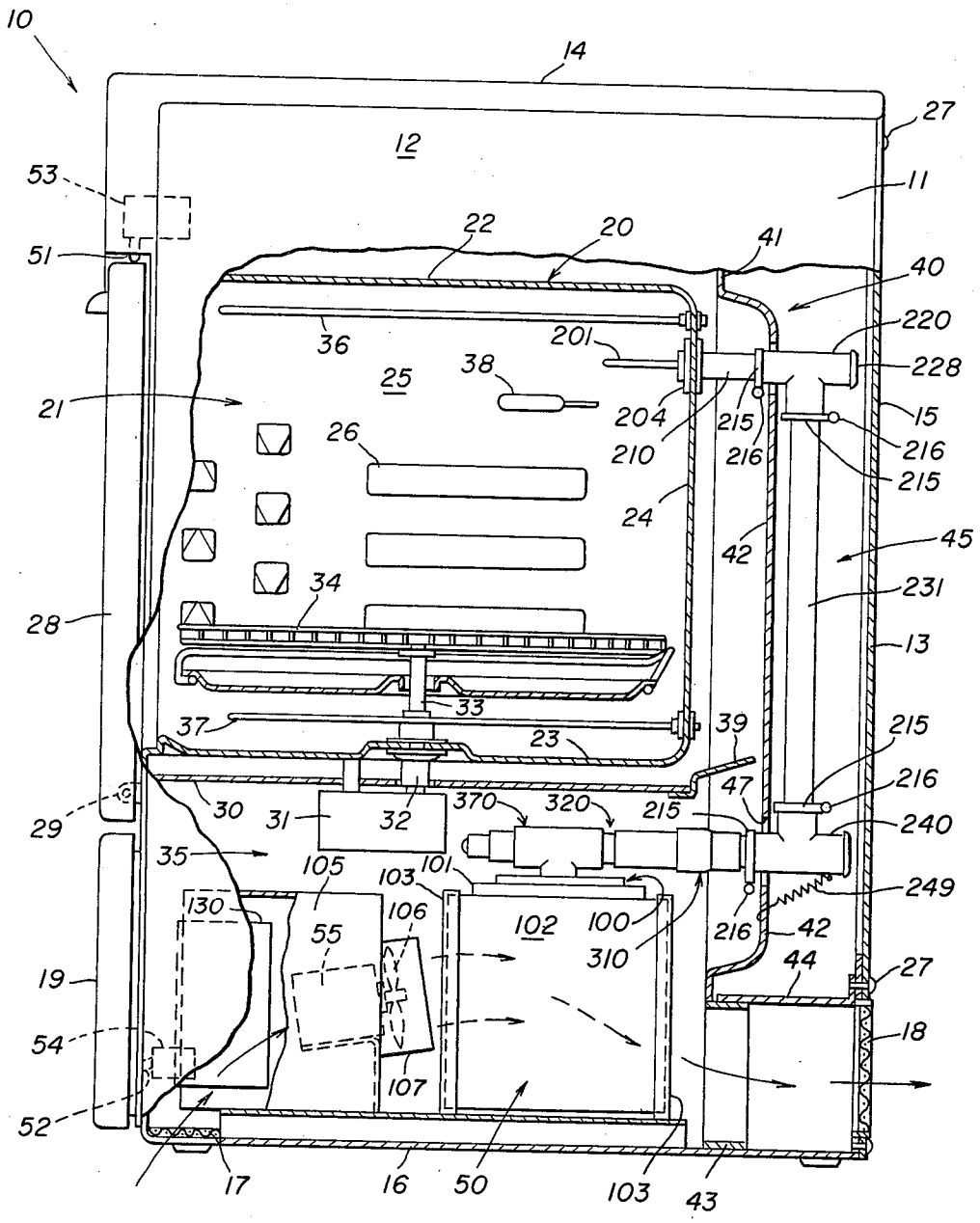
May 12, 1970 J. E. STAATS 3,511,958

ELECTRONIC OVEN INCLUDING MICROWAVE COUPLING STRUCTURE AND FOLDED CAVITY FILTERS THEREFOR

Filed Dec. 31, 1968

5 Sheets-Sheet 1

FIG. 1

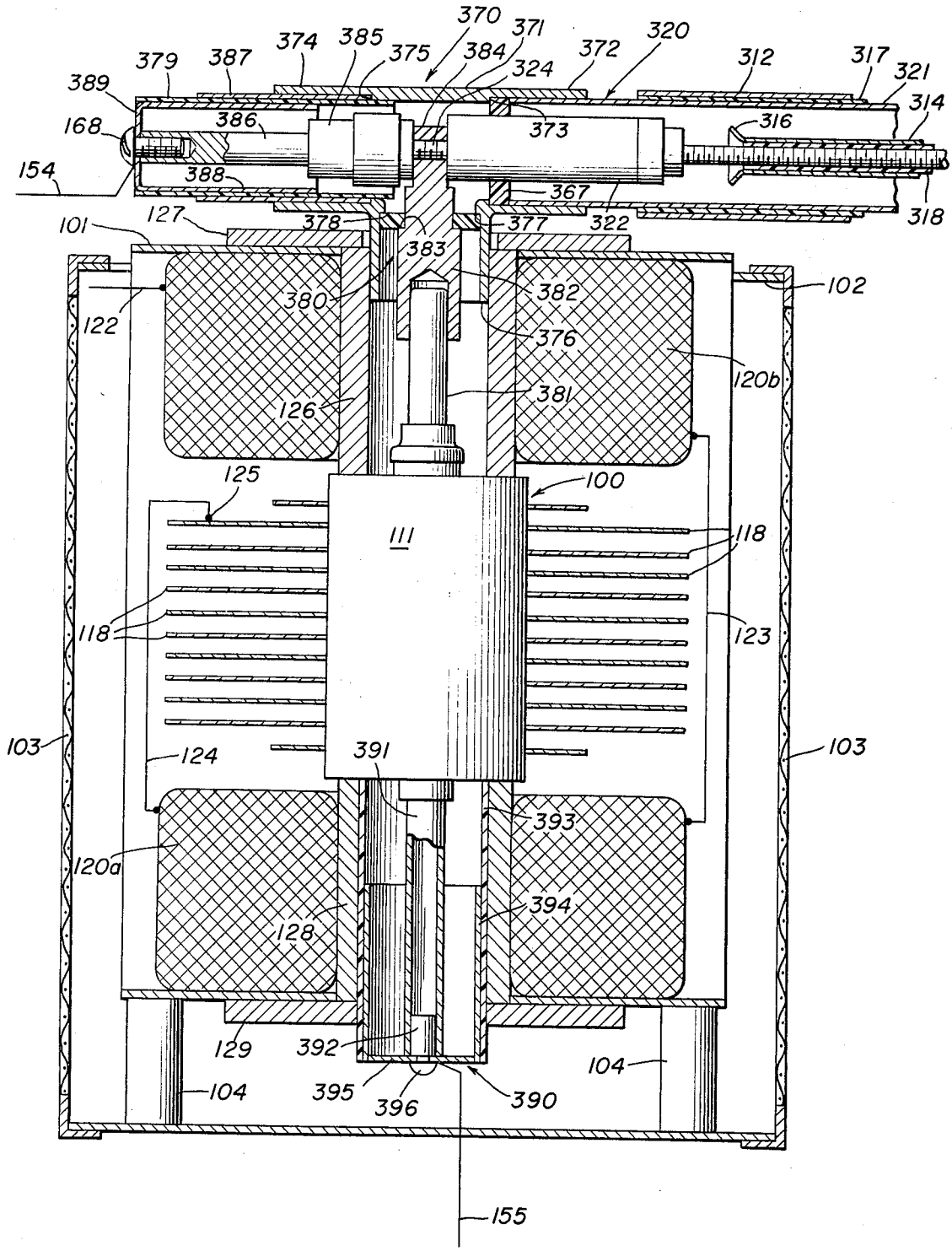


INVENTOR
JAMES E. STAATS

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

May 12, 1970 J. E. STAATS 3,511,958
ELECTRONIC OVEN INCLUDING MICROWAVE COUPLING STRUCTURE AND FOLDED CAVITY FILTERS THEREFOR
Filed Dec. 31, 1968 5 Sheets-Sheet 2

FIG. 2



May 12, 1970 J. E. STAATS 3,511,958

ELECTRONIC OVEN INCLUDING MICROWAVE COUPLING STRUCTURE AND FOLDED CAVITY FILTERS THEREFOR

Filed Dec. 31, 1968 5 Sheets-Sheet 3

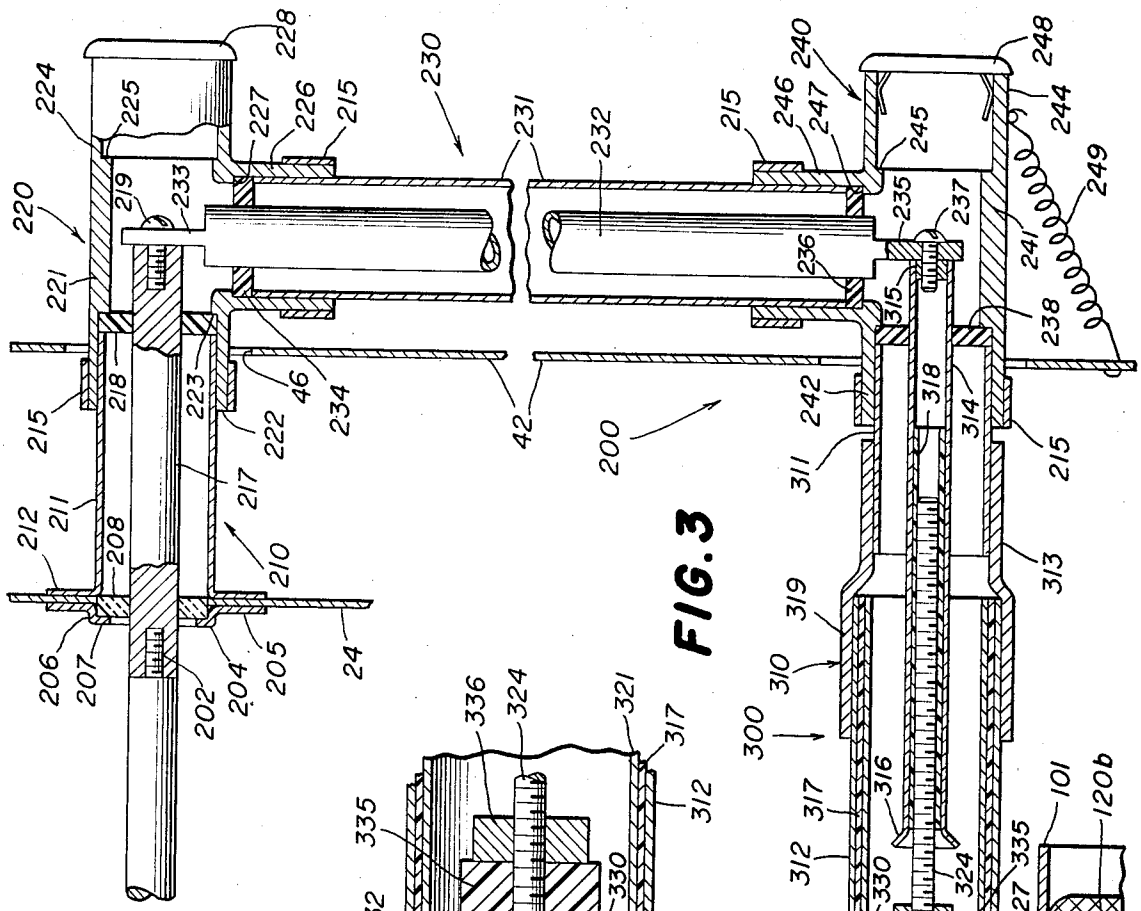


FIG. 3

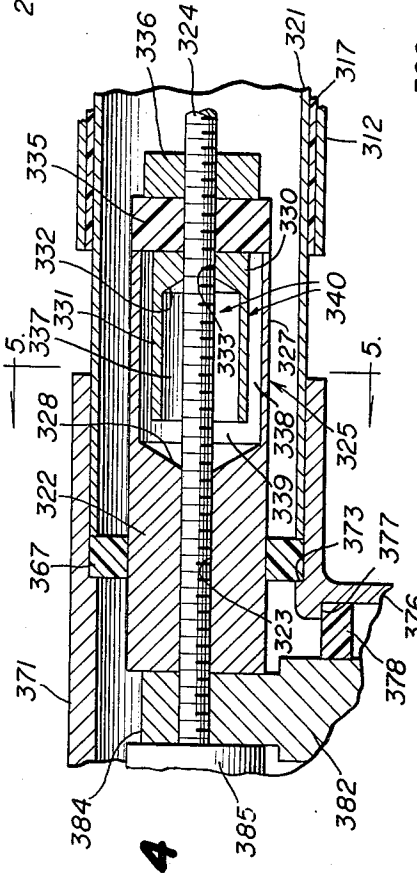


FIG. 4

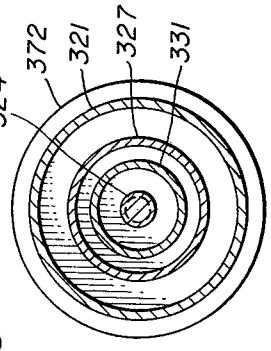


FIG. 5

May 12, 1970 J. E. STAATS 3,511,958

ELECTRONIC OVEN INCLUDING MICROWAVE COUPLING STRUCTURE AND FOLDED CAVITY FILTERS THEREFOR

Filed Dec. 31, 1968 5 Sheets-Sheet 4

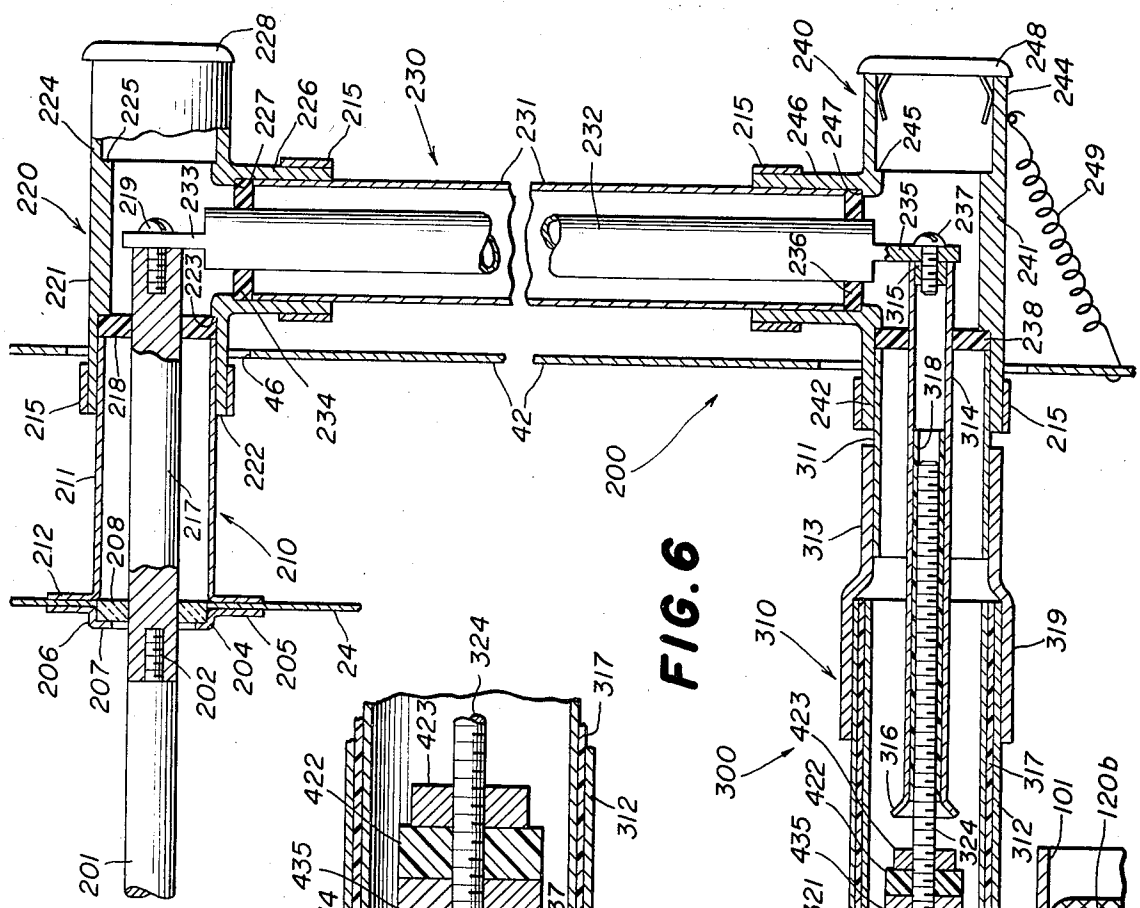


FIG. 6

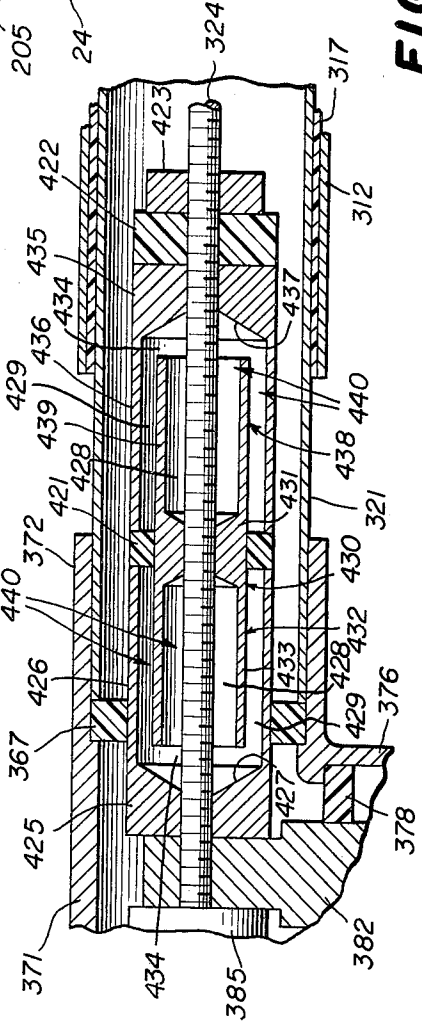


FIG. 7

FIG. 8

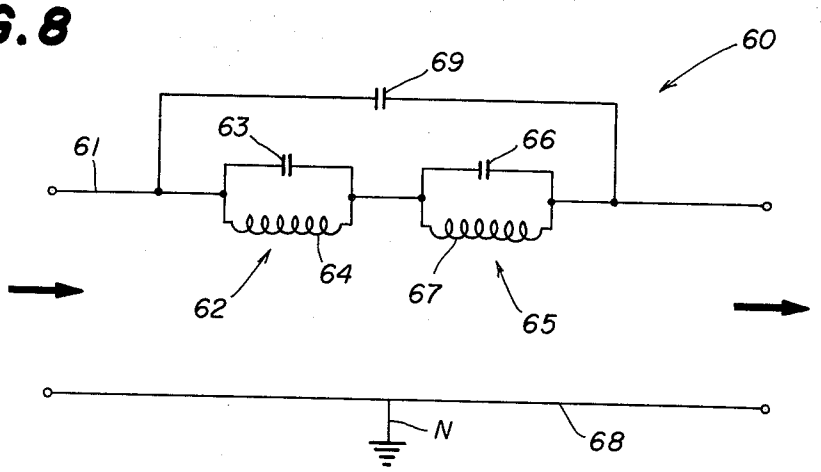
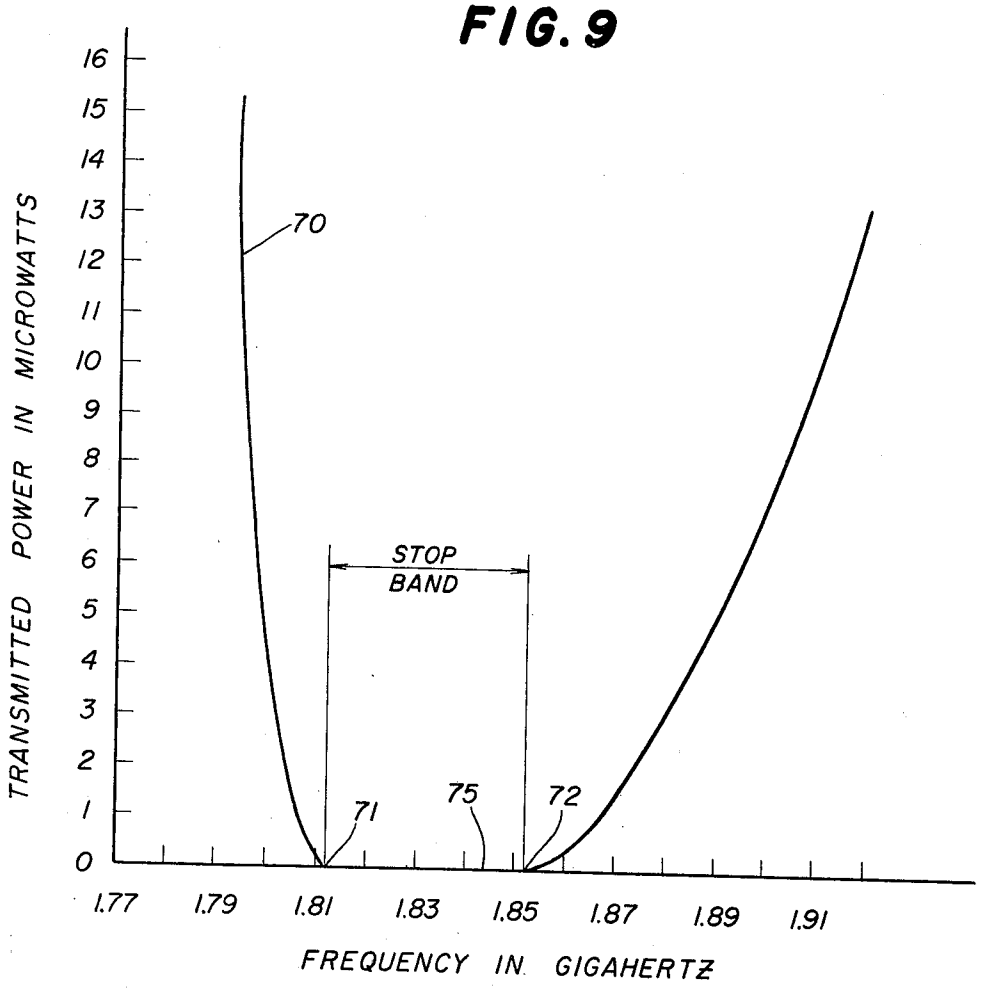

60
69
63
66
61
64
62
67
65
N
68

FIG. 9


TRANSMITTED POWER IN MICROWATTS
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
70
STOP BAND
71
75
72
1.77
1.79
1.81
1.83
1.85
1.87
1.89
1.91
FREQUENCY IN GIGAHERTZ

United States Patent Office

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Patented May 12, 1970

3,511,958

ELECTRONIC OVEN INCLUDING MICROWAVE COUPLING STRUCTURE AND FOLDED CAVITY FILTERS THEREFOR

James E. Staats, Louisville, Ky., assignor to General Electric Company, a corporation of New York

Filed Dec. 31, 1968, Ser. No. 788,204
Int. Cl. H05b 9/06; H03h 7/10
U.S. Cl. 219—10.55 15 Claims

ABSTRACT OF THE DISCLOSURE

There is disclosed an electronic oven comprising a generator of microwave energy of a predetermined frequency coupled to a cooking cavity and to a source of DC and 60-cycle AC operating potentials by a coaxial transmission line, the inner conductor of the transmission line including structure defining a folded resonant cavity rejection filter for the second harmonic of the predetermined frequency formed by two cup-like conductors facing in opposite directions and disposed one within the other, and also including a capacitive bypass filter between the inner and outer conductors for the second and higher harmonics of the predetermined frequency.

This invention is concerned with an improved transmission line forming a part of an electronic oven and, more particularly, with improved microwave filtering elements for the transmission line.

It is a general object of this invention to provide an electronic heating apparatus including structure defining a cooking cavity, a generator for generating electromagnetic wave energy and a transmission line for coupling the generator to the cooking cavity, wherein the transmission line includes improved resonant cavity filters for attenuating the second harmonic of the operating frequency of the generator, which filters comprise a compact structure occupying a relatively small portion of the transmission line.

It is a further object of this invention to provide in an electronic heating apparatus, structure defining a cooking cavity, a generator for generating electromagnetic wave energy of a predetermined ultra-high frequency and having a pair of output terminals, a transmission line coupling the generator to the cooking cavity and including a hollow outer conductor coupled to one terminal of the generator and an inner conductor coupled to the other terminal of the generator and a filter section in the inner conductor and comprising structure defining an inner space and an outer space disposed about the inner space and a passage interconnecting the inner space and the outer space to provide a folded cavity, the filter section structure having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, the folded cavity having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and being resonant at the second harmonic of the predetermined frequency, the filter section presenting a high impedance to the transmission of the second harmonic of the predetermined frequency along the inner conductor while having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, whereby during the transmission of the electromagnetic wave energy along the transmission line, the second harmonic of the predetermined frequency is highly attenuated by the filter section while the predetermined frequency is propagated to the cooking cavity substantially without attenuation.

In connection with the foregoing object it is another object of this invention to provide an electronic heating appartus of the type set forth, wherein the transmission line includes a first cup-like filter member including a cylindrical side wall surrounding the adjacent portion of the inner conductor concentric therewith and spaced therefrom and an end wall closing the side wall at one end thereof and connected to the inner conductor, the cylindrical side wall having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, and a second cup-like filter member including a cylindrical side wall surrounding the cylindrical side wall of the first filter member concentric therewith and spaced therefrom and an end wall closing the side wall of the second filter member at one end thereof and connected to the inner conductor, the cylindrical side wall of the second filter member having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, the first and second cup-like filter members cooperating with each other and with the inner conductor to form a folded cavity having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and being resonant at the second harmonic of the predetermined frequency.

Yet another object of this invention is to provide an electronic heating apparatus of the type set forth, wherein the transmission line includes a filter section in the inner conductor and comprising structure defining first and second inner spaces and first and second outer spaces respectively disposed about the first and second inner spaces and first and second passages respectively interconnecting the first inner and outer spaces and the second inner and outer spaces to provide first and second folded cavities, the filter section having a length equal to about one-quarter of the wavelength of the second harmonic of the predetermined frequency, the first and second folded cavities each having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and each being resonant at the second harmonic of the predetermined frequency, the filter section thereby providing two resonant cavities each presenting a high impedance to the transmission of the second harmonic of the predetermined frequency along the inner conductor.

In connection with the foregoing object, a further object of this invention is to provide an electronic heating apparatus of the type set forth wherein each of the first and second folded cavities is defined by first and second cup-like filter members concentrically disposed one within the other along the inner conductor and so arranged that the end walls of the inner ones of the cup-like members abut one another.

It is another object of this invention to provide a transmission line for interconnecting a generator for generating electromagnetic wave energy of a predetermined

ultra-high frequency and a load wherein the generator has a pair of output terminals, the transmission line comprising a hollow outer conductor coupled to one terminal of the generator, an inner conductor disposed within the outer conductor concentric therewith and coupled to the other terminal of the generator, and a filter section in the inner conductor and comprising structure defining an inner space and an outer space disposed about the inner space and a passage interconnecting the inner space and the outer space to provide a folded cavity, the filter section structure having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, the folded cavity having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and being resonant at the second harmonic of the predetermined frequency, the filter section presenting a high impedance to the transmission of the second harmonic of the predetermined frequency along the inner conductor while having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, whereby during the transmission of electromagnetic wave energy along the transmission line the second harmonic of the predetermined frequency is highly attenuated by the filter section while the predetermined frequency is propagated to the load substantially without attenuation.

In connection with the foregoing object, it is another object of this invention to provide a transmission line of the type set forth comprising a first cup-like filter member including a cylindrical side wall surrounding the adjacent portion of the inner conductor concentric therewith and spaced therefrom and an end wall closing the side wall at one end thereof and connected to the inner conductor, the cylindrical side wall having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, and a second cup-like filter member including a cylindrical side wall surrounding the cylindrical side wall of the first filter member concentric therewith and spaced therefrom and an end wall closing the side wall of the second filter member at one end thereof and connected to the inner conductor, the cylindrical side wall of the second filter member having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, the first and second cup-like filter members cooperating with each other and with the inner conductor to form a folded cavity having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and being resonant at the second harmonic of the predetermined frequency.

In connection with the foregoing objects, yet another object of this invention is to provide a transmission line of the type set forth comprising structure defining first and second inner spaces and first and second outer spaces respectively disposed about the first and second inner spaces and first and second passages respectively interconnecting the first inner and outer spaces and the second inner and outer spaces to provide first and second folded cavities, the filter section structure having a length equal to about one-quarter of the wavelength of the second harmonic of the predetermined frequency, the first and second folded cavities each having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and each being resonant at the second harmonic of the predetermined frequency, the filter section thereby providing two resonant cavities each presenting a high impedance to the transmission of the second harmonic of the predetermined frequency along the inner conductor.

In connection with the foregoing object, another object of the invention is to provide a transmission line of the type set forth wherein each of the first and second

folded cavities is defined by first and second cup-like filter members concentrically disposed one within the other along the inner conductor and so arranged that the end walls of the inner ones of the cup-like filter members abut one another.

Further features of the electronic heating apparatus pertain to the particular arrangement of the parts of the transmission line and coupling assembly forming a part thereof, whereby the above-outlined and additional operating features thereof are attained.

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

FIG. 1 is a side elevational view with certain portions broken away of an electronic heating apparatus made in accordance with and embodying the principles of the present invention;

FIG. 2 is a fragmentary view on an enlarged scale in vertical section of a crossed-field discharge device forming a part of the generator for the apparatus of FIG. 1;

FIG. 3 is a fragmentary view in vertical section through the transmission line forming a part of the apparatus of FIG. 1 and interconnecting the device of FIG. 2 to the cooking cavity of the apparatus and including a harmonic filter according to a first embodiment of the present invention;

FIG. 4 is an enlarged fragmentary view of that portion of the transmission line of FIG. 3 including the harmonic filter according to a first embodiment of the invention;

FIG. 5 is a view in vertical section along the line 5—5 of FIG. 4;

FIG. 6 is a fragmentary view in vertical section through the transmission line forming a part of the apparatus of FIG. 1 and including a harmonic filter according to a second embodiment of the invention;

FIG. 7 is an enlarged fragmentary view of that portion of the transmission line of FIG. 6 including the harmonic filter according to a second embodiment of the present invention;

FIG. 8 is a schematic representation of the equivalent electrical circuit for the harmonic filter of FIG. 7; and

FIG. 9 is a chart showing the frequency response of the filter of FIG. 4.

Referring now to FIG. 1 of the drawings, the electronic heating apparatus **10** there illustrated, and embodying the features of the present invention, is in the form of a combination electric and electronic range that is especially designed for home use. More particularly, the range **10** comprises an upstanding substantially box-like casing **11** formed of steel and including a pair of side walls **12**, a rear wall **13** having a removable closure member or panel **15** disposed therein, and a top wall **14** and a bottom wall **16**, the removable panel **15** being removably held in place by a plurality of screws **27**. The casing **11** houses in the upper central portion thereof a metal liner **20** defining a heating or cooking cavity **21** therein, the metal liner **20** preferably being formed of steel, and essentially comprising a box-like structure provided with a top wall **22**, a bottom wall **23**, a rear wall **24**, and a pair of opposed side walls **25**; whereby the liner **20** is provided with an upstanding front opening into the heating cavity **21** defined therein. Further, the casing **11** is provided with a front door **28** arranged in a front opening formed therein and cooperating with the front opening provided in the liner **20**, the front door **28** being mounted adjacent to the lower end thereof upon associated hinge structure **29**; whereby the front door **28** is movable between a substantially vertical closed position and a substantially horizontal open position with respect to the front opening provided in the liner **20**.

An electric heating unit **36** is arranged in the upper portion of the heating cavity **21** adjacent to and below

the top wall **22**, and an electric heating unit **37** is arranged in the lower portion of the heating cavity **21** adjacent to and above the bottom wall **23**; which electric heating units **36** and **37** are utilized in the carrying out of conventional baking and broiling cooking operations in the heating cavity **21**, as explained more fully hereinafter. Also, a temperature sensing bulb **38** is arranged in a pocket provided in one of the side walls **25**; which temperature sensing bulb **38** forms a part of an oven switch and temperature controller and is utilized in carrying out the previously mentioned conventional baking and broiling operations in the heating cavity **21**. The side walls **25** of the liner **20** further carry thereon a plurality of shelf supports **26** for the supporting of shelves (not shown) that in turn support items to be cooked within the heating cavity **21**. There also is provided below the front door **28** a lower front panel **19** that closes a front opening in the lower portion of the casing **11**, the bottom wall **16** further being provided with a reticulated member or screen **17** and the lower portion of the rear wall **13** being provided with a reticulated member or screen **18**, the screens **17** and **18** permitting the passage of air through the lower portion of the casing **11** to cool the electronic apparatus therein as will be described more fully hereinafter.

Disposed below the liner **20** and spaced therefrom is a generally horizontally arranged lower baffle **30** extending laterally across the casing **11** between the side walls **12** thereof and extending rearwardly from the front of the casing **11** to a point spaced forwardly of the rear wall **13**, the baffle **30** in cooperation with the casing **11** defining a bottom machinery compartment **35** in the lower portion of the casing **11**, the lower front panel **19** being removable to provide access to the bottom machinery compartment **35**.

Mounted on the underside of the baffle **30** is an electric motor **31** having an output drive shaft **32** including a reduced portion **33** extending upwardly into the liner **20** and supporting thereon a turntable **34** formed of expanded sheet metal and arranged in the lower portion of the heating cavity **21**. The turntable **34** is mounted for rotation and upon operation of the motor **31** is adapted to support food to be heated or cooked in the electronic operation that is carried out in the heating cavity **21**, as explained more fully hereinafter. The motor **31** has an associated gear train (not shown) that reduces the speed of the shaft **33** to approximately 6 r.p.m.

A rear baffle **40** is provided to the rear of the liner **20** and extends across the casing **11** between the side walls **12** thereof, the baffle **40** including a main wall **41** carrying centrally thereof a rearwardly offset wall **42** that is in general horizontal alignment with the rear of the liner **20** and spaced rearwardly therefrom. Disposed in the lower portion of the main wall **41** is an opening around which is disposed a flange **43** connecting with and air duct **44** that communicates with the screen **18** in the rear wall **13** of the casing **11**. It further will be noted that the bottom baffle **30** carries on the rear thereof an upwardly and rearwardly extending baffle section **39** that extends toward the offset wall **42** but is spaced therefrom, the baffles **30** and **40** being formed of metal, such as steel, whereby the spacing between the baffle section **39** and the rear baffle **40** minimizes the conduction of heat therebetween during the operation of the range **10**. The rear baffle **40** cooperates with the casing **11** to provide a rear machinery compartment **45**, the rear machinery compartment **45** being disposed behind the liner **20** and access thereto being provided through the removable panel **15** that covers the opening in the rear wall **13** described above.

There is arranged to the right (as viewed in FIG. 1) of the bottom machinery compartment **35** a generator **50** for supplying ultra-high frequency electromagnetic wave energy for electronic cooking within the cooking cavity **21**, the generator **50** including a crossed-field electronic discharge device **100** of the construction and arrangement disclosed in the copending application of James E. Staats, Ser. No. 559,267, filed June 21, 1966 now Pat. No. 3,458,755. Referring to FIGS. 1 and 2, it will be seen that the device **100** is disposed within a box-like structure or casing **101** that extends completely about the device **100** but is open on two opposed sides thereof, the sides disposed to the left and right in FIG. 2, the device **100** and the associated parts therefor being mounted within and electrically connected to the casing **101**. As will be explained more fully hereinafter, high operating DC potentials are present on the casing **101**, whereby it is desirable electrically to isolate and shield the casing **101**, and to this end a second box-like structure **102** has been provided that surrounds the casing **101** and is also provided on an opposed pair of sides thereof with openings in alignment with the opposed open sides of the casing **101**, all to accommodate the passage of air through the casing **101** and the box-like structure **103** to cool the device **100** and the associated parts housed therein. However, in order to prevent contact of the user with the casing **101** and the device **100** disposed therein, reticulated metal covers **103** are provided for covering the openings in the opposed sides of the box-like structure **102**, the covers **103** permitting passage of air therethrough and thus through the casing **101** and the structure **102** while preventing contact of a user with the casing **101** and the parts disposed therein that carry the high operating DC potentials. Further, the casing **101** is mounted upon insulators **104** carried by the structure **102**, thereby electrically to insulate the casing **101** from the structure **102**.

As viewed in FIG. 1, the structure **102** and the casing **101** disposed therein are disposed to the rear of the bottom apparatus **35**, and are disposed to the right within the bottom apparatus compartment **35** when the range **10** is viewed from the front. In order to provide cooling air for passage through the reticulated covers **103** and across the device **100**, there has been provided an open ended housing **105** disposed to the left in FIG. 1 or in front of the structure **102** and housing therein at least a part of a voltage doubler and rectifier circuit **130** that supplies DC operating potentials to the device **100** and also houses therein a fan **106** powered by a motor **55** within the housing **105**, an air duct **107** being provided about the fan **106** to direct air therefrom into the structure **102** and into the casing **101** and about the device **100**. More specifically, the fan **106** operates to draw air through the screen **17** at the bottom of the apparatus compartment **35**, the air being formed into a stream by the housing **105** and passed over the rectifier **130**, the motor **55** and through the air duct **107** into the structure **102**; the air stream within the structure **102** passes into the casing **101** and about the device **100** and cooling fins **118** disposed thereon and passes therefrom and into the air duct **44** to be discharged through the screen **18** in the rear wall **13** of the casing **11**.

In accordance with the present invention, the air stream generated by the fan **106** is used to cool all of the various parts of the generator **50**, and specifically the crossed-field discharge device **100** and the voltage doubler and rectifier circuit **130** associated therewith. To this end the housing **105** and the air duct **107** and the air duct **44** have been provided so as to concentrate the air stream upon the parts noted, all while attempting to deflect the air stream away from the baffles **30** and **40**. The baffles **30** and **40** further protect the liner **20** and the cooking cavity **21** disposed therein from the air stream thus generated so as to maintain more uniform cooking conditions within the cooking cavity **21** and thus to improve the cooking therein.

Referring now particularly to FIG. 2 the generator **50** there illustrated will be described in greater detail. An electron discharge device **100** is contained within a substantially cylindrical metal envelope **111** and includes anode and cathode structure (not shown). Surrounding

the envelope **111** and connected thereto is a plurality of cooling fins **118** for dissipating heat from the device **100** as explained above. In order to establish a unidirectional magnetic field within the device **100** there is provided a composite magnetic field winding **120***a* and **120***b* disposed at the upper and lower ends of the device **100** and connected in series relation by a conductor **123**. A DC operating potential from a voltage doubler and rectifier **130** is applied to the winding **120***b* by a conductor **122**, and from the winding **120***a* to the device **100** by a conductor **124** which is connected to one of the cooling fins **118** as at **125**. Further details of the construction and operation of the device **100** are disclosed in the previously mentioned Staats application Ser. No. 559,267 now Pat. No. 3,458,755, the disclosure of which is incorporated herein by reference.

The generator **50** is arranged to be advantageously operated in connection with suitable control and power supply apparatus, details of the construction and operation of which are disclosed in the copending U.S. applications of James E. Staats, Ser. No. 656,977, filed June 12, 1967 now Pat. No. 3,421,115, Ser. No. 569,006, filed June 27, 1966 now abandoned and Ser. No. 181,144, filed Mar. 20, 1962, the disclosures of all of which applications are incorporated herein by reference.

The device **100** is operative to supply microwave energy at an ultra-high frequency of about 915 mHz., with a power output at the output terminals in the general range of 50 to 800 watts. The device is arranged to supply the RF power for cooking and to this end a lower transmission line **300** extends from the device **100** and is coupled to an upper transmission line **200** which extends to the cooking cavity **21**, the transmission lines **200** and **300** being of the coaxial type including an inner conductor and an enclosing outer conductor electrically insulated therefrom. Both of the output terminals of the device **100** are at a substantial voltage DC with respect to ground potential, so that the output terminals are electrically insulated from ground potential, as well as from each other. One of the output terminals is coupled by a capacitor **317** to the adjacent end of the outer output conductor, and the other output terminal is coupled by a capacitor **318** to the adjacent end of the inner output conductor, the remote end of the inner conductor projecting as an antenna **201** into the oven cavity **21**; the remote end of the outer conductor is electrically connected to the metal liner **20**. Thus the RF power produced by operation of the device **100** is radiated from the antenna **201** into the cooking cavity **21**, so as to produce cooking effects upon food arranged therein, all in a conventional manner.

An important feature of the present invention resides in the construction and connection of the transmission lines **200** and **300** interconnecting the crossed-field discharge device **100** and the liner **20**, a detailed description of the transmission lines **200** and **300** being now presented with particular reference to FIGS. 3 through 5 of the drawings. The crossed-field discharge device **100** is provided with a magnet yoke **126** at the upper end thereof which connects to the anode of the device **100** (not shown) and forms an outer conductor and an output terminal for the device **100**, the lower end of the magnetic yoke **126** being more particularly connected to the anode of the device **100** and the upper end extending upwardly through the field winding **120***b* and being connected to a magnet flange **127**. The lower end of the device **100** is likewise provided with a magnet yoke **128** having the upper end thereof connected to the anode of the device **100** and the other end extending downwardly through the field winding **120***a* and being connected at the lower end to a magnet flange **129**. The cathode of the device **100** (not shown) has connected thereto a stud **381** forming a part of the upper coupling structure **380**, the stud **381** and the magnet yoke **128** forming a coaxial output connection for the device **100**.

Referring specifically to FIG. 3, it will be seen that the output from the other end of the upper transmission line **200** is coupled to the antenna **201** disposed in the heating cavity **21**, the antenna **201** being essentially a rod having a threaded stud **202** at one end thereof, the antenna **201** extending into the cavity **21** a short distance below the top wall **22** and essentially midway between the side walls **25**, see FIG. 1. The stud **202** extends into a complementarily threaded opening at the end of a rod **217** forming an inner conductor that extends into the cavity **21**, the conductor **217** being held in position by a bracket **204** and a cooperating electrical insulator **208**. More specifically, the bracket **204** includes an annular mounting flange **205** which is suitably secured as by welding to the rear wall **24** of the liner **20** and disposed about an opening therein, the flange **205** in turn carrying a forwardly directed annular flange **206** terminating in an inturned holding flange **207** disposed agaist the forward surface of the insulator **208**.

A top section **210** of the upper transmission line **200** is formed by a first tube **211** forming the outer conductor therefor and the inner conductor **217**. The forward edge of the tube **211** has an outwardly directed flange **212** thereon which is suitably secured as by welding on the rear side of the rear wall **24** and surrounding the opening therein and assisting in holding the insulator **208** in the operative position in cooperation with the bracket **204**.

The rear end of the tube **211** is received in a T **220**, the T **220** including a body **221** and a pair of arms **222** and **124** and a leg or arm **226** all provided with a seat or shoulder **223**, **225** and **227**, respectively internally thereof. The rear end of the tube **211** is disposed within the arm **222** and in telescopic relationship therewith and has the rearmost end thereof spaced slightly forwardly with respect to the shoulder **223**, an insulator **218** being disposed between the tube **211** and the shoulder and held in position thereby, the insulator having a central opening therein receiving the inner conductor **217** therethrough. Preferably the outer end of the arm **222** has longitudinally extending slots (not shown) formed therein and receives therearound a clamp **215** having associated therewith a screw **216** (see FIG. 1) for tightening the clamp **215** about the outer end of the arm **222**, thus releasably to clamp the arm **222** about the rear end of the tube **211** to hold it in the operative position. It further is pointed out that the arm **222** extends through an opening **46** in the baffle wall **42**, whereby the major portion of the T **220** is disposed to the rear of the baffle wall **42** and thus in the rear machinery compartment **45**, whereby the T **220** is accessible for service and maintenance through the removable panel **15** (see FIG. 1 also). The other arm **224** carries on the outer end thereof a dust cover **228** that serves to close the same to prevent the entry of dust, dirt, water and the like into the interior of the T **220**.

A rear section **230** for the upper transmission line **200** is provided by an outer tube **231** and an inner conductor **232** disposed within the outer tube **231**. The upper end of the tube **231** extends into the lower arm or leg **226** of the T **220** and is spaced from the shoulder **227** thereof, an insulator **234** being disposed between the upper end of the tube **231** and the shoulder **227** and held in position therebetween. The insulator **234** has an opening therethrough to receive the upper end of the inner conductor **232**, the inner conductor **232** having an upper flattened end **233** having an opening therein receiving therethrough a screw **219** engaging in a complementarily threaded opening in the rear end of the rod **217**, whereby to interconnect the rear end of the inner conductor **217** and the upper end of the inner conductor **232**. There further is provided around the lower portion of the leg **226** one of the clamps **215**, the lower end of the leg **226** preferably being slotted (not shown) whereby tightening of the screw **216** associated with the clamp **216** serves to tighten the leg **226** about the upper end of the tube **231** releasably to hold the parts in the assembled telescoping positions.

The lower end of the rear transmission line section **230**

is received in a T 240, the T 240 including a body 241 having a pair of arms 242 and 244 and a leg on arm 246 each provided with a cooperating internal seat or shoulder 243, 245 and 247, respectively. More particularly, the leg 246 is positioned upwardly and receives telescopically therein the lower end of the tube 231, the lower end of the tube 231 being spaced upwardly with respect to the seat 247 to receive therebetween an insulator 236 to mount the same within the T 240, the insulator 236 having an opening therethrough receiving the lower end of the inner conductor 232 therethrough. The outer end of the leg 246 is preferably slotted (not shown) and receives therearound one of the clamps 215, whereby by means of the associated screw 216, the clamp 215 can be tightened about the outer end of the leg 246 to clamp it against the lower end of the tube 231 releasably to hold the parts in the assembled position. The arm 244 preferably carries thereon a dust cover 248 which cover serves to prevent the entry of dust, dirt, water and other debris into the interior of the T 240 and the upper transmission lines 200 and 300.

There is operatively associated with the other arm 242 of the T 240 a rear section 310 of the lower transmission line 300, the rear section 310 including a tube 311 as the outer conductor and a tube 314 as the inner conductor spaced therefrom and electrically insulated therefrom. The tube 311 extends into and is telescopically associated with the arm 242 of the T 240, the inner end of the tube 311 being spaced from the shoulder 243 and receiving therebetween an insulator 238 that is held in position thereby. One of the clamps 215 is disposed about the outer end of the arm 242 which is preferably slotted (not shown), whereby by means of the associated screw 216 the clamp 215 can be tightened to press the arm 242 about the adjacent end of the tube 311 releasably to hold the parts in the assembled position. The insulator 238 has an opening therein receiving therethrough the inner conductor 314, the rear end of the inner conductor 314 carrying a plug 315 secured thereto and having a threaded opening therein, the lower end of the rear inner conductor 232 having a flattened portion as at 235 having an opening therein receiving a screw 237 that threadedly engages the opening in the plug 315, thus to interconnect the lower end of the inner conductor 232 and the rear end of the inner conductor 314. The forward end (the end disposed to the left of FIG. 3) of the inner conductor 314 is outwardly flared as at 316 to permit ready assembly with other portions of the lower transmission line 300 as will be described more fully hereinafter. Telescopically overlapping the tube 311, in surrounding relationship therewith, is an annular coupling member 313, having an enlarged diameter portion 319 extending to the left of the tube 311 as viewed in FIG. 3. Telescopically received within the enlarged portion 319 of the coupling member 313 is a tube 312 having a diameter slightly greater than the diameter of the tube 311.

The rear lower section 310 cooperates with and is telescopically associated with a front lower transmission line section 320, the front lower section 320 including a tube 321 serving as the outer conductor and an annular inner conductor 322 disposed within the tube 321 and spaced therefrom and electrically insulated therefrom. The tube 321 has an external diameter slightly less than the internal diameter of the tube 312 whereby the rear end of the tube 321 is telescopically received therein, a layer of insulation 317 being disposed therebetween to provide a capacitive coupling at RF frequencies. The annular inner conductor 322 has received in an opening 323 therethrough and threadedly engaged therewith a probe or inner conductor 324, the probe 324 having an external diameter slightly less than the internal diameter of the inner conductor 314, whereby the rear end of the probe 324 can be disposed therein, a layer of insulation 318 being provided therebetween and forming therewith a capacitive coupling at RF frequencies.

The rearward end of the inner conductor 322 has a hollow portion generally designated 325 and including a relatively thin cylindrical side wall 327 and an annular end wall 328. The cylindrical side wall 327 is disposed in surrounding relationship with the adjacent portion of the inner conductor 324 concentric therewith and spaced therefrom. Disposed within the hollow end portion 325 of the inner conductor 322 is a cup-like electrically conductive filter member 330 having a cylindrical side wall 331 closed at the rearward end thereof by an annular end wall 332. The cylindrical side wall 331 is disposed in surrounding relationship with the adjacent portion of the inner conductor 324 concentric therewith and spaced therefrom. The side wall 331 is also spaced slightly from the side wall 327 of the inner conductor 322, and the open end of the side wall 331 is spaced longitudinally rearwardly from the end wall 328 of the inner conductor 322. The end wall 332 of the cup-like member 330 has an internally threaded opening 333 therein, the inner conductor 324 being received therethrough and threadedly engaged thereat with the cup-like member 330. The inner conductor 324, the hollow end 325 of the inner conductor 322 and the cup-like member 330 all cooperate to define a folded cavity 340 comprising an annular inner space 337 between the inner conductor 324 and the side wall 331, an outer annular space 338 defined between the side walls 327 and 331 and a passage 339 interconnecting the inner and outer spaces 337 and 338 at the forward ends thereof. An annular insulator 335 is disposed about the inner conductor 324 and abuts the outer surface of the end wall 332 and the open end of the cylindrical side wall 327, thereby closing the folded cavity 340 and insulating the side walls 327 and 331 from each other. A lock nut 336 is threadedly engaged with the inner conductor 324 and bears against the insulating spacer 335 fixedly to retain the parts in their assembled position. The folded cavity 340 is of such dimensions as to be resonant at the second harmonic of the operating frequency of the device 100 to provide a rejection filter for the second harmonic as will be more fully described hereinafter.

The forward end of the front lower transmission line section 320 is coupled to the crossed-field discharge device 100 by means of a T 370, the T 370 including a body 371 having a pair of arms 372 and 374 and a leg or arm 376 each provided with a cooperating internal seat or shoulder 373, 375 and 377, respectively. More particularly, the leg 376 is positioned downwardly and is telescopically received in the upper end of the magnet yoke 126 for coupling thereto, the T 370 forming a part of the upper coupling structure 380. Also forming a part of the upper coupling structure 380 is a bullet 382 receiving into the lower end thereof the stud 381 that is coupled to the cathode of the device 100, the bullet 382 having a shoulder 383 thereon that cooperates with the shoulder 377 to hold in operative position an insulator 378 that serves to center the bullet 382 with respect to the leg 376. The upper end of the bullet 382 abuts the forward end of the inner conductor 322 and carries an internally threaded eye 384 through which is threadedly inserted the probe 324, the rear end of the probe 324 being threadedly received in the complementarily threaded opening 323 in the inner conductor 322, thereby to support the forward end of the inner conductor 322, there also being provided therearound a supporting insulator 367. The forward end of the tube 321 is telescopically received within the leg 372 and is spaced a short distance away from the shoulder 373, thereby to clamp the insulator 367 in the operative position therebetween. Preferably the forward end of the tube 321 is fixedly secured as by soldering to the arm 372.

A decoupling structure is carried by the other arm 374 of the T 370, and more particularly comprises an inner conductor 385 having a rear end connected to the forward end of the probe 324 by means of a threaded connection therebetween, the inner conductor 385 having a reduced forward portion 386. Fixedly mounted on the arm 374

and telescopically received therein is an outer conductor **387** within which is disposed an insulating sleeve **379**. Disposed within the insulating sleeve **379** is a cup-like inner conductor **388** having the outer end closed by a wall **389**, a screw passing through an opening in the outer wall **389** and engaging in a threaded opening in the forward end of the reduced portion **386** of the inner conductor **385** fixedly to interconnect the parts and to provide the input terminal **368**.

It is noted that the outer conductors **312** and **321** overlap a distance corresponding to about one-quarter wavelength at the freqeuncy of operation of the device **100** and the inner conductor **314** overlaps the probe **324** a distance corresponding to about one-quarter of the wavelength of the frequency of operation of the device **100**, thereby to provide a filter for the second and higher even harmonics of the frequency of operation of the device **100**. However, in the operation of microwave generators of the type set forth herein for use with electronic cooking apparatus some harmonics of the frequency of operation of generator, particularly the second, may be of sufficient power level to require a more effective filter than that provided by the usual choke and capacitive filters. For example, the above-described capacitive filter has a fairly narrow band width on the order of about 5 mHz. which is insufficient to cover the wide frequency pulling range caused by various food load impedances in an electronic oven. Accordingly, there is provided by this invention a fairly broad band rejection filter for the second harmonic of the frequency of operation of the device **100**, the method of operation of which will now be more fully described. The cylindrical side wall **327** of the hollow end portion **325** of the inner conductor **322** has a length equal to about one-eighth of the wavelength of the second harmonic of the frequency of operation of the device **100**. However, the side wall **327**, in cooperation with the side wall **331** and the inner conductor **324** and the end wall **328** defines a cavity having an effective electrical length equal to one-quarter of the wavelength of the second harmonic, the cavity being formed by the outer space **338**, the connecting passage **339** and the inner space **337**. There is thereby defined a folded cavity **340** of such dimensions as to form a quarter-wave resonant cavity at the second harmonic of the frequency of operation of the device **100**, which resonant cavity presents a high series impedance of the tarnsmission of this second harmonic along the transmission line **300** thereby producing high attenuation of this second harmonic frequency. The above-described filter structure is particularly advantageous in that it provides a quarter-wave resonant cavity in a section of transmission line having a length equal to only about one-eighth of the wavelength of the frequency of resonance, thereby affording a valuable economy of space. Furthermore, the folded-cavity harmonic filter of this invention has been found to provide low cost construction, low insertion loss, high power capability, a high degree of harmonic attenuation and fairly broad band operation.

In FIG. 9, there is shown a curve **70** representing the frequency response of the folded-cavity harmonic filter of this invention, the power transmitted through the filter in microwatts being plotted along the ordinate and the frequency in gigahertz being plotted along the abscissa. The response curve **70** has a relatively flat portion **75** of high attenuation. From FIG. 9 it can be seen that the stop band of the filter measured from the point **71** to the point **72** has a width of about 40 mHz., the filter providing at least 40 db attenuation over this stop band. It is noted that the filter has fairly sharp cutoff at the low frequency end of the stop band, it being understood, of course, that only the bottom of the response curve is shown, the curve **70** extending nearly vertically upward to approximately 800 watts. Thus, while the filter provides very high attenuation of the second harmonic, the fundamental (915 mHz.) frequency of operation of the device **100** is passed by the filter substantially without attenuation.

In the transmission line **300**, the bullet **382**, the T **370**, the inner conductor **322** and the tube **321** are shaped and arranged to provide a quarter-wave transformer section at the frequency of operation of the device **100**. More particularly, the shouldered portion of the bullet **382** and the conductor **322** have dimensions such that the impedance of the device **100** is matched to the impedance of the transmission lines **200** and **300** that are in turn matched to the impedance of the heating cavity **21**. Likewise, the bullet **382**, the inner conductor **385**, the outer conductor **387** and the inner conductor **388** are all shaped and arranged to provide a quarter wave transformer section that assists in decoupling RF energy from the input terminal **368** to prevent the propagation of RF energy into the power supply. Furthermore, the inner conductor **385**, the outer conductor **387**, the insulator **379**, the inner conductor **388** and the end wall **389** cooperate to provide the parallel capacitive impedance and reactive impedance. To this end the distance between the inner surface of the end wall **389** and the center of the bullet **382** preferably corresponds to about one-quarter wavelength of the frequency of operation of the device **100**, and the conductors **387** and **388** overlap a distance corresponding to about one-eighth wavelength of the frequency of operation of the device **100**. It is noted that the stepped configuration of the inner conductor **385** permits a shorter mechanical connection while maintaining an electrical characteristic equavilent to one-quarter wavelength of the operating frequency of the device **100**.

Referring now to FIGS. 6 and 7, there is shown a second embodiment of the folded-cavity harmonic filter according to this inventoin whereby even greater attenuation of the second harmonic of the frequency of operation of the device **100** is attained by providing two folded cavity filters connected in series along the inner conductor of the transmission line **300**. The structure of FIG. 6 is essentially the same as the structure of FIG. 3 with the exception of the inner conductor portion of the forward section **320** of the lower transmission line **300**. Therefore, the description of that portion of the structure of FIG. 6 which is identical to the structure of FIG. 3 will not be here repeated and the identical portions of FIGS. 3 and 6 are shown with the same reference numerals in both figures.

The rear lower section **310** of the transmission line **300** cooperates with and is telescopically associated with the front lower section **320**, as described above, the front lower section **320** including the tube **321** serving as the outer conductor and the probe **324** serving as the inner conductor. There is provided along the inner conductor **324** a filter section **420** comprising a pair of rejection filters for the second harmonic of the frequency of operation of the device **100**. Disposed adjacent to the forward end of the inner conductor **324** is a cup-like electrically conductive filter member **425** comprising a cylindrical side wall **426** surrounding the adjacent portion of the inner conductor **324** concentric therewith and spaced therefrom and being closed at the forward end thereof by an end wall **427**, the outer surface of which abuts the eye portion of the stud **382**. An inner filter member **430** is disposed rearwardly from the end wall **427** about the inner conductor **324**. The inner filter member **430** is cylindrical in shape comprising a solid central portion **431** and a pair of hollow end portions **432** and **438**, the end portion **432** and **438** respectively comprising cylindrical side walls **433** and **439** closed at the inner ends thereof by the central portion **431**. The cylindrical side wall **433** is disposed within the cylindrical side wall **426** of the cup-like member **425** and is concentric with and disposed approximately midway between the side wall **426** and the inner conductor **324**. Surrounding the other cylindrical end **438** of the inner filter member **430** is a second cup-like filter member **435** compris-

ing a cylindrical side wall **436** surrounding the side wall **439** of the inner filter member **430** concentric therewith, the side wall **436** being closed at the rearward end thereof by an end wall **437**. The side wall **439** of the inner filter member **431** is surrounded by the cup-like member **435** and is disposed approximately midway between the side wall **436** and the inner conductor **324** concentric therewith. Disposed around the central portion **431** of the inner filter member **430** is an annular insulating spacer **421** insulating the open ends of the cylindrical side walls **426** and **436** from each other and from the inner filter member **430**. An annular insulating spacer **422** is disposed about the inner conductor **324** and abuts the outer surface of the end wall **437** of the cup-like member **435**. The parts of the filter section **420** are all held in their assembled position by a lock nut **423** threadedly engaged with the inner conductor **324** and bearing against the insulating spacer **422**.

It can be seen from FIGS. 6 and 7 that the filter section **420** is essentially a combination of two folded-cavity filters of the type shown in FIG. 3 arranged back-to-back. The cup-like filter members **425** and **435** each have a length corresponding to about one-eighth of the wavelength of the second harmonic of the frequency of operation of the device **100**. The inner conductor **324**, the inner filter member **430** and the cup-like filter members **425** and **435** cooperate with one another to define two cavities **440**, each having an effective electrical length equal to one-quarter of the wavelength of the second harmonic frequency, and each comprising an inner annular space **428**, an outer annular space **429** and a connecting passage **434** interconnecting the spaces **428** and **429** at one end thereof. There are thereby defined two folded cavities **440**, each having such dimensions as to be resonant at the second harmonic of the frequency of operation of the device **100**, and each thereby presenting a high series impedance to the transmission along the transmission line **300** of the second harmonic to effect high attenuation thereof. Each of the folded cavities in the filter section **420** provides all of the advantages afforded by the filter of FIG. 3, but the filter section **420** achieves a compact and economical series arrangement of two such filter sections to afford increased attenuation of the second harmonic.

There is shown in FIG. 8 the schematic representation of a lumped-impedance equivalent circuit, generally designated **60**, for the filter section **420** of FIG. 6. The circuit includes a pair of conductors **61** and **68**, respectively corresponding to the inner and outer conductors of the transmission line **300**, the conductor **68** being grounded as at N. Connected in series relationship in the conductor **61** are two parallel resonant circuits **62** and **65**, each comprising an inductive impedance and a capacitive impedance. More particularly, the parallel resonant circuit **62** comprises a capacitance **63** and an inductance **64** while the parallel resonant circuit **65** comprises a capacitance **66** and an inductance **67**. Each of the parallel circuits **62** and **65** is tuned to resonance at the second harmonic of the frequency of operation of the device **100** and they respectively correspond to the two folded resonant cavities of filter section **420**. The resonant circuits **62** and **65** thus present a high series impedance to transmission of the second harmonic along the conductor **61** while transmitting the fundamental frequency of operation of the device **100** substantially without attenuation. Connected in parallel with the resonant circuits **62** and **65** is a capacitance **69** corresponding to the insulating spacer **421** in FIG. 6 and having a value such as to present a low impedance to the frequency of operation of the device **100** while presenting a high impedance to the second harmonic thereof.

Because the potentials for operating the device **100** are derived from the voltage doubler and rectifier circuit **130**, neither the stud **381** forming the inner conductor or any of the parts such as the yoke **126** and the T **370** forming the outer conductor of the coupling structure **380** can be grounded. However, it is highly desirable to ground the portion of the transmission line **200** disposed to the rear of the rear baffle **40**, and to this end the capacitive coupling at **317** and **318** has been provided between the rear lower transmission line portion **310** and the front lower transmission line portion **320**. Furthermore, the outer conductors **312** and **321** overlap a distance corresponding to about one-quarter wavelength at the frequency of operation of the device **100** and the inner conductor **314** overlaps the probe **324** a distance corresponding to about one-quarter wavelength of the frequency of operation of the device **100**, whereby to provide a filter for the second and higher even harmonics as well as providing a DC insulation between the parts named. Accordingly, the outer conductor **312** can be grounded as on the casing **11** and the baffle member **40**, thereby to present only grounded parts to workmen gaining access to the rear machinery compartment **45** through the removable panel **15**.

It further is pointed out that the T **220**, the entire rear transmission line section **230**, the T **240** and the rear lower transmission line section **310** form a removable transmission line assembly that can be bodily moved rearwardly through the opening provided by the removable panel **15** for maintenance and repair of the parts. Such movement of the transmission line assembly rearwardly is accomplished by simply loosening the clamp **215** about the leg **222** which frees the T **220** from the tube **211** and removing the screw **219** to free the inner conductor **232** from the inner conductor **217**. Due to the telescoping arrangement of the lower transmission line portions there is no need to remove or disconnect any parts other than by the relative sliding movement of the conductors **314** and **324** with respect to each other and of the coupling member **313** and tube **312** with respect to each other. Reassembly of the parts is facilitated by the flared end **316** on the inner conductor **314** and by the enlarged diameter portion **319** on the coupling member **313**. It further is necessary to hold the removable transmission line assembly in the assembled position, and to this end a spring **249** under tension has been provided interconnecting the T **240** and the baffle wall **42**, thus continually to urge the removable transmission line assembly into the assembled operative position. It is also noted that the front panel **19** of the range **10** is preferably removable to afford easy access to the device **100** which, together with the front portion **320** of the transmission line **300**, may be disengaged from the rear portion **310** of the line and removed through the front of the machinery compartment **35** for servicing.

Another important feature of the transmission lines **200** and **300** resides in the fact that the tubes **211**, **231**, **312**, **321** and **387** can all be formed essentially of standard tubing shaped as required and cut to length, the tubing preferably being formed of copper, brass or other good electrically conductive metal. The inner conductors **232** and **314** also can be formed essentially of standard tubing shaped as required and cut to length, this tubing also preferably being formed of copper, brass or the like. The T's **220**, **240** and **370** are also of standard configuration and are all identical one to the other, the T's preferably being formed of copper, brass or other material having good electrical conductivity. Finally, the insulators **218**, **234**, **236**, **238**, **335**, **367**, **378**, **421** and **422** are preferably all formed of a polytetrafluoroethylene resin such as that sold under the trademark "Teflon."

A lower coupling structure **390** cooperates with the magnet yoke **128** serving as an outer conductor of a transmission line and a tube **391** connected at the upper end to one end of the heater of the device **100** (not shown) and serving as an inner conductor of a coaxial transmission line, the lower end of the tube **391** carrying an insert **392** therein and receiving the screw **396** serving as an

input terminal. Disposed within and essentially lining the magnet yoke **128** is a sleve **393** of electrically insulating material, an inner conductor **394** being disposed against the sleeve **393** and telescopically overlapping a portion of the yoke **128** and having the outer end thereof closed by an end wall **395**, the end wall **395** having an opening therethrough receiving the shank of the screw **396** that engages in a complementarily threaded opening in the insert **392**. The yoke **128**, the tube **391**, the insulating sleeve **393**, the inner conductor **394** and the end wall **395** cooperate to provide a parallel resonant circuit including a reactive impedance and a capacitive impedance, the structure comprising a high impedance to RF energy to prevent propagation thereof onto the conductor **155**. More specifically, the distance between the lower adjacent end of the anode of the device **100** and the inner surface of the end wall **395** is equivalent to a quarter wavelength at the operating frequency of the device **100**, and the yoke **128** and the inner conductor **394** telescopically overlap a distance equivalent to one-eighth wavelength at the operating frequency of the device **100**.

From the above it will be seen that the liner **20** is effectively isolated from the bottom machinery compartment **35** and the rear machinery compartment **45** by the baffle members **30** and **40**, respectively, thereby to provide a more uniform distribution of heat within the liner **20** and thus to permit good cooking therein. The entire generator **50** including the crossed-field discharge device **100** and the voltage doubler and rectifier circuit **130** therefor are housed within the bottom machinery compartment **35** which provides a protecting housing therefor. The fan **106** serves to cool all of the electrical components of the generator **50** by drawing air inwardly through the screen **17** into the bottom machinery compartment **35** and across the crossed-field discharge device **100** and outwardly through the screen **18**. The stream of air thus created is effectively prevented from coming into contact with the liner **20** due to the presence of the baffle members **30** and **40**. Also, the improved coupler structure and transmission line **200** has been provided, the major portion of which can be readily removed from the assembled relation with the liner **20** and the device **100** for repair and services purposes through the removable panel **15**, and can thereafter be readily reassembled therewith.

Finally, there has been provided a folded-cavity rejection filter for the second harmonic of the frequency of operation for the device **100**, which filter affords economical and compact construction allowing the construction of a quarter-wave resonant cavity in a section of transmission line having a length equal to only about one-eighth of the wavelength of the frequency of resonance. There has also been provided a harmonic filter which affords broad-band operation, low insertion loss, high power capability and a high degree of harmonic attenuation. It will be understood, of course, that while the filters described above are designed to filter the second harmonic of the frequency of operation of the device **100**, they may be designed to filter any desired harmonic with appropriate changes in the dimensions of the various parts.

From the above it will be seen that there has been provided an improved electronic heating apparatus **10** and microwave coupling structure **380–390** and improved transmission lines **200** and **300** therefore and improved harmonic filters in the transmission line **300** which fulfill all of the objects and advantages set forth above.

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

What is claimed is:

1. In an electronic heating apparatus, structure defining a cooking cavity, a generator for generating electromagnetic wave energy of a predetermined ultra-high frequency and having a pair of output terminals, a transmission line coupling said generator to said cooking cavity and including a hollow outer conductor coupled to one terminal of said generator and an inner conductor coupled to the other terminal of said generator, and a filter section in said inner conductor and comprising structure defining an inner space and an outer space disposed about said inner space and a passage interconnecting said inner space and said outer space to provide a folded cavity, said filter section structure having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, said folded cavity having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and being resonant at the second harmonic of the predetermined frequency, said filter section presenting a high impedance to the transmission of the second harmonic of the predetermined frequency along said inner conductor while having a length equal to about one-eighth of the wave length of the second harmonic of the predetermined frequency, whereby during the transmission of electromagnetic wave energy along said transmission line the second harmonic of the predetermined frequency is highly attenuated by said filter section while the predetermined frequency is propagated to said cooking cavity substantially without attenuation.

2. The electronic heating apparatus set forth in claim **1**, and further including a second filter section in said transmission line including a high impedance path in said inner and outer conductors for the second and higher even harmonics of the predetermined frequency to effect high attenuation thereof.

3. In an electronic heating apparatus, structure defining a cooking cavity, a generator for generating electromagnetic wave energy of a predetermined ultra-high frequency and having a pair of output terminals, a transmission line coupling said generator to said cooking cavity and including a hollow outer conductor coupled to one terminal of said generator and an inner conductor coupled to the other terminal of said generator, a first cup-like filter member including a cylindrical side wall surrounding the adjacent portion of said inner conductor concentric therewith and spaced therefrom and an end wall closing said side wall at one end thereof and connected to said inner conductor, said cylindrical side wall having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, and a second cup-like filter member including a cylindrical side wall surrounding the cylindrical side wall of said first filter member concentric therewith and spaced therefrom and an end wall closing said side wall of said second filter member having a length equal to nected to said inner conductor, said cylindrical side wall of said second filter members having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, said first and second cup-like filter members cooperating with each other and with said inner conductor to form a folded cavity having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and being resonant at the second harmonic of the predetermined frequency, said first filter member being disposed within said second filter member and said second filter member having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency while presenting a high impedance to the transmission of the second harmonic of the predetermined frequency along said inner conductor, whereby during the transmission of electromagnetic wave energy along said transmission line the second harmonic of the predetermined frequency is highly attenuated by said filter members while the predetermined frequency is propagated to said cooking cavity substantially without attenuation.

4. The electronic heating apparatus set forth in claim 3, and further including a filter section in said transmission line including a high impedance path in said inner and outer conductors for the second and higher even harmonic of the predetermined frequency to effect high attenuation thereof.

5. The electronic heating apparatus set forth in claim 3, wherein each of said inner and outer conductors comprises two portions insulated from each other and telescopically overlapping a distance equal to about one-quarter of the wavelength of the predetermined frequency to provide a low impedance capacitive bypass path between said inner and outer conductors for the second and higher harmonics of the predetermined frequency.

6. The electronic heating apparatus set forth in claim 3, wherein the end walls of said first and second cup-like filter members are respectively disposed in opposite directions along said inner conductor and wherein said second cup-like filter member surrounds and is spaced from said first cup-like filter member.

7. The electronic heating apparatus set forth in claim 3, wherein the end walls of each of said first and second cup-like filter members has an internally threaded opening therein, said inner conductor being disposed through said internally threaded openings and being threadedly engaged thereat with said first and second cup-like filter members.

8. In an electronic heating apparatus, structure defining a cooking cavity, a generator for generating electromagnetic wave energy of a predetermined ultra-high frequency and having a pair of output terminals, a transmission line coupling said generator to said cooking cavity and including a hollow outer conductor coupled to one terminal of said generator and an inner conductor coupled to the other terminal of said generator, and a filter section in said inner conductor and comprising structure defining first and second inner spaces and first and second outer spaces respectively disposed about said first and second inner spaces and first and second passage respectively interconnecting said first inner and other spaces and said second inner and outer spaces to provide first and second folded cavities, said filter section structure having a length equal to about one-quarter of the wavelength of the second harmonic of the predetermined frequency, said first and second folded cavities each having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and each being resonant at the second harmonic of the predetermined frequency, said filter section having a length equal to about one-quarter of the wavelength of the second harmonic of the predetermined frequency while providing two resonant cavities, each presenting a high impedance to the transmission of the second harmonic of the predetermined frequency along said inner conductor, whereby during the transmission of electromagnetic wave energy along said transmission line the second harmonic of the predetermined frequency is highly attenuated by said filter section while the predetermined frequency is propagated to said cooking cavity substantially without attenuation.

9. The electronic heating apparatus set forth in claim 8, and further including a second filter section in said transmission line including a high impedance path in said inner and outer conductors for the second and higher even harmonics of the predetermined frequency to effect high attenuation thereof.

10. In an electronic heating apparatus, structure defining a cooking cavity, a generator for generating electromagnetic wave energy of a predetermined ultra-high frequency and having a pair of output terminals, a transmission line coupling said generator to said cooking cavity and including a hollow outer conductor coupled to one terminal of said generator and an inner conductor coupled to the other terminal of said generator, and a first cup-like filter member including a cylindrical side wall surrounding the adjacent portion of said inner conductor concentric therewith and spaced therefrom and an end wall closing said side wall at one end thereof and connected to said inner conductor, said cylindrical side wall having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, and a second cup-like filter member including a cylindrical side wall surrounding the cylindrical side wall of said first filter member concentric therewith and spaced therefrom and an end wall closing said side wall of said second filter member at one end thereof and connected to said inner conductor, said cylindrical side wall of said second filter member having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, said first and second cup-like filter members cooperating with each other and with said inner conductor to form a first folded cavity having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and being resonant at the second harmonic of the predetermined frequency to effect high attenuation thereof, a third cup-like filter member including a cylindrical side wall surrounding the adjacent portion of said inner conductor concentric therewith and spaced therefrom and an end wall closing said side wall of said third filter member at one end thereof and abutting the end wall of said first filter member and connected to said inner conductor, said cylindrical side of said third filter member having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, and a fourth cup-like filter member including a cylindrical side wall surrounding the cylindrical side wall of said third filter member concentric therewith and spaced therefrom and an end wall closing said side wall of said fourth filter member at one end thereof and connected to said inner conductor, said cylindrical side wall of said fourth filter member having a length equal to about one-eighth of the wavelength of the second harmonic of the predetermined frequency, said third and fourth cup-like filter members cooperating with each other and with said inner conductor to form a second folded cavity having an effective electrical length equal to one-quarter of the wavelength of the second harmonic of the predetermined frequency and being resonant at the second harmonic of the predetermined frequency to effect high attenuation thereof, whereby during the transmission of electromagnetic wave energy along said transmission line the second harmonic of the predetermined frequency is highly attenuated by said filter members while the predetermined frequency is propagated to said cooking cavity substantially without attenuation.

11. The electronic heating apparatus set forth in claim 10, and further including a filter section in said transmission line including a high impedance path in said inner and outer conductors for the second and higher even harmonics of the predetermined frequency to effect high attenuation thereof.

12. The electronic heating apparatus set forth in claim 10, wherein each of said inner and outer conductors comprises two portions insulated from each other and telescopically overlapping a distance equal to about one-quarter of the wavelength of the predetermined frequency to provide a high impedance path in said inner and outer conductors for the second and higher even harmonics of the predetermined frequency.

13. The electronic heating apparatus set forth in claim 10, wherein the end walls of said first and second cup-like filter members are respectively disposed in opposite directions along said inner conductor and the end walls of said third and fourth cup-like filter members are respectively disposed in opposite directions along said inner conductor, and wherein said first and third cup-like filter members are respectively spaced from said second and fourth cup-like filter members.

14. The electronic heating apparatus set forth in claim

13, wherein the end walls of said first and third cup-like filter members are integral with each other.

15. The electronic heating apparatus set forth in claim 14, and further including an annular insulating spacer disposed about the end walls of said first and third cup-like filter members and separating the cylindrical side walls of said second and fourth cup-like filter members from each other.

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JOSEPH V. TRUHE, Primary Examiner

L. H. BENDER, Assistant Examiner

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333—73