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[54] ELECTRONIC OVEN WITH MODE EXCITER AND TUNING PROBES

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

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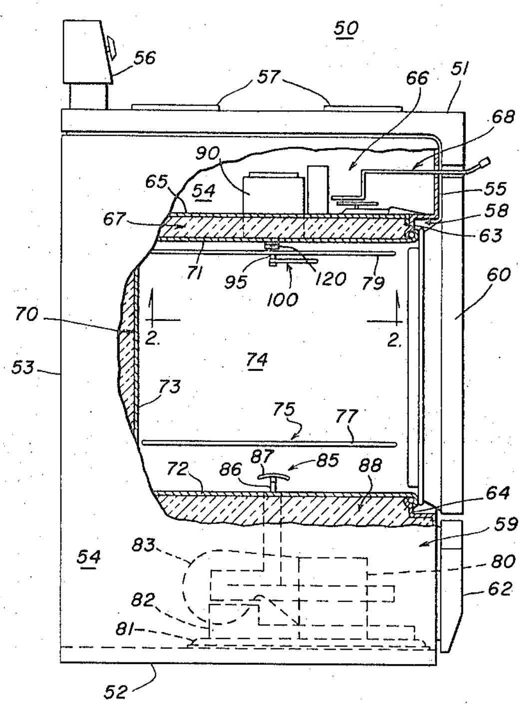
[57] ABSTRACT

An electronic oven includes a heating cavity, a microwave antenna coupled to a source of microwave energy and disposed centrally of the bottom of said cavity for radiating thereinto microwave energy of a predetermined frequency for exciting a predetermined primary mode electromagnetic field in the cavity, a conductive member in the cavity adjacent to the top thereof and rotatably driven about the axis of the antenna for exciting secondary modes complementary to the primary mode at frequencies somewhat higher than the predetermined frequency, and two tuning members mounted at the top of the cavity adjacent to the path of the conductive members and symmetrically with respect thereto for coupling the highest frequency one of the secondary modes and reducing the frequency thereof without altering coupling of the primary mode.

12 Claims, 6 Drawing Figures



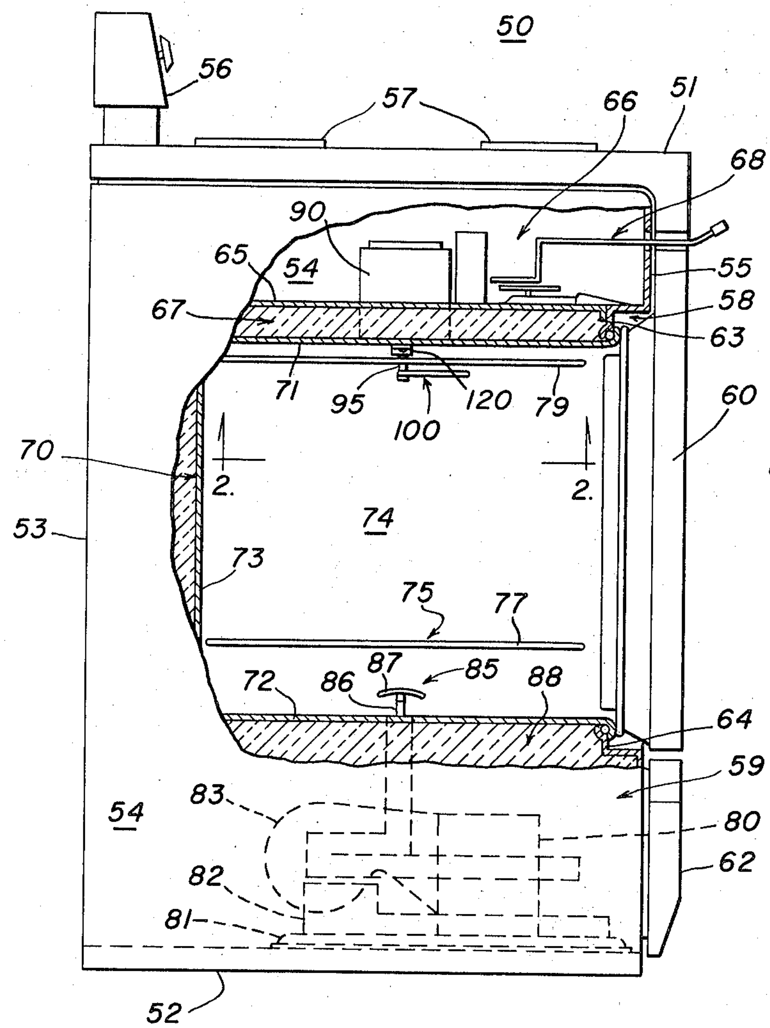

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FIG. I

FIG. 2

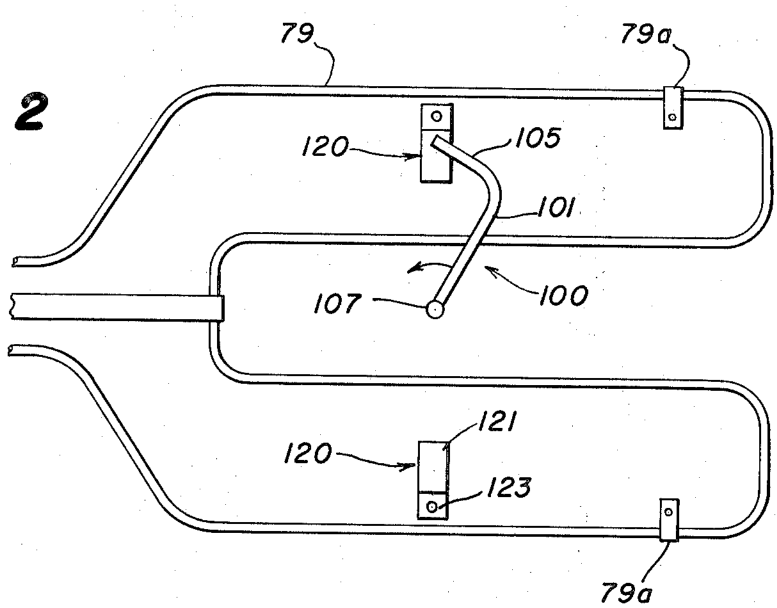
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FIG. 3

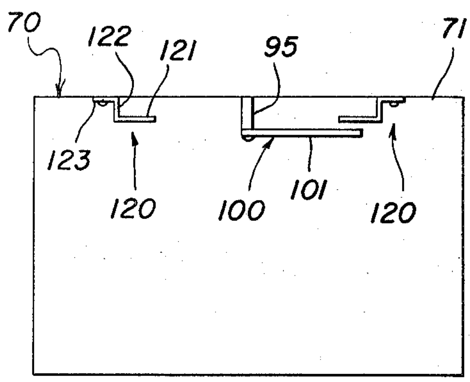


FIG. 4

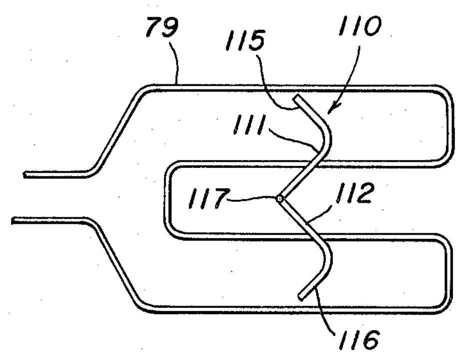


FIG. 5

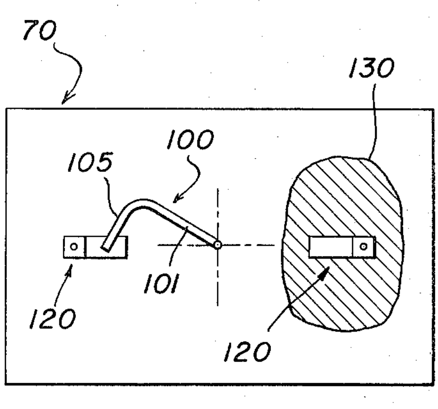
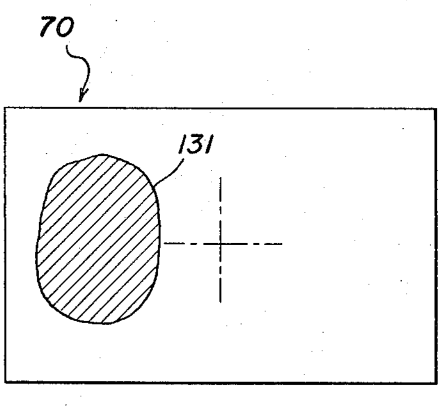


FIG. 6



ELECTRONIC OVEN WITH MODE EXCITER AND TUNING PROBES

The present invention is an improvement of the invention disclosed in our copending U. S. application, Ser. No. 317,206, filed Dec. 21, 1972, and entitled ELECTRONIC OVEN WITH MODE EXCITER, and assigned to the assignee of the present invention. More particularly, the present invention relates to a device for providing a substantially uniform time-averaged field distribution in an electronic oven cavity to facilitate uniform heating of the material placed in the oven.

It is the general object of this invention to provide an electronic oven operating at a predetermined ultra-high frequency and having primary and secondary electromagnetic field modes excited in the cavity with the secondary modes being at frequencies above the predetermined frequency, and including tuning means for coupling the secondary mode and lowering the frequency thereof toward the predetermined frequency, thereby to improve the operation of the electronic oven with light, shallow loads.

It is an important object of this invention to provide electronic heating apparatus comprising an enclosure including two opposed parallel walls and defining a heating cavity for receiving therein a body to be heated, an antenna disposed adjacent to one of the opposed walls and projecting into the cavity along an axis substantially perpendicular to the one wall, the antenna being adapted for coupling to an associated source of electromagnetic energy of a first predetermined ultra-high frequency for transmitting the energy into the cavity to excite therein a predetermined primary electromagnetic field mode, a grounded conductive member disposed in the cavity adjacent to the other of the opposed walls, drive means coupled to the conductive member for effecting rotation thereof about the axis of the antenna for exciting in the cavity a predetermined secondary mode complementary to the primary mode and at a second predetermined ultrahigh frequency, and tuning means mounted in the cavity for coupling the secondary electromagnetic field mode and changing the frequency thereof toward the first predetermined frequency substantially without effecting the coupling of the primary electromagnetic field mode, whereby there is established within the cavity a field distribution adapted to provide improved heating of the associated body.

In connection with the foregoing object, it is another object of this invention to provide electronic heating apparatus of the type set forth, wherein the conductive member includes a grounded conductive shaft extending into the cavity with the longitudinal axis thereof disposed substantially parallel to the electric field component of the primary mode, and a generally L-shaped conductive member connected to the shaft and having two interconnected leg portions disposed in the cavity in a plane substantially normal to the axis of the shaft, and two tuning members mounting in the cavity adjacent to the predetermined path and arranged symmetrically with respect to the axis thereof.

Further features of the invention pertain to the particular arrangement of the parts of the electronic heating apparatus 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:

FIG. 1 is a side elevational view in partial section of an electric range incorporating therein an electronic heating apparatus constructed in accordance with and embodying the features of the present invention;

FIG. 2 is an enlarged fragmentary bottom-plan view of the oven broil unit and a mode exciter and tuning probes, taken along the line 2—2 in FIG. 1;

FIG. 3 is a fragmentary front elevational view of the oven cavity showing the arrangement therein of the mode exciter and tuning probes of the present invention;

FIG. 4 is a view similar to FIG. 2, showing an alternative embodiment of mode stirrer for use with the present invention;

FIG. 5 is a top-plan diagrammatic representation of the oven cavity of the present invention showing the area of strong resultant electric field of the $TE_{1,3,1}$ and $TE_{2,2,}$ 1 modes when the mode exciter is in the position illustrated; and

FIG. 6 is a bottom-plan diagrammatic view similar to FIG. 5 and showing the region of strong resultant electric when the mode exciter is in the position illustrated in FIG. 5.

Referring now more particularly to FIGS. 1 and 2 of the drawings, there is illustrated an electric range, generally designated by the numeral 50. The detailed construction of the electric range 50 is disclosed in the copending U.S. application Ser. No. 256,093 of ROLAND V. FOWLER et al., filed May 23, 1972, entitled MULTIPLE POSITION DOOR LATCH MECHANISM, and assigned to the assignee of the present invention. Accordingly, only so much of the structure of the range 50 will herein be described as is necessary for an understanding of the present invention.

The range 50 is generally box-like in shape and includes a top wall 51, a bottom wall 52, an upstanding rear wall 53, a front wall 55, and a pair of opposed upstanding side walls 54. Mounted on the top wall 51 of the range 50 is a plurality of standard electrical resistance heating units, these units and the other heating apparatus of the range 50 being controlled by a set of controls carried by a control panel 56 mounted on the top wall 51 at the rear end thereof. The front wall 55 has a relatively large rectangular upper opening 58 and a relative small rectangular lower opening 59 therein for providing access to the interior of the range 50. Connected to the front wall 55 and extending inwardly therefrom at the upper and lower edges of the opening 58 are two angle mounting flanges 63 and 64 which cooperate with similar flanges (not shown) at the sides of the opening 58 for defining a doorway.

A door 60 is mounted on the front wall 55 for movement between an open position (not shown) providing access to the interior of the range 50 and a closed position illustrated in FIG. 1 disposed in the doorway for closing the opening 58. In like manner, a door 62 is mounted on the front wall 55 adjacent to the opening 59 for movement between an open position (not shown) providing access to the interior of the range 50 and a closed position, illustrated in FIG. 1, for closing the opening 59. Connected to the upper mounting flange 63 and extending rearwardly therefrom substantially normal to the front wall 55 is a rectangular partition 65 for dividing the interior of the range 50 into an upper machinery compartment 66 and a lower oven compartment 67. Mounted in the upper machinery compartment 66 upon the partition 65 is a latch assembly 68 for latching the front door 60 in the closed position thereof.

Mounted in the lower oven compartment 67 a slight distance below the partition 65 is a generally boxlike metallic oven enclosure, generally designated by the numeral 70, the oven enclosure being substantially in the shape of a rectangular parallelepiped and including a top wall 71, a bottom wall 72, an upstanding rear wall 73, and a pair of opposed upstanding side walls 74, the front end of the oven enclosure 70 being open at the front end thereof and communicating with the opening 58 of the front wall 55 of the range 50. The top and bottom walls 71 and 72 and the side walls 74 of the enclosure 70 are connected at the front edges thereof to the mounting flanges 63 and 64 for supporting and positioning the oven enclosure 70 in the compartment 67.

Preferably, the side walls 74 of the oven enclosure 70 are provided on the inner surfaces thereof with mounting means (not shown) for supporting a rack 75, the rack 75 comprising a plurality of laterally spaced-apart parallel rods 77 extending parallel to the side wall 74 and interconnected at the front and rear ends thereof by end rods 78 disposed substantially parallel to the rear wall 73 (see FIGS. 3 and 4). Disposed within the oven enclosure 70 closely adjacent to the top wall 71 and substantially parallel thereto is a broil unit 79 secured to the top wall 71 by means of mounting clips 71a, the broil unit 79 preferably being a resistance treating element arranged in the serpentine configuration illustrated in FIG. 2.

The bottom wall 72 of the oven enclosure 70 is spaced a predetermined distance above the bottom wall 52 of the range 50 and cooperates therewith to define therebetween a lower machinery compartment 88, access to which is provided through the front opening 59. Mounted in the lower machinery compartment 88 on the bottom wall 52 is a component tray 81 having mounted thereon a magnetron generator 80 for generating electromagnetic energy of a predetermined ultrahigh frequency, preferably 915 MHz. The magnetron 80 is energized by a power supply unit 82 which is also mounted on the component tray 81. The magnetron 80 and the power supply unit 82 may be of the type disclosed in the copending U. S. Pat. application Ser. No. 181,144 of James E. Staats, filed Mar. 20, 1962, entitled Control and Power Supply Systems for Magnetron Devices, and assigned to the assignee of the present invention.

Also mounted in the lower machinery compartment 88 is a blower 83 for directing a stream of cooling air over the magnetron 80 and the power supply 82 for effecting cooling thereof in a well-known manner. Coupled to the RF output terminals the magnetron 80 is a waveguide 84, the upper end of which is received in a complementary opening disposed centrally of the bottom wall 72 of the oven enclosure 70 and is coupled to an antenna, generally designated by the numeral 85, for radiating the microwave energy to the heating cavity defined by the oven enclosure 70 and the closed front door 60. The antenna 85 preferably includes a cylindrical metal post 86 extending vertically upwardly into the oven cavity substantially perpendicular to the bottom wall 72 and coaxially connected at the upper end thereof to a circular slightly concave disk-like capacitive member 87. Preferably, the post 86 has an electrical length approximately equal to ⅛ of the wavelength λ of the microwave energy generated by the magnetron 80, the total electrical length of the antenna 85 being approximately equal to the λ/4.

Mounted in the upper machinery compartment 66 is an electric drive motor 90 having a grounded conductive output shaft 95 extending vertically downwardly through a complementary opening disposed centrally in the top wall 71 of the oven enclosure 70. The output shaft 95 is preferably disposed substantially coaxially with the post 86 of the antenna 85 and extends a predetermined distance into the oven into the heating cavity. Preferably, the shaft 95 has an electrical length approximately equal to λ/8.

Connected to the shaft 95 at the bottom end thereof is a mode stirrer or exciter which is one of several types, but is preferably of an L-shaped member or a W-shaped member, generally designated respectively by the numerals 100 and 110, the L-shaped exciter 100 being illustrated in FIGS. 1 and 2, and the W-shaped exciter 110 being illustrated in FIG. 4.

The mode exciter 100 is preferably integrally formed of a single piece of conductive material such as metal, the mode exciter 100 including a relatively long leg 101 and a relatively short leg 105, the leg 105 being disposed substantially normal to the leg 101. Preferably, the mode exciter 100 is formed of a relatively thin flat piece of metal having a width and thickness sufficient to provide appropriate mechanical strength and current-carrying capacity, the width however preferably being less than or equal to λ/8. In the preferred embodiment of the invention, the mode exciter 100 is disposed in a plane substantially parallel to the top wall 71 of the oven enclosure 70 and is connected at the free end of the leg 101 to the bottom end of the shaft 95 for rotation therewith by the drive motor 90. The leg 101 preferably has an electrical length approximately equal to 3 λ/8, while the short leg 105 preferably has an electrical length approximately equal to λ/4, whereby the total electrical length of the shaft 95 and the mode exciter 100 is approximately equal to 3 λ/4.

The length, width and height of the heating cavity defined by the oven enclosure 70 are all preferably greater than λ. Thus, in operation, the dimensions of the heating cavity and the dimensions of the antenna 75 are such that when the microwave energy is radiated into the cavity by the antenna 75, the heating cavity acts as a cavity resonator and there is established therein the $TE_{1,3,1}$ mode at approximately 920 MHz, the electric field component of which is maximum at the middle of the heating cavity and is minimum at the front and rear ends thereof, with the direction of the field 100 being substantially parallel to the axis of the grounded shaft 95, all as is clearly explained in our aforementioned copending U. S. application, Ser. No. 317,206.

As the mode exciter 100 is rotated through the electric field 110, the mode exciter 100 is itself excited by the electric field 110 and in turn excites secondary modes in the heating cavity. More particularly, when the short leg 105 of the mode exciter 100 is disposed in positions parallel to the rear wall 73, it excites in the oven heating cavity the $TE_{1,3,2}$ mode at approximately

930–935 MHz, the electric field component of which is maximum adjacent to the front and rear ends of the cavity and is minimum at the center thereof. Similarly, when the long leg 101 of the mode exciter 100 is disposed in positions substantially parallel to the back wall 73, it excites in the cavity the $TE_{2,2,1}$ mode at approximately 690 MHz, the electric field component of this mode being maximum at the center of the heating cavity and minimum adjacent to the front and rear ends thereof.

Both the $TE_{1,2,2}$ and the $TE_{2,2,1}$ secondary modes are complementary to the primary $TE_{1,3,1}$ mode and cooperate therewith to equalize the electric field pattern in the heating cavity. More particularly, it will be appreciated that, as the secondary modes $TE_{1,2,2}$ and the $TE_{2,2,1}$ are periodically excited as the mode exciter 100 is rotated in the heating cavity, the electric fields of the several modes add algebraically so that the resultant time-averaged electric field distribution in the oven cavity will be equalized, thereby facilitating more even heating of food placed in the oven cavity to be cooked.

It will be observed that, as the long leg 101 of the mode exciter 100 rotates, the phase orientation of the $TE_{2,2,1}$ mode excited thereby, with respect to the primary $TE_{1,3,1}$ mode, is automatically continually changed to provide optimum equalization of the resultant electric field pattern. However, the $TE_{1,2,2}$ mode excited by the short leg 105 maintains the same phase orientation with respect to the primary mode $TE_{1,3,1}$ as the mode exciter 100 is rotated. Thus, there will be a distortion of the resultant field of the $TE_{1,3,1}$ and $TE_{1,2,2}$ modes. In order to eliminate this distortion in the resultant field of the superimposed $TE_{1,3,1}$ and $TE_{1,2,2}$ modes, it is necessary to effect a periodic phase reversal of the mode orientation of the electric field of the $TE_{1,2,2}$ mode with respect to the electric field of the $TE_{1,3,1}$ mode.

The mode exciter 110 is for effecting this phase reversal. The mode exciter 110 is generally W-shaped and comprises two identically constructed L-shaped sections, each of which is substantially identical to the mode exciter 100. More particularly, the mode exciter 110 includes a first long leg portion 111 being integral at one end thereof with a first short leg portion 115 disposed substantially normal thereto. Connected to the first long leg portion 111 at the other end thereof is one end of a second long leg portion 112 extending from the first leg portion 111 substantially normal thereto and in a direction opposite to the direction of the short leg portion 115. Integral with the second long leg portion 112 at the other end thereof and extending therefrom substantially normal thereto in a direction opposite to the direction of the first long leg portion 111 is a second short leg portion 116. Preferably, the leg portions 111, 112, 115 and 116 of the mode stirrer 110 are all disposed in a common plane substantially parallel to the top wall 71 of the oven enclosure 70, with the mode exciter 200 being connected at a point 117 at the junction of the long leg portions 111 and 112 to the lower end of the shaft 95 for rotation therewith by the motor 90.

In operation, the mode exciter 110 acts in the same manner as two of the L-shaped mode exciters 100. More particularly, the short leg portions 115 and 116 excite the secondary $TE_{1,2,2}$ mode when they are disposed substantially parallel to the front and rear walls of the oven cavity, while when the long leg portions 111 and 112 are disposed parallel to the front and rear walls, the secondary $TE_{2,2,1}$ mode is excited. The interaction between these two modes effects a periodic phase reversal of the orientation of the $TE_{1,2,2}$ mode with respect to the $TE_{1,3,1}$ mode, thereby evening out or equalizing the diagonal distortion of the field, as is explained in our aforementioned copending U. S. application, Ser. No. 317,206.

It has been found that when the electronic oven is operating with light shallow loads, the operation is improved if the frequency of the secondary mode electric field, and in particular the $TE_{2,2,1}$ mode, is closer to the frequency of the primary mode. Accordingly, in order to effect this narrowing of the difference between the frequencies of the primary and secondary modes of the electric field, there are provided in the present invention two tuning probes substantially identical in construction and each generally designated by the numeral 120. Each of the tuning probes 120 is preferably integrally formed of metal and includes a flat generally rectangular main body portion 121 having integral therewith at one end thereof and extending substantially normal thereto an upright flange 122. Integral with the upright flange 122 at the upper end thereof and extending therefrom substantially normal thereto away from the direction of the main body portion 121 is a short rectangular mounting flange 123.

In use, the mounting flange 123 is disposed flat against the top wall 71 of the oven enclosure 70 and is fixedly secured thereto as by screws or bolts or other suitable fasteners. In this configuration, the main body portion 121 is disposed in a plane substantially parallel to the top wall 71 and spaced therebelow a distance equal to the length of the upright flange 122, as is best shown in FIG. 3. Preferably, the tuning probes 120 are respectively disposed on opposite sides of the shaft 95, with the main body portions 121 extending inwardly toward each other with the longitudinal axes thereof disposed in a common vertical plane passing through the longitudinal axis of the shaft 95 and above the plane of rotation of the mode exciter 100. Preferably, the tuning probes 120 are equidistantly spaced from the shaft 95 a distance approximately equal to the length of the long leg 101 of the mode exciter 100.

The length and position of the tuning probes 120 are such that the tuning probes 120 do not affect the tuning of the primary $TE_{1,3,1}$ mode at 920 MH_z by more than several MH_z, while at the same time coupling the $TE_{2,2,1}$ mode at 960 MH_z and lowering the frequency thereof into the 890–940 MH_z band, thereby to improve the operation of the electronic oven at light and shallow loads. In a constructional model of the electronic oven, the oven enclosure 70 has a height of approximately 16 inches, a width of approximately 23 inches, and a depth from front to back of approximately 17-¼ inches, each of the tuning probes 120 having an effective electrical length of approximately $\lambda/4$ and being spaced approximately 4–5 inches from the shaft 95, the tuning probes 120 being individually adjusted to tune the $TE_{2,2,1}$ mode between 890 and 940 MH_z.

As the long leg 101 of the mode exciter 100 approaches the vicinity of one of the tuning probes 120, as illustrated in FIG. 5, it detunes that probe causing an unbalance of the system resulting in the other tuning probe 120 coupling more of the $TE_{2,2,1}$ mode than would normally be coupled by the long leg 101 of the mode exciter **100** by itself. When this happens, the resultant electric field pattern in the oven, which is a composite of the $TE_{1,3,1}$ and $TE_{2,2,1}$ modes, becomes unbalanced, with the areas of strong resultant field being disposed at the upper right-hand portion and lower left-hand portion of the oven enclosure **70** as indicated in FIGS. **5** and **6**. When the mode exciter **100** approaches the other tuning probe **120** an opposite unbalance occurs in the resultant electric field pattern. It will be appreciated that if the tuning probes **120** are properly located, the unbalance in the resultant electric field moves from side to side in the oven enclosure **70** as the mode exciter **100** rotates, whereby there is no net excitation of the $TE_{2,2,1}$ mode.

It will, of course, be appreciated that a similar phenomenon occurs when the W-shaped mode exciter **110** is used in place of the mode exciter **100**. More particularly, as the long legs **111** and **112** of the mode exciter **110** approach one of the tuning probes **120**, they detune that probe, it being understood that with the W-shaped mode exciter **110** each of the tuning probes **120** will be detuned twice during each revolution of the mode exciter **110**. However, the resulting unbalance in the resultant electric field pattern in the oven cavity will move alternately from side to side in the oven cavity as the mode exciter **110** rotates, just as was explained above with respect to the mode exciter **100**, whereby there will be no net excitation of the $TE_{2,2,1}$ mode.

From the foregoing, it can be seen that there has been provided a novel arrangement of electronic heating apparatus which provides a substantially uniform time-averaged electromagnetic field distribution in the oven cavity, while at the same time minimizing the difference between the frequencies of the primary and secondary electric field modes, thereby to facilitate uniform heating of bodies in the oven cavity and to improve operation of the electronic oven at light, shallow loads.

More particularly, there has been provided in combination a mode exciter which is rotatably driven in the primary mode electric field to excite secondary mode electric fields at frequencies above the frequency of the primary mode, and novel tuning members positioned and dimensioned in the oven cavity for coupling at least one of the secondary modes and lowering the frequency thereof toward the frequency of the primary mode.

There has also been provided an electronic heating apparatus of the character described, wherein the tuning means comprises a pair of tuning members arranged symmetrically with respect to the mode exciter so as to equalize any unbalance of the resultant electric field in the oven cavity produced by interaction between the tuning means and the mode exciter, thereby to effect a lowering of the frequency of the secondary mode while effecting no net excitation thereof.

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 as fall within the true spirit and scope of the invention.

What is claimed is:

1. Electronic heating apparatus comprising an enclosure including two opposed parallel walls and defining a heating cavity for receiving therein a body to be heated, an antenna disposed in said cavity adjacent to one of said opposed walls and having a longitudinal axis substantially perpendicular to said one wall, said antenna being adapted for coupling to an associated source of microwave electromagnetic energy for transmitting said energy into said cavity to excite therein a predetermined primary electromagnetic field mode at a first mode frequency, a grounded conductive member disposed in said cavity adjacent to the other of said opposed walls, drive means coupled to said conductive member for effecting rotation thereof about said axis of said antenna for exciting in said cavity a predetermined secondary electromagnetic field mode complementary to said primary mode and at a second mode frequency, and tuning means mounted in said cavity for coupling said secondary electromagnetic field mode and changing the mode frequency thereof toward said first mode frequency substantially without affecting the coupling of said primary electromagnetic field mode, whereby there is established within said cavity a field distribution adapted to provide improved heating of the associated body.

2. The electronic heating apparatus set forth in claim **1**, wherein said second mode frequency is higher than said first mode frequency, said tuning means effecting lowering of the frequency of said secondary mode to a range below said second mode frequency and including said first mode frequency.

3. The electronic heating apparatus set forth in claim **1**, wherein said first mode frequency is approximately 920 MH_z, and said second mode frequency is approximately 960 MH_z, said tuning means effecting reduction of the frequency of said secondary mode to a range of frequencies between 890 and 940 MH_z.

4. Electronic heating apparatus comprising an enclosure defining a heating cavity for receiving therein a body to be heated, source means electrically coupled to said heating cavity for transmitting thereinto microwave electromagnetic energy to excite a predetermined primary electromagnetic field mode in said cavity at a first mode frequency, drive means including a rotatably driven grounded conductive shaft extending into said cavity with the longitudinal axis thereof disposed substantially parallel to the electric field component of said primary mode, a generally L-shaped conductive member disposed in said cavity and having two interconnected leg portions intersecting at an angle and lying in a common plane substantially normal to the axis of said shaft, said shaft being connected to said conductive member at the free end of one of the said leg portions thereof for effecting rotation thereof in a predetermined path about the axis of said shaft, said conductive member being responsive to continuous rotation thereof by said drive means for interaction with said primary mode electric field periodically to excite in said cavity a predetermined secondary electromagnetic field mode complementary to said primary mode and at a second mode frequency, and two tuning members mounted in said cavity adjacent to said predetermined path and arranged symmetrically with respect to the axis of said shaft for coupling said secondary mode and changing the frequency thereof toward said first mode frequency substantially without affecting the coupling of said primary electromagnetic field mode, whereby there is established within said cavity a substantially uniform time-averaged field distribution to facilitate uniform heating of the associated body.

5. The electronic heating apparatus set forth in claim 4, wherein said conductive member is responsive to continuous rotation thereof for interaction with said primary mode electric field periodically to excite in said cavity two predetermined secondary electromagnetic field modes complementary to said primary mode, one of said secondary modes being at said second mode frequency and the other of said secondary modes being at a frequency between said first and second mode frequencies.

6. The electronic heating apparatus set forth in claim 4, wherein said first mode frequency is approximately 920 MH_z, and said second mode frequency is approximately 960 MH_z.

7. The electronic heating apparatus set forth in claim 4, wherein each of said tuning members has an effective electrical length approximately equal to one-fourth of the wavelength of the electromagnetic energy transmitted into said cavity from said source means.

8. The electronic heating apparatus set forth in claim 4, wherein each of said tuning members is generally L-shaped and includes a first leg disposed substantially perpendicular to said shaft and a second leg integral with said first leg and disposed substantially normal thereto, said tuning members being respectfully disposed on opposite sides of said shaft and being equidistantly spaced therefrom.

9. The electronic heating apparatus set forth in claim 4, wherein each of said tuning members is generally L-shaped and includes a first leg disposed substantially perpendicular to the axis of said shaft and a second leg integral with said first leg and disposed essentially normal thereto, said tuning members being respectively disposed on opposite sides of said shaft and equidistantly spaced therefrom with the longitudinal axes of said first legs being substantially collinear.

10. The electronic heating apparatus set forth in claim 4, wherein said conductive member is generally L-shaped including a pair of interconnected leg portions disposed in a common plane substantially normal to the axis of said shaft, each of said tuning members being generally L-shaped and including a first leg disposed substantially perpendicular to the axis of said shaft and a second leg integral with said first leg and disposed essentially normal thereto, said tuning members being respectively disposed on opposite sides of said shaft and equidistantly spaced therefrom with said first legs being disposed above the plane of said conductive member with the longitudinal axes thereof being substantially collinear.

11. The electronic heating apparatus set forth in claim 4, wherein said conductive member is generally W-shaped and is arranged symmetrically with respect to the axis of said shaft, each of said tuning members being generally L-shaped and including a first leg disposed substantially perpendicular to the axis of said shaft and a second leg integral with said first leg and disposed essentially normal thereto, said tuning members being respectively disposed on opposite sides of said shaft and equidistantly spaced therefrom with the longitudinal axes of said first legs being substantially colinear, said tuning members being respectively disposed on opposite sides of said shaft and equidistantly spaced therefrom with said first legs being disposed above the plane of said conductive member with the longitudinal axes thereof being substantially collinear.

12. Electronic heating apparatus comprising an enclosure defining a heating cavity for receiving therein a body to be heated, source means electrically coupled to said heating cavity for transmitting thereinto microwave electromagnetic energy to excite a predetermined primary electromagnetic field mode in said cavity at a first mode frequency, a grounded conductive member mounted in said cavity for rotation about an axis disposed substantially parallel to the electric field component of said primary mode to excite in said cavity a predetermined secondary electromagnetic field mode complementary to said primary mode and at a second mode frequency, and tuning means mounted in said cavity for coupling said secondary electromagnetic field mode and changing the mode frequency thereof toward said first mode frequency substantially without affecting the coupling of said primary electromagnetic field mode, whereby there is established within said cavity a field distribution adapted to provide improved heating of the associated body.

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