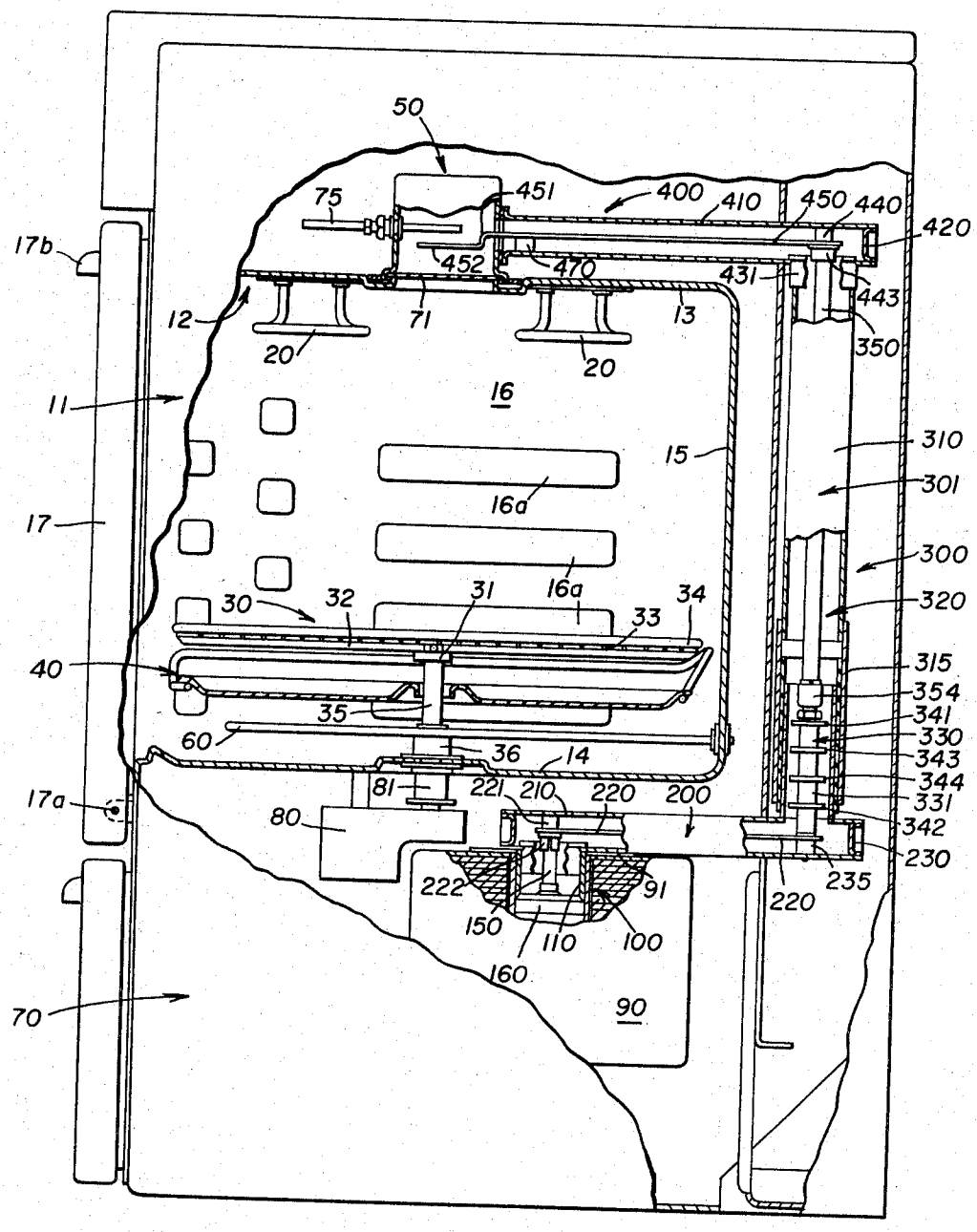
May 23, 1967 F. A. REKER 3,321,605

ELECTRONIC OVEN

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FIG. 1



INVENTOR
FREDRICK A. REKER
BY
Prangley Baird Clayton, Miller & Vogel,
ATTYS.

May 23, 1967 F. A. REKER 3,321,605

ELECTRONIC OVEN

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FIG. 2

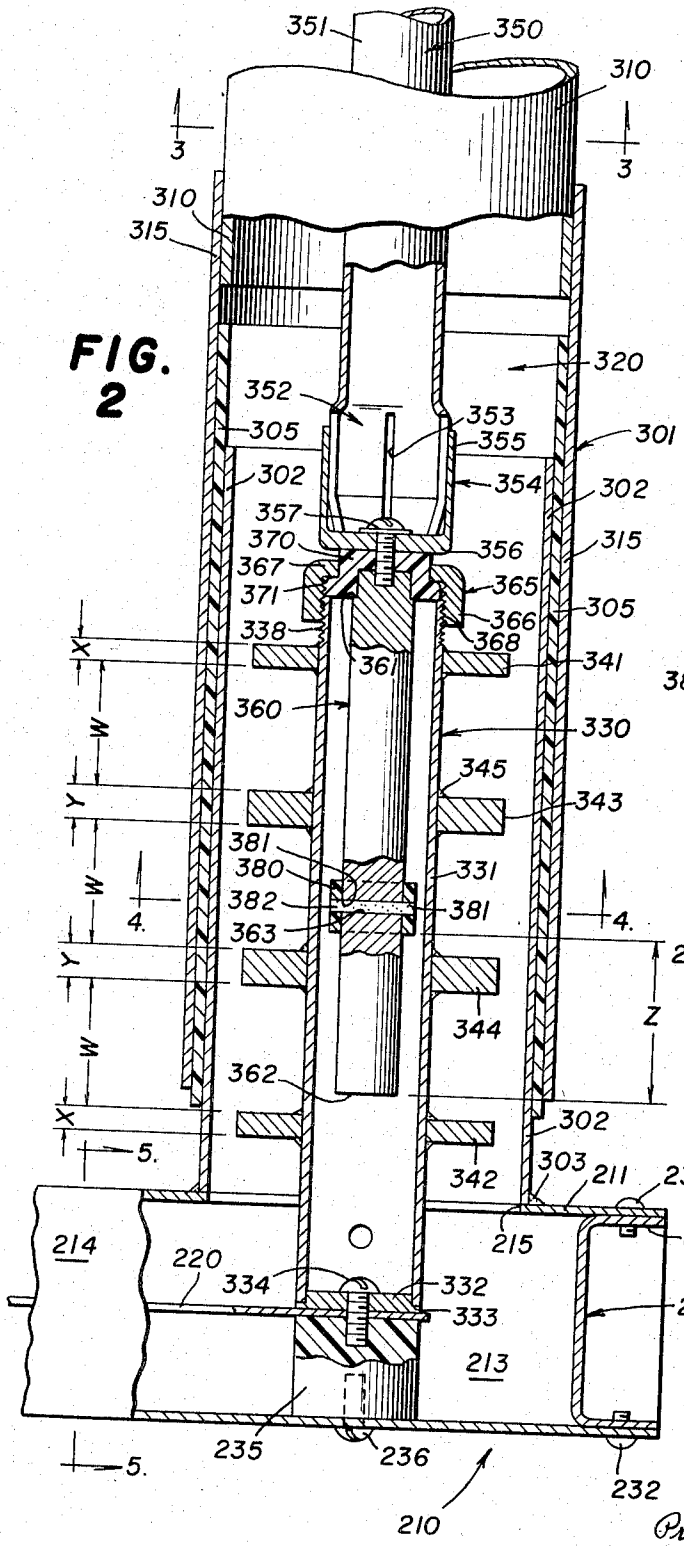


FIG. 3

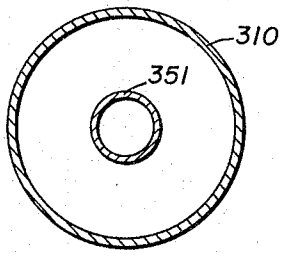


FIG. 4

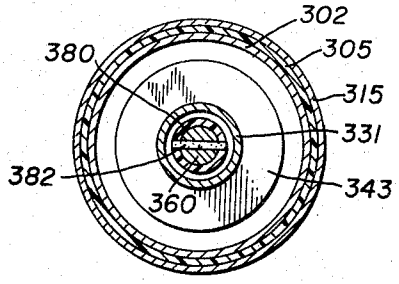
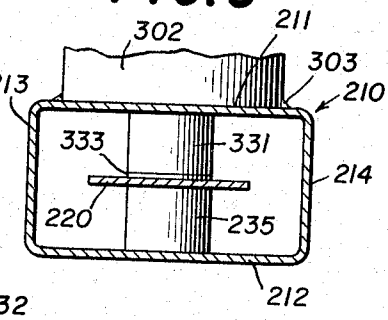


FIG. 5



INVENTOR
FREDRICK A. REKER

BY
Brumley, Baird, Clayton, Miller & Vogel,
ATTYS.

United States Patent Office 3,321,605
Patented May 23, 1967

3,321,605

ELECTRONIC OVEN

Frederick A. Reker, Scarsdale, N.Y., assignor to General Electric Company, a corporation of New York

Filed Aug. 6, 1964, Ser. No. 387,861
8 Claims. (Cl. 219—10.55)

The present invention relates to electronic ovens, and more particularly to such ovens incorporating therein ultra-high frequency electromagnetic wave energy transmission lines.

It is a general object of the invention to provide an improved electronic oven incorporating therein a transmission line of the type including a tubular outer conductor and an enclosed inner conductor for transmitting ultra-high frequency electromagnetic wave energy from a generator therefor to a cooking cavity in the interior of the oven.

Another object of the invention is to provide an electronic oven having an improved transmission line of the type set forth, wherein the transmission line includes a tubular outer conductor and an inner conductor disposed therein, the inner conductor including two longitudinally disposed sections electrically insulated from each other, one of the inner conductor sections including a tube and the other of the inner conductor sections including a probe extending into the tube, and a ring of low-loss dielectric material carried by the probe in surrounding relation therewith and spaced away from the inner end of the probe and toward the outer end of the tube by substantially a predetermined distance, whereby in the transmission of the electromagnetic wave energy between the inner conductor sections there is effected high attenuation of a corresponding predetermined harmonic and substantial attenuation of the higher harmonics of the fundamental operating frequency of the generator.

Yet another object of the invention is to provide an electronic oven having an improved transmission line of the type set forth, wherein the tube and the probe and the ring provide a filter for effecting high attenuation of the second harmonic and substantial attenuation of the higher harmonics of the fundamental operating frequency of the generator.

Still another object of the invention is to provide an electronic oven having an improved transmission line of the type set forth, wherein the tube and the probe and the ring provide a filter for effecting high attenuation of the fourth harmonic and substantial attenuation of the higher harmonics of the fundamental operating frequency of the generator.

Yet another object of the invention is to provide an electronic oven having an improved transmission line of the type set forth, wherein the transmission line includes a tubular outer conductor and an inner conductor disposed therein, the inner conductor including two longitudinally disposed sections electrically insulated from each other, one of the inner conductor sections including a tube and the other of the inner conductor sections including a probe extending into the tube, a first ring of low-loss dielectric material carried by the probe in surrounding relation therewith and spaced away from the inner end of the probe and toward the outer end of the tube by substantially a first predetermined distance, whereby in the transmission of the electromagnetic wave energy between the inner conductor sections there is effected high attenuation of a corresponding first predetermined harmonic and substantial attenuation of the higher harmonic of the fundamental operating frequency of the generator, and a second ring of low-loss dielectric material carried by the probe in surrounding relation therewith and spaced away from the inner end of the probe and toward the outer end of the tube by substantially a second predetermined distance, whereby in the transmission of the electromagnetic wave energy between the inner conductor sections there is effected high attenuation of a corresponding second predetermined harmonic and substantial attenuation of the higher harmonics of the fundamental operating frequency of the generator.

Yet another object of the invention is to provide an electronic oven having an improved transmission line of the type set forth, wherein the low-loss dielectric material therein consists essentially of a synthetic organic polymer having a softening point at a relatively high temperature, the preferred synthetic organic polymer being polytetrafluoroethylene.

A further object of the invention is to provide an electronic oven having an improved transmission line of the type set forth, wherein there is further provided a plurality of longitudinally spaced-apart conducting discs carried by the inner conductor and extending radially outwardly toward the outer conductor to provide a relatively low impedance between the conductors for harmonics of the fundamental operating frequency of the generator.

A still further object of the invention is to provide an electronic oven having an improved transmission line of the type set forth, wherein the outer conductor includes two sections arranged in telescopic relation with each other, and further comprising a sleeve of electrical insulating material arranged in intervening relation to the two outer conductor sections at the telescopic joint therebetween.

Further features of the invention pertain to the particular arrangement of the parts and elements of the electronic oven, whereby the above-outlined and additional operating features thereof are attained.

The invention both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which:

FIGURE 1 is a side view with certain parts broken away of an electronic oven embodying therein the present invention;

FIG. 2 is a fragmentary view in vertical section on an enlarged scale with certain parts broken away of the improved transmission line forming a part of the electronic oven of the present invention;

FIG. 3 is a view on a reduced scale in horizontal section through the upper portion of the transmission line along the line 3—3 of FIG. 2;

FIG. 4 is a view on a reduced scale in horizontal section along the line 4—4 of FIG. 2; and

FIG. 5 is a view on a reduced scale in vertical section through the horizontal transmission line along the line 5—5 of FIG. 2.

Referring to FIG. 1 of the drawings, the electronic oven **10** there illustrated, and embodying the features of the present invention if of the fundamental construction and arrangement of that disclosed and claimed in the copending application of Louis H. Fitzmayer, Ser. No. 135,582, filed Sept. 1, 1961, now Patent No. 3,172,987, granted Mar. 9, 1965. More particularly, the oven **10** comprises an oven chamber or cooking cavity **11** defined by electrically conductive walls, and particularly by a box-like metal liner **12** including a top wall **13**, a bottom wall **14**, a rear wall **15** and two side walls **16**, the front opening of the liner **12** being closed by a metallic oven door **17**. The door **17** is provided with a hinge **17***a* and a handle **17***b*, whereby the door **17** may be moved between an open position and a closed position, suitable interlocking and switching apparatus (not shown) being provided to insure that there is no electromagnetic wave

energy present within the cooking cavity **11** when the door **17** is in its open position.

As illustrated in the drawings, the appliance **10** is in fact a combination electric and electronic oven and includes a pair of spaced-apart electric heating units of the sheathed resistance conductor type mounted on the lower surface of the liner top wall **13** and generally designated by the numeral **20**. The heating units **20** are generally rectangular in form and extend substantially parallel to the oven door **17** and are spaced-apart from front to rear of the liner **11** so that electromagnetic wave energy can be injected into the cooking cavity therebetween. A lower electric heating unit of the sheated resistance conductor type is also provided and is mounted slightly above the bottom wall **14** of the liner **12** and is generally designated by the numeral **60**.

Disposed above the bottom wall **14** of the liner **12** and also above the bottom heating unit **60** is a cooking platform generally designated by the numeral **30** and including a central hub **31** from which extend radially outwardly a plurality of metallic rod-like arms **32** which carry thereon a floor **33** of metallic open-work construction, the outer ends of the arms **32** and the periphery of the floor **33** carrying a generally circular upstanding metallic rim **34** thereon. Formed integral with the hub **31** and extending downwardly therefrom in an arbor **35** that fits into a bearing **36** mounted on the bottom wall **14** and including a drive connection **81** for the arbor **35** to a drive unit **80** mounted below the bottom wall **14**, the drive unit **80** being preferably an electric motor. Food to be cooked is placed upon the cooking platform **30** and the platform **30** is in turn driven by means of the drive unit **80** and the drive connection **81** and the arbor **35** at a rate of six revolutions per minute, for example, to pass the food upon the platform **80** through the electromagnetic field within the cooking cavity **11** so that various portions of the food being cooked are subjected to different field intensities, thereby equalizing the cooking thereof.

In order to collect the drippings and juices that are generated and which may fall from the cooking platform **30**, a drip tray generally designated by the numeral **40** is provided beneath the cooking platform **30** but above the electric heating unit **60** so as to protect the electric heating unit **60** from the drippings. The drip tray **40** is formed of metal and performs a further function of shielding the electric heating unit **60** from the electromagnetic wave energy by providing a protective choke for the wave energy throughout substantially the lower portion of the cooking cavity **11**, whereby to prevent the formation of parasitic currents in the lower heating unit **60**, thereby protecting the heating unit **60** and preventing loss of electromagnetic wave energy therein. Conveniently, the drip tray **40** is supported upon the usual embossments **16***a* provided upon the side wall **16** of the liner **12**.

Positioned below the upper cooking cavity **11** is an apparatus compartment **70** within which is disposed a generator in the form of a magnetron **90** which serves as a source of ultra-high frequency electromagnetic wave energy for the cooking cavity **11**, the magnetron **90** being of conventional form and having, for example, an operating frequency of 925 megacycles. The electromagnetic wave energy from the magnetron **90** is transmitted to the cooking cavity **11** via a transmission line of the coaxial conductor type made in accordance with an embodying the principles of the present invention and including four sections **100**, **200**, **300** and **400** connected in series and communicating with the interior of the cooking cavity **11** through a distribution box **50**. More specifically, the magnetron **90** is disposed beneath the cooking cavity **11** and toward the rear thereof and is provided with a lower vertically extending transmission line section **100** of circular configuration connecting at a right angle with the lower horizontal transmission line section **200** of rectangular configuration which extends

below and to the rear of the rear wall **15** of the cooking cavity **11**. The rear end of the transmission line section **200** is connected at a right angle to the lower end of an upper vertical transmission line section **300** of circular configuration which has the upper end thereof connected at a right angle to the rear end of an upper horizontal and forwardly extending transmission line section **400** of rectangular configuration having the front end thereof connected at right angle to the distribution box **50**.

The magnetron **90** is provided with a field coil housing **91** including a central cylindrical member providing a metallic tubular outer conductor **110** that is substantially circular in cross section and has disposed centrally thereof a metallic stud **150** connected to the output terminal of the magnetron **90** and spaced from the conductor **110** by insulators including an insulator **160**, the stud **150** being substantially circular in cross section. The tubular outer conductor **110** and the enclosed inner conductor or stud **150** comprise the first section **100** of the transmission line interconnecting the magnetron **90** and the distribution box **50**. The second transmission line section **200** includes a metallic tubular outer conductor **210** which is substantially rectangular in cross section as may be best seen in FIGS. 2 and 5 of the drawings, and includes wider upper and lower side walls **211** and **212** joined by narrower side walls **213** and **214**. The bottom side wall **212** has a circular opening therein to the periphery of which is connected the outer tubular conductor **110** forming a part of the first transmission line section **100**. An inner conductor **220** is provided in the second transmission line section **200**, the conductor **220** having a substantially rectangular cross section and being of ribbon-like configuration as can best be seen in FIGS. 2 and 5 of the drawings, the inner conductor **220** being disposed centrally of the outer conductor **210** with the flat surfaces thereof substantially parallel to the side walls **211** and **212**. The end of the inner conductor **220** adjacent to the magnetron **90** is mounted on the outer conductor **210** by means of a suitable insulating block **221** which is held in position on the upper wall thereof and which also mounts thereon a resilient metallic conductor or bullet **222** which releasably and grippingly engages the stud **150**. As may be best seen in FIGS. 1 and 2 of the drawings, the transmission line **200** extends rearwardly from the magnetron **90** and the rear end thereof is closed by a metallic end cap **230** having an annular flange **231** therearound fitting into the interior of the outer conductor **210** and enclosing the rear end thereof, the end cap **230** being held in position by screws **232**. The rear end of the conductor **220** terminates a short distance from the end cap **230** and is supported by an insulator block **235** held in position within the outer conductor **210** by means of a screw **236**.

The lower end of the transmission line section **300** connects with the rear or right hand end of the transmission line section **200** as viewed in FIG. 1, the transmission line section **300** including an outer tubular conductor generally designated by the numeral **301** and an enclosed inner conductor generally designated by the numeral **320**. The outer conductor **301** includes a first metallic conductor section **302** which is generally circular in cross section and has the lower end thereof mounted upon and connected to the top wall **211** of the outer conductor **210** as at **303**, the lower end of the conductor section **302** surrounding a circular opening **215** in the top wall **211**. The conductor section **302** extends upwardly from the top wall **211** a substantial distance and has the outer surface thereof surrounded by a sleeve **305** formed of an electrically insulated material, the sleeve **305** extending upwardly beyond the upper end of the conductor section **302** and terminating at the lower end thereof at a point spaced a short distance from the side wall **211** of the outer conductor **210**. The preferred material of construction of the insulating sleeve **305** is a synthetic organic polymer, and more particularly a polymer formed of

polytetrafluoroethylene resin sold under the trademark "Teflon." A second metallic conductor section **310**, also substantially circular in cross section, is provided, the inner diameter of the conductor section **310** being slightly greater than the outer diameter of the conductor section **302** and substantially equal to the outer diameter of the insulating sleeve **305**. Surrounding the insulating sleeve **305** is a cylindrical metallic sleeve **315** which closely interfits with the insulating sleeve **305** and extends from a point adjacent to the lower end thereof upwardly and beyond the upper end thereof and into overlying relationship with the lower end of the metallic conductor section **310**. The internal diameter of the metallic sleeve **315** is slightly greater than the external diameter of the conductor section **310** to provide lateral mechanical support therefor while holding the conductor section **310** in contact with the upper end of the insulating sleeve **305**, whereby the conductor sections **302** and **310** are held in firm mechanical alignment but are electrically insulated from each other by means of the electrically insulating sleeve **305**.

The inner conductor **320** includes two longitudinally disposed conductor sections **330** and **350** electrically insulated from each other. The lower conductor section **330** includes a generally cylindrical tube **331** which has an outer diameter substantially less than the inner diameter of the outer conductor section **302**, the lower end of the tube **331** being closed by a plug **332** having an outwardly extending flange **333** thereon, the plug **332** being suitably secured to the lower end of the tube **331** such as by brazing, both the tube **331** and the plug **332** being formed of a good electrical conducting material, preferably copper. The plug **332** rests upon the upper surface of the inner conductor **220** supported by the insulating block **235**, and a suitable fastener in the form of a screw **334** passes through the plug **332**, the conductor **220** and into the insulating block **235** firmly to mount the tube **331** thereon and to provide a good electrical interconnection between the inner conductor **220** and the inner conductor section **330**.

Spaced along the inner conductor section **330** and extending radially outwardly therefrom are four discs, two of the discs having a lesser thickness and being designated by the numerals **341** and **342**, and two of the discs having a greater thickness and being designated by the numerals **343** and **344**. All of the discs **341**, **342**, **343** and **344** have a generally circular shape as is best seen in FIG. 4 and are disposed concentrically with respect to the inner surface of the outer conductor section **302** and completely surround the inner conductor section **330**, the discs being suitably mounted in the desired position along the inner conductor **330** by brazing as at **345**. The thinner discs **341** and **342** preferably have a predetermined thickness X as indicated in FIG. 2, the thicker discs **343** and **344** have a predetermined thickness Y, and the distance between the facing surface of adjacent discs is a predetermined value W. The discs **341**, **342**, **343** and **344** in cooperation with the outer conductor section **302** provide a relatively low impedance path between the conductor sections **302** and **330** for the harmonics of the fundamental operating frequency of the generator **90**, whereby to bypass the major portion of those harmonics and prevent transmission thereof along the transmission line section **300** to the conductors **310** and **350**.

The second inner conductor section **350** includes a metallic tube **351** having a substantially circular cross section. There is provided on the lower end of the tube **351** an enlargement **352** which is provided with slots **353** to facilitate insertion thereof into a cup **354** including a cylindrical upstanding wall **355** receiving the enlargement **352** therein and having the lower end thereof closed by a transverse wall **356**. The cup **354** carries therebeneath a probe **360** which is formed as a solid rod of a good electrical conducting material such as copper, the cross section of the probe **360** being substantially circular as is best seen in FIG. 4. The probe **360** is more specifically mounted upon the cup **354** by means of a screw **357** extending through an opening in the bottom of the cup **354** and threadedly engaging a complementarily threaded opening in the upper end of the probe **360**, the probe **360** being disposed substantially concentrically with respect to the upstanding wall **355** of the cup **354** and being disposed substantially concentrically with respect to the tube **330** within which it is disposed and into which it extends.

The upper end of the probe **360** is provided with an annular shoulder **361** extending therearound and receiving thereon a ring **370** of low-loss dielectric material which is disposed in surrounding relationship with respect to the upper end of the probe **360** and particularly about the portion of the probe **360** disposed above the shoulder **361** thereon. The ring **370** further has an opening generally centrally thereof receiving therethrough the shank of the screw **357** and also has an outwardly extending flange **371** extending well beyond the outer surface of the upper end of the probe **360** and engaging and overlying and substantially closing the upper end of the tube **330**. In order fixedly to mount the cup **354** upon the tube **330** and fixedly to position the ring **370** upon the upper end of the tube **330** in closing relationship with respect thereto, and in order firmly to position the probe **360** centrally with respect to the tube **330**, a cap **365** is provided including an annular outer wall **366** surrounding the upper end of the tube **330** and an inturned flange **360** engaging the ring flange **371**. The inner surface of the wall **366** is threaded as at **368** and threadedly engages external threads **338** on the upper end of the tube **330**, the cooperating threads **338** and **368** enabling the cap **365** firmly to clamp the ring **370** upon the upper end of the tube **330**; more specifically the flange **367** on the cap **365** engages the flange **371** on the ring **370** and urges it downwardly against the upper end of the tube **330** to provide a firm and tight seal therearound.

The ring **370** serves as a good electrical insulator between the lower inner conductor section **330** and the upper inner conductor section **350**, and more specifically, provides good electrical insulation between the tube **331** and the probe **360** disposed therein. In addition, the ring **370** serves to insulate the cup **354** from the cap **365**, a predetermined capacitance being formed between the cup **354** and the cap **365** as will be described more fully hereinafter. Preferred materials of construction of the ring **370** are synthetic organic polymers, any such polymer having the requisite electrical insulating properties and the low-loss characteristics at the higher harmonics of the operating frequency of the generator **90** being suitable, such as for example, polyethylene, polystyrene, polytetrafluoroethylene, and the like. Of particular utility are those synthetic organic polymers that have a softening point at a relatively high temperature since the metallic parts of the transmission line section **300** are heated by the operation of the electronic oven **10**, a preferred example of a polymer having a softening point at a relatively high temperature being polytetrafluoroethylene which has a softening point above 550° F.

A second ring **380** of low-loss dielectric material is carried by the probe **360** intermediate the ends thereof and in surrounding relationship therewith. There is provided in the probe **360** a diametrally oriented opening **363** disposed in the illustrative example approximately one-third of the length thereof away from the inner end **362**, and the ring **380** has therein aligned openings **381** which are disposed in registration with the opening **363** in the probe **360**. A body **382** of cement is disposed in the aligned openings **363** and **381** fixedly to secure the ring **381** longitudinally with respect to the probe **360**. The preferred material of construction of the ring **380** is the same as that of the ring **370** described above, i.e., a synthetic organic polymer, and particularly such a polymer having a softening point at a relatively high

temperature, the preferred material of construction being polytetrafluoroethylene. The body **382** of cement must also be insulating in character and capable of withstanding the relatively high temperatures that may be encountered in the transmission line section **300**.

During the operation of the transmission line section **300**, the tube **331** and the probe **360** cooperate to provide a filter whereby substantially to prevent transmission of the second and higher harmonics of the fundamental operating frequency of the generator **90** along the transmission section **300**, and specifically, from the lower inner conductor section **330** to the upper inner conductor section **350**. By lengthening or shortening the probe **360**, the attenuation of the higher harmonics of the generator **90** can be increased or decreased, and positioning the ring **380** at different points along the probe **360** serves to cause preferential attenuation of one frequency with respect to another frequency or other frequencies. In the from of the invention illustrated in the drawings, the filter formed by the tube **331** and the probe **360** is designed specifically to provide high attenuation of the second harmonic and fourth harmonic of the fundamental operating frequency of the generator **90**, and to provide a desired balance of the attenuation between the second harmonic and the fourth harmonic of the fundamental operating frequency of the generator **90**. To this end, the length of the probe **360** and the position of the ring **370** thereon, i.e., the distance between the ring **370** and the inner end **362** of the probe **360**, is predetermined so that there is effected high attenuation of the second harmonic of the fundamental operating frequency of the generator **90**, the distance between the ring **370** and the inner end **362** of the probe **360** in the illustrative example being equal substantially to three-eighths wave length of the second harmonic of the fundamental operating frequency of the generator **90**. The position of the ring **380** from the outer end **362** of the probe **360** is also predetermined and is selected so that there is effected a high attenuation of the fourth harmonic of the fundamental operating frequency of the generator, the predetermined distance being equal substantially to a quarter wave length of the fourth harmonic of the fundamental operating frequency of the generator **90**. When the parts are so arranged and related with respect to each other, a maximum attenuation of the second and fourth harmonics is achieved, and there further is provided high attenuation of the higher harmonics of the fundamental operating frequency of the generator **90**. The ring **370** being of a low-loss dielectric material and positioned as indicated provides a high-loss or attenuation of the fourth harmonic, whereby to achieve a balanced maximum attenuation of the second and fourth harmonics and higher harmonics of the fundamental operating frequency of the generator **90**.

In the operation of the filter including the tube **331**, the cup **354**, the probe **360** and the cap **365** a predetermined capacitance is provided between the tube **331** and the probe **360**, and particularly between the cap **365** closing the upper end of the tube **331** and the cup **354** at the upper end of the probe **360**. The length of the probe **360** is chosen so that the inductance thereof at the second and fourth harmonics of the fundamental operating frequency of the generator **90** resonates with the capacitance between the cup **354** and the cap **365** and the other capacitance between the tube **331** and the probe **360**. The higher the capacitance between these parts, the lower the resonant frequency of the filter formed thereby, and vice versa, the lower the capacitance between these parts the higher the resonant frequency of the filter formed thereby. The ring **380** serves as a transformer and is positioned along the probe **360** a proper distance from the end **362** thereof so that the filter formed by the various parts named will filter both the second and fourth harmonics of the fundamentel operating frequency of the generator **90**. If the tranformer provided by the ring **380** is not properly located along the length of the probe **360**, a maximum rejection will not occur at two frequencies that are multiples of each other, i.e., there will not be maximum rejection at the second and fourth harmonics of the fundamental operating frequency; on the other hand, proper positioning of the transformer represented by the ring **380** will provide for maximum rejection of the second and fourth harmonics. The attenuation of the second and fourth harmonics is fundamentally obtained because the inductance provided by the probe **360** resonates with the capacitance between the probe **360** including the connected parts thereof such as the cup **354** and the tube **331** including the connected parts thereof such as the cap **365** at the second and fourth harmonics. The tube **331**, the probe **360** and the ring **380** together with the attached parts provide a filter which can be considered to be essentially a parallel resonant circuit in series with the inner conductor **320** of the transmission line section **300**, and more particularly a parallel resonant circuit in series between the inner conductor section **330** and the inner conductor section **350**.

The provision of the insulating sleeve **305** between the outer conductor sections **302** and **310**, and the provision of the insulating ring **370** between the inner conductor section **330** and the inner conductor section **350** further provides insulation between the respective conductor sections so that there is no D.C. connection therebetween, whereby the relatively high D.C. potentials on the outer conductor **210** are not applied to the outer conductor section **310**, and likewise any D.C. potentials on the inner conductor **220** are not applied to the inner conductor section **350**, and in fact the outer conductor section **310** or the inner conductor section **350** can be grounded if desired, the outer conductor section **310** in fact being grounded as will be described more fully hereinafter. In addition, the parts thus described, including the lower end of the outer conductor section **310** cooperating with the outer metallic sleeve **315** and the lower end **352** of the inner conductor section **350** cooperating with the cup **354**, provide a readily separable connection which facilitates assembly and diassembly of the upper transmission line sections **310–350** with respect to the lower transmission line sections **302–330**.

The upper end of the transmission section **300** is connected at a right angle to the rear end of the transmission line section **400**. Referring to FIG. 1 of the drawings, it will be seen that the transmission line section **400** is provided with a metallic tubular outer conductor **410** which has a substantially rectangular cross section. Disposed within the outer conductor **410** and enclosed thereby is a metallic inner conductor **450** which also is rectangular in cross section and is disposed substantially centrally of the outer conductor **410**. The end of the outer conductor **410** disposed adjacent to the upper end of the transmission line section **300** is closed by an end cap **420** which is adapted to fit within the outer conductor **410**, the end cap **420** substantially filling and closing the outer conductor **410** and being held in position thereon by fasteners, not shown. The adjacent end of the inner conductor **450** is supported within the outer conductor **410** on an insulating block **440** which is held in position upon the conductor **410** and which carries a metallic connector **443** in electrical connection with the electrical conductor **450** and which receives and forms an electrical connection with the upper end of the inner conductor section **350**, the inner conductor section **350** extending upwardly through a circular opening in the lower side of the outer conductor **410**. The upper end of the outer conductor section **310** surrounds the circular opening in the lower wall of the outer conductor **410** and is held in proper relationship therewith by means of a fitting **431** mounted on the lower wall of the outer conductor **410**.

The other or front end of the transmission line section **50** is connected to the distribution box **50**, the outer conductor **410** abutting and being joined to the adjacent wall of the distribution box **50** and surrounding an opening therein through which extends the adjacent end of the

inner conductor **450**. More specifically, the adjacent end of the inner conductor **450** is mounted upon an insulating block **470** supported by the lower wall of the outer conductor **410** and further extends into the distribution box **50** and thus beyond the forward end of the outer conductor **410**. The inner conductor **450** is bent downwardly as at **451** and terminates in an outwardly extending probe **452** disposed below the parallel to the main body on the inner conductor **450**.

The distribution box **50** is formed of metal and is substantially closed around the four vertical sides of the top thereof, the bottom of the distribution box **50** being closed by a pane **71** of material which is impervious to oven gases but which is highly transparent to electromagnetic wave energy, a preferred material of construction being a fused mixture of powdered glass and mica sold under the trademark "Mykroy." The pane **71** also is in registration with a window formed on the top wall **13** of the liner **12** so that the electromagnetic wave energy delivered to the distribution box **50** can be directed through the pane **71** and into the interior of the cooking cavity **11**.

There further is provided in the distribution box **50** a metallic tuning rod **75** which extends into the distribution box **50** and overlies the probe **452**, the position of the tuning rod **75** being adjustable so as to obtain the desired tuning action.

In a preferred constructional example of the electronic oven **10**, the magnetron **90** is designed and operated to produce a fundamental frequency of about 925 megacycles, whereby the fundamental frequency has a wave length of about 12.77 inches. In such a construction, it is desired highly to attenuate the second harmonic of 1850 megacycles and the fourth harmonic of 3700 megacycles by means of the filter provided by the tube **331** and the probe **360**. To achieve the maximum attenuation of the second and fourth harmonics, and further to achieve a balanced attenuation thereof, the parts have the following illustrative dimensions and ranges of dimensions:

The tube **331** has an overall length in the range 3.48 to 3.49 inches, an internal diameter in the range 0.539 to 0.543 inch and an external diameter of 0.625 inch; the probe **360** has a length measured between the shoulder **361** and the inner end **362** in the range 2.58 to 2.59 inches, a diameter in the range 0.311 to 0.314 inch and a distance in the range 0.99 to 1.00 inch from the center of the opening **363** to the inner end **362** thereof; the ring **380** has an outer diameter in the range 0.425 to 0.435 inch, and a longitudinal extent in the range 0.245 to 0.255 inch; and the distance Z, i.e., the distance between the lower edge of the ring **380** and the inner end **362** of the probe **360** is in the range 0.86 to 0.88 inch. In such an oven construction, the discs **341**, **342**, **343** and **344** have a diameter in the range 1.31 to 1.32 inches; the discs **341** and **342** have a thickness X in the range 0.122 to 0.128 inch; the discs **343** and **344** have a thickness Y in the range 0.193 to 0.199 inch; and the distance W between the facing surfaces of adjacent discs is 0.625 inch.

From the above it will be seen that there has been provided an improved electronic oven incorporating therein a transmission line of the type including a tubular outer conductor and an enclosed inner conductor for transmitting ultra-high frequency electromagnetic wave energy from a generator therefor to a cooking cavity in the interior of the oven, the inner conductor including two longitudinally disposed sections electrically insulated from each other, one of the inner conductor sections including a tube and the other of the inner conductor sections including a probe extending into the tube, and a ring of low-loss dielectric material carried by the probe in surrounding relation therewith and spaced away from the inner end of the probe and toward the outer end of the tube by substantially a predetermined distance, whereby in the transmission of electromagnetic wave energy between the inner conductor sections there is effected high attenuation of the higher harmonics of the fundamental operating frequency of the generator. There further has been provided a second ring of low-loss dielectric material carried by the probe in surrounding relation therewith and spaced from the inner end of the probe and toward the outer end of the tube by substantially a second predetermined distance whereby in the transmission of the electromagnetic wave energy between the inner conductor sections there is effected high attenuation of a corresponding other predetermined harmonic and substantial attenuation of the higher harmonics of the fundamental operating frequency of the generator. Further the attenuations of the second and higher harmonics of the fundamental operating frequency of the generator and the attenuations of the fourth and higher harmonics of the fundamental and operating frequency of the generator are balanced to provide the desired attenuations thereof within the improved transmission line.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein and it is intended to cover in the appended claims all such modifications that fall within the true spirit and scope of the invention.

What is claimed is:

1. An electronic oven comprising structure defining an apparatus compartment and a cooking cavity, a generator disposed in said apparatus compartment for generating ultra-high frequency electromagentic wave energy, a transmission line of the coaxial conductor type interconnecting said generator and said cooking cavity, whereby the electromagnetic wave energy is supplied into said cooking cavity via said transmission line from said generator, said transmission line including a tubular outer conductor and an inner conductor disposed therein, said inner conductor including two longitudinally disposed sections electrically insulated from each other, one of said inner conductor sections including a tube and the other of said inner conductor sections including a probe extending into said tube, and a ring of low-loss dielectric material carried by said probe in surrounding relation therewith and spaced away from the inner end thereof by a predetermined distance equal substantially to a quarter wave length of the fourth harmonic of the fundamental operating frequency of said generator, whereby in the transmission of the electromagnetic wave energy between said inner conductor sections there is effected high attenuation of the fourth harmonic and substantial attenuation of the higher harmonics of the fundamental operating frequency of said generator.

2. An electronic oven comprising structure defining an apparatus compartment and a cooking cavity, a generator disposed in said apparatus compartment for generating ultra-high frequency electromagnetic wave energy, a transmission line of the coaxial conductor type interconnecting said generator and said cooking cavity, whereby the electromagnetic wave energy is supplied into said cooking cavity via said transmission line from said generator, said transmission line including a tubular outer conductor and an inner conductor disposed therein, said inner conductor including two longitudinally disposed sections electrically insulated from each other, one of said inner conductor sections comprising a tube and the other of said inner conductor sections including a probe extending into said tube, the capacitance between said inner conductor sections cooperating with the inductance presented by the length of said probe within said tube to provide in series in said inner conductor a parallel resonant circuit having a high impedance at a predetermined harmonic of the fundamental operating frequency of said generator highly to attenuate the predetermined harmonic, and a transformer ring of low-loss dielectric material carried by said probe in surrounding relation therewith and spaced from the inner end thereof a predetermined distance equal substantially to a quarter wave

length of a frequency higher than the predetermined harmonic, whereby in the transmission of the electromagnetic wave energy between said inner conductor sections there is effected high attenuation of both the predetermined harmonic and the frequency higher than the predetermined harmonic and the yet higher harmonics of the fundamental operating frequency of said generator.

3. The electronic oven set forth in claim 2, wherein said predetermined distance is equal substantially to a quarter wave length of the second harmonic of the predetermined harmonic, whereby in the transmission of the electromagnetic wave energy between said inner conductor sections there is effected high attenuation of both the predetermined harmonic and the second harmonic of the predetermined harmonic and the higher harmonics of the fundamental operating frequency of said generator.

4. The electronic oven set forth in claim 2, wherein said capacitance and said inductance provide in series in said inner conductor a parallel resonant circuit having a high impedance at the second harmonic of the fundamental operating frequency of said generator highly to attenuate the second harmonic, and said predetermined distance is equal substantially to a quarter wave length of the fourth harmonic of the fundamental operating frequency of said generator, whereby in the transmission of the electromagnetic wave energy between said inner conductor sections there is effected high attenuation of both the second harmonic and the fourth harmonic and higher harmonics of the fundamental operating frequency of said generator.

5. The electronic oven set forth in claim 2, and further comprising a plurality of longitudinally spaced-apart conductive discs carried by said inner conductor and extending radially outwardly toward said outer conductor to provide a high impedance in series for the third and higher harmonics of the fundamental operating frequency and to provide a relatively low impedance path between said inner and outer conductors for the third and higher harmonics of the fundamental operating frequency.

6. The electronic oven set forth in claim 2, wherein said outer conductor includes two sections arranged in telescopic relation with respect to each other at a point disposed between the juncture of said inner conductor sections and said cooking cavity, and further comprising a sleeve of electrically insulating material arranged in intervening relation to said two outer conductor sections at the telescopic joint therebetween.

7. An electronic oven comprising structure defining an apparatus compartment and a cooking cavity, a generator disposed in said apparatus compartment for generating ultra-high frequency electromagnetic wave energy, a transmission line of the coaxial conductor type interconnecting said generator and said cooking cavity, whereby the electromagnetic wave energy is supplied into said cooking cavity via said transmission line from said generator, said transmission line including a tubular outer conductor and an inner conductor disposed therein, said inner conductor including two longitudinally disposed sections electrically insulated from each other, one of said inner conductor sections comprising a tube and the other of said inner conductor sections including a probe extending into said tube, a first ring of low-loss dielectric material carried by said probe in surrounding relation therewith and spaced away from the inner end thereof by substantially a first predetermined distance, the capacitance between said inner conductor sections cooperating with the inductance presented by the length of said probe within said tube and said first predetermined distance to provide in series in said inner conductor a parallel resonant circuit having a high impedance at the second harmonic of the fundamental operating frequency of said generator highly to attenuate the second harmonic, and a second ring of low-loss dielectric material carried by said probe in surrounding relation therewith and spaced from the inner end thereof by substantially a second predetermined distance equal substantially to a quarter wave length of the fourth harmonic of the fundamental operating frequency of said generator, whereby in the transmission of the electromagnetic wave energy between said inner conductor sections there is effected the maximum high attenuation of both the second harmonic and the fourth harmonic of the fundamental operating frequency of said generator and high attenuation of yet higher harmonics of the fundamental operating frequency of said generator.

8. The electronic oven set forth in claim 7, and further comprising four longitudinally spaced-apart conductive discs carried by said tube and extending radially outwardly toward said outer conductor to provide a high impedance to the transmission along said transmission line of the third and higher harmonics of said fundamental operating frequency and to provide a relatively low impedance path between said discs and said outer conductor for the third and higher harmonics of said fundamental operating frequency, whereby to prevent the transmission of the third and higher harmonics of said fundamental operating frequency to said cooking cavity.

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RICHARD M. WOOD, *Primary Examiner.*

L. H. BENDER, *Assistant Examiner.*