower ends conductively connected to the elements 16, 18.

In this latter connection, the elements 16, 18 may have a variety of shapes. In the particular arrangement shown, each element is formed with a U-shaped center portion in which the bend is located adjacent the rear wall of the chamber 12. Thus, the connecting bar 30 is located at the rear of the chamber, and hence is clear of the supporting rack 15.

In the embodiment shown, the waveguide 24 extends along the exterior of the back wall of the cabinet 10 and past the chamber 12 to the rear of a compartment 34. Referring to FIGURES 1 and 3, the compartment 34 houses a magnetron power supply 36, a fan 38 and its motor 40, and a cooling fin structure 42 supporting a magnetron 44 which has its output probe extending into a shield 46 that is inserted in the waveguide 24. As best seen in FIGURE 1, one or more air inlet pipes, shown as elbow pipes 48, extend from the end of the waveguide 24 and toward the interior of the compartment 34. Thus, air from the fan 38 passes through the cooling fin structure 42 and enters the waveguide through the pipes 48.

The pipes 48 are made sufficiently small to prevent leakage of microwave energy therethrough. With this arrangement, air blown past the cooling fins 42 is utilized both to enhance dissipation of heat from the magnetron through the fins, and also to project air through the waveguide 24 and into the interior of the oven chamber 12.

Extending through the top of the chamber 12 are a plurality of openings, shown provided by cylindrical elements 52 (see FIGURE 2) inserted between the outer and inner metal walls. As with the pipes 48, the cylindrical elements 52 are sufficiently small to prevent undesired leakage of microwave energy from the chamber to the exterior of the cabinet 10. By thus forcing air through the waveguide 24 and into the chamber 12, I insure that grease particles and vapors from foodstuffs cooked in the chamber 12 cannot enter and contaminate the waveguide 24, but are instead forced through the openings in the top of the chamber and to the exterior of the cabinet. Further, such forcing of air through the waveguide aids in cooling the waveguide, as where the elements 16, 18 are heated by current to raise the temperature within the oven for thermal cooking. For preventing undesired matter from entering the waveguide, I prefer to operate the fan during microwave and/or thermal cooking.

The magnetron 44 is supported in the fin structure 42. Further, and in accordance with another feature of my invention, the magnetron is releasably locked to the waveguide 24. In this latter connection, and referring to FIGURES 3-5, a short, externally threaded element 56 is secured to the magnetron structure and surrounds the shield 46. A disc-like coupler element 58 is threaded onto the element 56, and is provided with a flange 60 that is undercut to form a reduced diameter axial shoulder 62 which is matingly received in an opening 64 in the confronting wall of the waveguide 24.

As shown, the inner face of the flange 60 abuts the confronting wall of the waveguide. The dimension of the abutting surface of the flange 60, i.e., the distance from the periphery of the shoulder 62 to the periphery of the flange 60, is at least a quarter of a wavelength of the microwave energy injected into the waveguide 24. In this manner, the annular space between the confronting walls of the shoulder 62 and the opening 64 is made micro-

wave-tight, i.e., leakage of microwave energy between the abutting surfaces of the flange 60 and the waveguide 24 is avoided.

The flange 60 is releasably locked in place, and in the example shown this is accomplished by means of spring-biased lock elements 66. As best seen in FIGURE 4, the lock element 66 is carried on the end of a stub shaft 68 which extends through a body 70 that is secured to the top of the waveguide 24, e.g., as by brazing. At its outer end, the shaft 68 carries a handle 72, and spring biasing means, shown in the form of Belleville springs 74, is located between the handle 72 and the sleeve 70. Thus, the handle 72 and hence the shaft 68 and lock element 66, are biased to the right in FIGURE 4.

The lock element 66 has a tapered end which is adapted to be brought against the outer surface of the flange 60, by suitably forcing the handle 72 to the left against the bias springs 74, then rotating the handle to bring the extension 76 against the outer surface of the flange 60. Thereupon, the handle 72 is released to permit the biasing springs 74 to force the extension 76 against the flange 60, and thereby hold it against the confronting surface of the waveguide 24.

With this arrangement, it will be seen that I provide a means for easily and releasably locking the magnetron structure 44 to the waveguide 24. By simply rotating the handle 72 to remove the extension 76 from locking engagement on the flange 60, the magnetron is quickly disengaged from the waveguide for replacement or repair.

As previously mentioned, the magnetron 44 is supported in the cooling fin structure 42, and the magnetron and cooling fin structures are structurally cooperatively related to effect efficient heat dissipation. Referring to FIGURES 1 and 6-8, the cooling fin structure is formed of a pair of identical cooling fin packages 80. As best seen in FIGURE 7, each of the packages is a fan-shaped cooling fin structure formed of a plurality of heat dissipating elements, e.g., aluminum plates, which are stacked together at one end, and which are bent at different angles to form the desired fan shape. Plates 82 are positioned on the opposite ends of the stacked portions of the plates, and are suitably fastened together with the stack, as by rivets 84. The inner edges of the stacked portions of the plates are made circular, and the radius of curvature conforms to that of the anode body 86 of the magnetron 44 (see FIGURE 6). Each of the plates 82 is provided with an axial extension 88, to permit the cooling fin packages to be clamped to the anode body 86, as by locking or snap rings 89.

The magnetron structure 44 fits in the space between the confronting portions of the cooling fin packages. Referring to FIGURES 6 and 8, pole pieces 90 extend from the opposite ends of the anode body 86. Slidably placed over the pole pieces 90 are magnetic sleeves 92 which have flat external surfaces (see FIGURE 8). A U-shaped permanent magnet 94 is positioned on the side of the anode body 86 opposite the shield 46, with the flat surfaces at the ends of its legs placed against the confronting flat surfaces of the magnetic sleeves 92.

Referring to FIGURE 6, the magnetron is arranged to be evacuated through a tube 96 that extends through the lower pole piece 90, and such tube 96 is surrounded by a protective cover or shield 98 which extends into and is secured to the pole piece 90. Electrical connections to the magnetron are made through a tube 100 extending out of the upper pole piece 90. A connector 102 is fitted over the upper end of the tube 100, and a cable 104 extends from the tube for connection to the power supply.

Thus, the magnetron 44 is arranged so that all parts are located between the confronting plates of the two cooling packages. Such arrangement facilitates optimum surface-to-surface contact between the anode body 86 and the edges of the plates forming the cooling fin packages. In this latter connection, the circumferential length of the edges of the cooling plates which engage the anode body

86 are between one-fourth and one-half the circumference of the anode body.

As previously mentioned, the axial extensions 88 on the plates 82 are provided to be encircled by snap rings 89 for holding the cooling fin packages in place. In this connection, and referring to FIGURES 6 and 8, the plates 82 are located above and below the anode body 86, and the snap rings 89 encircle the extensions 88 on both plates 82, thereby firmly securing the cooling fin packages 80 in place.

To enhance contact between the abutting portions of the anode body 84 and the cooling fin packages 80, a suitable heat conducting material, e.g., a silicone grease, may be coated on the edges of the plates of the cooling fin structures before they are clamped to the anode body.

FIGURES 9 and 10 illustrate the details of internal construction of the improved magnetron of my invention. The magnetron is one having a strapped vane-type tuning cavity, and to this end there is brazed to the inner wall of the anode body or block 86 a plurality of space vanes 110, to one of which the probe 112 is brazed and extended out of the body and into the shield 46, all in a conventional manner.

However, I employ unique means for strapping the vanes for mode stabilizing purposes. In this connection, each of the vanes 110 is provided adjacent its inner end with a groove 114, the sides of which are straight and parallel, and the bottom of which is V-shaped. Unlike conventional strapped vane magnetron cavities, wherein adjacent grooves are radially staggered, the grooves 114 in my improved structure are not staggered. As best seen in FIGURE 10, the inner sides of all the grooves 114 are spaced the same radial distance from the inner wall of the body 86. Similarly, the outer sides of all the grooves are spaced the same distance from the inner wall of the body.

Thus, all vanes 110 are made of the same dimensions, with grooves located in the same positions in all such elements. Accordingly, the vanes can be easily assembled by an operator without taking the time heretofore required to make certain that adjacent vanes have their grooves staggered.

Such ease of assembly of the vanes is made possible by my unique strapping arrangement. Twelve vanes are shown in the particular example, and alternate ones of these vanes are connected by respective outer and inner hexagonal straps 116, 118. The corner portions of the outer strap 116 are brazed to the outer sides of alternate grooves, and the mid-portions of the sides of the inner strap 118 are brazed to the inner sides of the remaining grooves. Inspection of FIGURE 10 will show that the corner portions of the inner strap are located inwardly of respective grooves, and do not touch the adjacent inner wall of such grooves. Also, the mid-portions of the sides of the outer strap 116 pass through alternate grooves without touching any portion thereof.

In addition, the shapes of the grooves 114 and straps 116, 118 facilitate assembly of the straps. The inner strap 118 preferably is dimensioned so that when it is slipped into the grooves, the mid-portions of its sides are in frictional engagement with the inner sides of the grooves to which such mid-portions are to be brazed. The strap is thus restricted against angular displacement prior to brazing. Also, since the bottoms of the grooves slope away from the sides thereof, the bottom edges of the mid-portions of the sides of the strap 118 come to rest against the outer end of the V, i.e., where the sides and bottoms of the grooves are joined.

The corners or angles of the outer strap 116 are similarly located in position against the outer sides of the grooves in which they are inserted. In assembly, the outer strap 116 is positioned with its corners aligned with those of the inner strap 118, which automatically orients the strap 116 properly for connection to alternate vanes. As with the other strap, the shape of the groove

limits inner movement of the strap 116, and hence serves to locate it properly for brazing. Also, the strap 116 preferably is dimensioned so that slight force has to be exerted to force it inwardly, whereby its corners frictionally engage the outer sides of the grooves in which they are located. Such corner portions are then brazed and secured in place.

As previously indicated, the straps 116, 118 perform the usual mode stabilizing function. In this connection, my strap arrangement is one that is readily adjustable after assembly to provide such corrections as are necessary for the desired mode stabilization and resonance frequency. To this end, all that is necessary is to deform one or more portions of the straps intermediate the points at which they are brazed. Thus, one or more corner portions of the inner strap 118 and/or one or more of the mid-portions of the sides of the strap 116 may be forced inwardly or outwardly to change the capacitance of the straps as needed. Since the straps are ribbon-like metal elements, they retain such deformation.

For ease of manufacture and assembly, the pole pieces 90 are made identical. As best seen in FIGURE 9, each of the pole pieces is formed as a cylindrical element having a central opening that has a small cylindrical portion 124, a frusto-conical portion 126, and a recessed, enlarged diameter portion 128.

The pole pieces 90 are mounted in the anode block 86 with their rounded end faces extending into the ends of the block. In the arrangement shown, the pole pieces are secured at the ends of the block by means of flanged rings 130, 132 that are brazed, respectively, to the pole piece 90 and the block. In the particular arrangement shown, the rings 130 nest in the rings 132, and are welded together as indicated at 134, e.g., as by heliarc welding.

The tube 100 is supported in one of the pole pieces 90, as by inserting it in the enlarged diameter portion 128 of the opening therein, and brazing it to the pole piece. An end cap 140 is inserted in the outer end of the tube 100 and bonded thereto, and connector pins 141-144 (see FIGURES 8 and 9) extend through and are bonded to the cap. In the arrangement shown, the pin 141 extends through the center of the cap 140 and the pins 142-144 are spaced pins equidistant from the center pin 141.

Within the interior of the tube 100, the center pin 141 is connected to the heater lead 146 for a heater element 148 located in a sleeve cathode 150 that passes through the center of the vanes 110. The heater 148 is connected at 152 to an end shield 154 that is fitted around the cathode 150 at one end thereof.

A similar end shield 156 is fitted around the opposite end of the cathode 150, and a tube 158 is secured at one end to the shield 156. As shown, the tube 158 surrounds the heater lead 146 and the inner end of the connector 141, the outer end of the tube 158 being spaced from the inner face of the cap 140. Frictionally fitted around the outer end of the tube 158 is a clip element 160 which, as best seen in FIGURE 8, has outwardly extending legs which pass around and frictionally engage the connector pins 142-144. Thus, the connector pins 142-144 are connected together electrically.

Through the connector 102 and the cable 104, the heater 148 (via the pin 141) and the cathode 150 (via the pins 142-144) are adapted for connection to suitable heater and cathode potentials. To this end, the connector 102 is formed with an insulating body 166, through which leads 168 extend from the cable 104 for connection to respective pins 141, 142. In the arrangement shown, the ends of the leads 168 are supported in socket connectors frictionally fitted over the outer ends of the pins 141, 142. The body 166 is surrounded by a shield 170 which is frictionally fitted over the outer end of the tube 100.

The improved magnetron of my invention includes a novel choke structure for isolating the power supply from the microwave energy developed in the anode block 86.

To this end, I provide a tubular element 172 which has a surface configuration that generally conforms to the portions 124, 126, 128 of the opening in the pole piece 90. The element 172 has its smaller end fitted over the tube 158 and secured thereto adjacent its inner end, as by spot welding. The length of the element 172 is such that the length of the gap surrounding the element 172, measured from the outer end of the element 172 to the inner end of the pole piece 90, is a quarter-wavelength of the fundamental frequency of the energy generated within the anode block 86.

At such fundamental frequency, which for microwave cooking purposes preferably is in the region of 2,400 mHz., the confronting surface portions of all elements defining the gap, i.e., the portions of the elements 172 and the end shield 156 together with the confronting surface portions of the pole piece 90 and tube 100, function as a low impedance coaxial line at such fundamental frequency. Since such line terminates at the outer end of the element 172, the space within the tube 100 beyond the outer end of the element 172 constitutes an effective high impedance to the microwave energy. Accordingly, this construction forms an effective choke to prevent the microwave energy from being coupled through the pin connectors to the power supply.

In addition, the choke construction of my invention is adapted to minimize the effects of troublesome harmonics. In this connection, it will be observed that the coaxial line above-mentioned is a stepped affair. The gap is smallest in the region of the portion 124 of the opening in the pole piece 90, is somewhat wider in the frusto-conical region thereof, and is widest along the enlarged diameter portion of the element 172. Such stepwise variations in the width of the gap, together with the differing lengths of the cylindrical and frusto-conical portions thereof, provide effective coaxial lines which are successive low-to-high impedance transformers. The dimensions preferably are selected to effectively isolate the most troublesome harmonics, e.g., the second and fourth harmonics.

After the magnetron is assembled, it is evacuated via the tube 96. The tube 96 is brazed at its inner end within the small diameter portion of the pole piece 90 in which it is inserted. After assembly of the magnetron, the tube 96 is connected to a vacuum pump for evacuating the entire structure in a conventional manner, following which the tube 96 is pinched off and closed at its outer end as indicated in FIGURE 9.

In addition to the advantages of my magnetron structure as above described, I achieve a marked improvement over prior art structures in the concentration of magnetic lines of force at the ends of the vanes 110. Since the inner ends of the pole pieces 90 are rounded, whereby their center portions are closest to the inner ends of the vanes 110, and since the pole pieces are inwardly tapered as described and have the greatest portion of their masses located immediately adjacent the ends of the vanes, they are effective to concentrate the flux from the magnet in the center portion of the anode block 86.

Any suitable switching means may be employed to effect cooking by microwave and/or thermal energy with the above-described apparatus. For example, one switch circuit may be provided for connecting the ends of the elements 16, 18 to a source of heating current, and another for connecting the power supply 36 to the magnetron connector cable 104. Such switch circuits may be operated by separate knobs, or by a single control knob as shown at 180 in FIGURE 1 on the front panel of the compartment 34.

In this latter connection, there is illustrated in FIGURE 3 a switch box 182 to which are connected the power supply 36 and a cord 184 having a plug 186 to be connected to the house current supply. The switch box 182 has output connections to the cable 104 and to the ends of the elements 16, 18. Switch circuits as referred to are included in the switch box, for operation in different positions of the

knob 180, as through a mechanical connection 188 for operating movable contacts of the circuits.

Preferably, such circuits have some fixed contacts in common, so that in certain positions of the knob 180 there is cooking simultaneously by microwave and thermal energy. Still further, the fan motor 40 is preferably directly connected via the switch box 182 to the cord 184, through a switch that remains closed in all but the "off" position of the knob. In this manner, the fan is kept running at all times the oven is in use.

While the switch 182 and connections are shown schematically outside the oven structure in FIGURE 3, it is preferred that a corresponding physical structure be located in the compartment 34. In such case, a shaft from the switch box or housing preferably is on the axis of the knob 180 and directly connected thereto; the cord 104 extends through the compartment to the switch housing; the connections from the power supply 36 and the connections from the switch mechanism to the fan 40 and the cable 104 are all leads confined in the compartment 34; and the connections to the ends of the elements 16, 18 are leads that extend from the switch housing through the rear of the compartment, from which they extend to and are secured to the terminals of the elements projecting through the back of the oven structure.

From the foregoing, it will be apparent that various modifications can be made in the structures illustrated and described without departing from the spirit and scope of my invention. Accordingly, I do not intend that my invention be limited, except as by the appended claims.

I claim:

1. In combination:

a microwave cavity having openings to the exterior thereof through which to permit vapor to pass, wherein said cavity is an oven chamber with a front door, said chamber having bottom, top, rear and side walls, the openings to the exterior of the cavity being in the top wall;

a conduit through which to introduce microwave energy into said cavity, comprising a waveguide, said waveguide adjacent one end having an opening, said waveguide being mounted exteriorly of the rear wall, said rear wall having an opening aligned with the waveguide opening;

antenna means in said chamber;

an output probe extending through said waveguide opening and coupled to said antenna means, said waveguide adjacent its other end having a second opening through which to introduce microwave energy into the waveguide;

a magnetron having an output probe extending into said second opening;

means releasably holding said magnetron and waveguide together; and

means to force air through said conduit and into the cavity at sufficient pressure to keep vapor in the cavity from passing into said conduit, such forced air aiding the escape of vapor through said openings.

2. The combination of claim 1, wherein said waveguide has an opening in said other end through which to admit air into the waveguide;

a pipe connection to said end opening; and fan means for blowing air into said pipe connection.

3. The combination of claim 1, wherein said antenna means includes an element which is adapted to be heated by electric current;

means to supply electric current to said element;

a power supply for said magnetron; and

switch means operable for connecting said element to a source of electric current and for connecting said power supply to said magnetron separately or simultaneously.

4. The combination of claim 3, including means for operating said fan means at all times during operation of said switch means.

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5. The combination of claim 1, wherein said magnetron has a cylindrical anode block, said magnetron output probe extending out of the lateral surface of said block; a pair of pole pieces extending out of the ends of the block; an evacuation tube extending out of one pole piece; an electrical lead support tube extending out of the other pole piece; and a permanent magnet extending along and spaced from said block opposite said magnetron output probe and having its ends engaging said pole pieces.
6. The combination of claim 5, further including; a pair of cooling fin packages formed of stacked plates, the plates at one edge of each stack being curved with the same radius of curvature as said block, said packages being located on opposite sides of said block with the curved plates of each package extending a quarter of the circumference of said block; and means to hold said packages with the curved edges of the plates thereof in contact with the lateral surface of said block.
7. The combination of claim 6, including a pair of magnetic sleeves surrounding said pole pieces, said sleeves having a flat external surface, said magnet being U-shaped and having flat faces at the ends of its legs engaging said flat external surfaces.
8. The combination of claim 6, wherein the plates of each package are shaped to define a fan-shaped cooling package; C-shaped plates secured at the opposite ends of each stack of plates; and snap-rings encircling corresponding C-shaped plates of said packages and to releasably hold the curved edges of said plates against said block.
9. The combination of claim 5, including: a circular element surrounding said magnetron output probe and extending from said block, the exterior portion of said circular element being threaded; a disc element threadedly secured to said circular element, said disc element having a circular shoulder slidable in said second waveguide opening, said disc

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- element having a face abutting said waveguide around said second waveguide opening, the radial dimension of said face being at least a quarter wavelength of the microwave energy propagated through said waveguide; and means for releasably clamping said disc element and waveguide together.
10. In combination: a microwave cavity having openings to the exterior thereof through which to permit vapor to pass, wherein said cavity is an oven chamber with a front door, said chamber having bottom, top, rear and side walls, the openings to the exterior of the cavity being in the top wall; antenna means in said chamber; a source of microwave energy; a waveguide outside said cavity and having an input opening coupled to said source, said waveguide having an output opening; means for directing microwave energy at said output opening solely to said antenna means to cause said antenna means to radiate microwave energy throughout said cavity; and means to force air through said waveguide into said chamber at sufficient pressure to keep vapor in the chamber from passing into said waveguide, such forced air aiding the escape of vapor through said openings.

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