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3,221,132

NON-RESONANT OVEN CAVITY AND RESONANT ANTENNA
SYSTEM FOR MICROWAVE HEATING OVEN

Filed July 22, 1963

2 Sheets-Sheet 1

FIG. 1

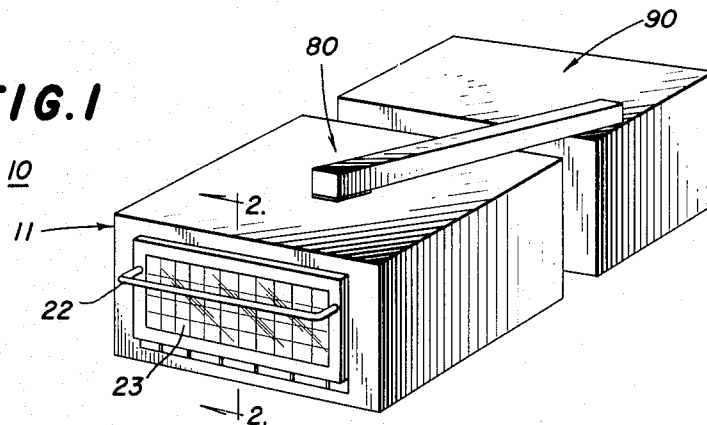


FIG. 2

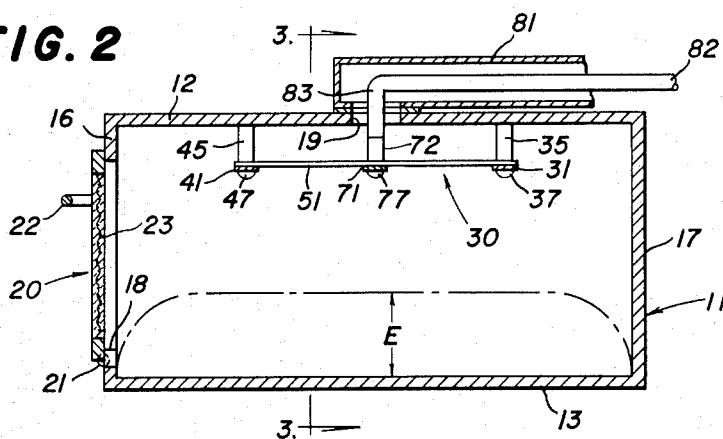
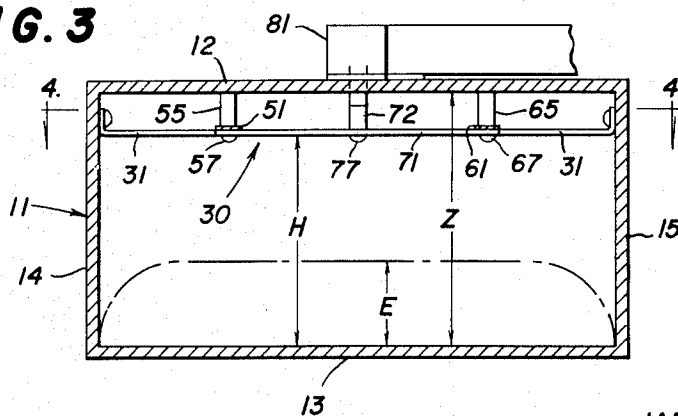


FIG. 3



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SYSTEM FOR MICROWAVE HEATING OVEN

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3,221,132

NON-RESONANT OVEN CAVITY AND RESONANT ANTENNA SYSTEM FOR MICROWAVE HEATING OVEN

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Filed July 22, 1963, Ser. No. 296,622

16 Claims. (Cl. 219—10.55)

The present invention relates to microwave heating ovens, and more particularly to non-resonant oven cavities and resonant antenna systems therefor.

In the co-pending application of James E. Staats, Serial No. 181,144, filed March 20, 1962, there is disclosed a control and power supply system for a multiple cavity magnetron device that is especially constructed and arranged to achieve stable and efficient operation at anode-cathode voltages of relatively low amplitude, thereby rendering the magnetron device particularly well suited for incorporation in electronic cooking apparatus designed for home use. More particularly, this magnetron device is designed to oscillate at an ultra-high frequency of about 915 mc., employing anode-cathode voltages in the general range of 250 to 1000 volts D.C., with corresponding R.F. power outputs in the general range of 80 to 2400 watts. Specifically, the circuit of the above application Serial No. 181,144 is particularly designed to operate from the household A.C. supply source having a frequency of about 60 cycles and an R.M.S. voltage in the general range of 220 to 250 volts, producing a plate voltage of about 570 volts D.C., thus providing continuous R.F. power output of about 700 watts at the ultra-high frequency of 915 mc. The microwave heating oven of the present invention is particularly adapted for use with such a magnetron and power supply system therefor operating under the conditions noted.

In the microwave heating ovens common in the art heretofore, the dimensions of the object to be heated and the dimensions of the enclosure or oven cavity for receiving the object to be heated have been generally comparable to the wavelength of the microwave energy utilized or multiples thereof, and as a result there is always present the possibility of having one or more resonant modes excited or existing in the oven cavity. The perturbations of the resonant modes caused by the dielectric properties of the object to be heated result in non-uniform heating; and accordingly, it has been customary heretofore to utilize so-called "mode stirring" devices in an effort to counteract the perturbations of the resonant modes caused by the dielectric objects to be heated, but the "mode stirring" devices in turn may create undesired modes resulting in non-uniform heating.

Accordingly, it is a general object of the present invention to provide an oven cavity and an antenna therefor in a microwave heating oven of the type set forth, wherein the oven cavity is non-resonant and free of resonant modes during the operation thereof.

Another object of the invention is to provide a microwave heating oven of the type set forth in which the dimensions of the oven cavity are related to the wavelength of the microwave energy used in the oven cavity so that the oven cavity is free of resonant modes at the wavelength of the microwave energy.

Another object of the invention is to provide a microwave heating oven of the type set forth which quickly and uniformly heats a wide variety of objects having a wide range of dielectric characteristics.

Another object of the invention is to provide a microwave heating oven of the type set forth utilizing a source of microwave energy operating at the authorized frequency of 915 mc., wherein the oven cavity is box-like

with an X dimension of the same order of magnitude as the wavelength of the microwave energy and with a Y dimension substantially equal to the X dimension and with a Z dimension not greater than one-half the X dimension, so as to provide an oven cavity that will be non-resonant at the authorized frequency.

Another object of the invention is to provide an improved microwave heating oven incorporating in the non-resonant oven cavity an improved resonant antenna structure.

Another object of the invention is to provide in a microwave heating oven of the type set forth, a box-like oven cavity having an antenna arranged therein adjacent to and below the top wall and cooperating therewith to provide a radiating device of the plane reflector array type, the antenna being spaced from the top wall a distance to provide a maximum gain.

In connection with the foregoing object, it is another object of the present invention to provide in combination, a box-like oven cavity having an antenna disposed therein adjacent to the top wall thereof and spaced from the cooking surface a distance of at least one-quarter wavelength of the operating frequency of the microwave energy used in the oven cavity in order to obtain a uniform field at the cooking surface.

A further object of the invention is to provide in the oven cavity of a microwave heating oven of the type set forth, an antenna comprising two or more dipole elements disposed to establish two or more field patterns related in phase such that the vector field summation is substantially uniform over an area sufficiently large to encompass the object to be heated.

A further object of the invention is to provide in a box-like oven cavity for a microwave heating oven of the type set forth, an antenna including two substantially symmetrical arm structures with an electrical input terminal therebetween, each of the arm structures being of branched configuration and constituting one or more dipole elements.

A still further object of the invention is to provide in a microwave heating oven of the type set forth, a box-like non-resonant oven cavity having an antenna therein disposed substantially in a plane position adjacent to and below and substantially parallel with the top wall, the antenna including two substantially symmetrical antenna members extending between the side walls and having physical lengths shorter than the wavelength of the microwave energy supplied to the oven cavity, the antenna members being reactively loaded to impart thereto an electrical length equivalent to the wavelength of the microwave energy used.

Further features of the invention pertain to the particular arrangement of the elements of the microwave heating oven and of the oven cavity and antenna forming a part thereof, whereby the above-outlined and additional operating features thereof are attained.

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

FIGURE 1 is a perspective view of a microwave heating oven incorporating therein an oven cavity and an antenna embodying the present invention;

FIG. 2 is an enlarged longitudinal vertical sectional view through the oven cavity along the line 2—2 of FIG. 1;

FIG. 3 is an enlarged lateral vertical sectional view through the oven cavity along the line 3—3 of FIG. 2;

FIG. 4 is an enlarged horizontal section through the oven cavity along the line 4—4 of FIG. 3; and

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FIG. 5 is a further enlarged vertical sectional view of an upper corner of the oven cavity along the line 5—5 of FIG. 4.

Referring now to FIG. 1 of the drawings, the microwave heating oven 10 there illustrated, and embodying the features of the present invention, is in the form of an electronic heating oven specially designed for home use. More particularly, the microwave heating oven 10 comprises an upstanding substantially box-like wall structure 11 formed of steel and defining an oven cavity therein, the wall structure 11 having substantially the configuration of a simple tetragonal, and more particularly an orthohexahedron. Specifically, the oven cavity is defined by a top wall 12, a bottom wall 13, a pair of opposed side walls 14 and 15, a front wall 16, and a rear wall 17, the front wall 16 having a doorway 18 therein opening into the cooking cavity defined by the wall structure 11. Further, the front wall 16 is provided with a front door 20 hingedly connected thereto by associated hinge structure 21 and cooperating with the doorway 18, whereby the door 20 is movable between a substantially vertical closed position and a substantially horizontal open position with respect to the doorway 18 in the wall structure 11. Also the front door 20 includes a handle 22 and the usual inner foraminous metal sheet 23 formed of steel which cooperates with the wall structure 11 completely to enclose the oven cavity when the front door 20 occupies its closed position.

An antenna structure generally designated by the numeral 30 is arranged within the oven cavity defined by the wall structure 11 and is disposed adjacent to and immediately below the top wall 12. Referring particularly to FIG. 4, the antenna structure 30 includes two transversely extending spaced-apart antenna members 31 and 41 which extend the width of the oven cavity and have the outer ends thereof fixedly secured to the adjacent side walls 14 and 15, respectively, the antenna members 31 and 41 being formed of an electrically conductive material, such as aluminum. More specifically, the antenna member 31 is formed as an elongated flat strip extending the width of the oven cavity and having a first upturned flange 32 on one end thereof and a second upturned flange 33 on the other end thereof, the flanges 32 and 33 extending in the same direction from the antenna member 31 and being disposed substantially perpendicular thereto and parallel to each other; the flanges 32 and 33 are provided with openings therethrough to receive fasteners, such as the screws 34, for mounting the antenna member 31 upon the side walls 14 and 15, respectively. The other antenna member 41 likewise constitutes a narrow strip of metal provided at the opposite ends with upturned flanges 42 and 43, respectively, the flanges 42 and 43 extending in the same direction from the antenna member 41 and being disposed substantially perpendicular thereto and substantially parallel to each other; the flanges 42 and 43 are provided with openings therethrough to receive fasteners such as the screws 44, for mounting the antenna member 41 upon the side walls 14 and 15, respectively. Two connecting members 51 and 61 are provided to interconnect spaced points of the antenna members 31 and 41, the connecting members 51 and 61 being also formed of an electrically conductive material, preferably aluminum metal, and having a length equal to the distance between the outer edges of the antenna members 31 and 41 and having widths equal substantially to the widths of the antenna members 31 and 41. More particularly, the connecting member 51 is disposed toward the side wall 14 and arranged with the axis thereof generally parallel to the side wall 14, the outer ends of the connecting member 51 lying upon the antenna members 31 and 41, whereby the ends of the connecting member 51 overlie intermediate portions of the antenna members 31 and 41. Aligned openings are formed in the overlapping portions of the connecting member 51 and the antenna members

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31 and 41 for the reception therethrough of fasteners, such as the screws 57 (see FIG. 5 also) that serve to interconnect the antenna members 31, 41 and 51. The connecting member 61 is disposed toward the side wall 15 and arranged with the axis thereof generally parallel to the side wall 15, the outer ends of the connecting member 61 being disposed respectively upon intermediate portions of the antenna members 31 and 41. Aligned openings are formed in the overlapping portions of the antenna members 31, 41 and 61 for the reception therethrough of fasteners, such as the screws 67 (see FIG. 3 also). An antenna feed member 71 is provided interconnecting the midpoints of the connecting members 51 and 61, the feed member 71 having substantially the same width and thickness as the antenna members 31, 41, 51 and 61 and being disposed below the connecting members 51 and 61 and in substantially the same plane as the antenna members 31 and 41, the longitudinal axis of the feed member 71 being substantially parallel to the rear wall 17 and to the axes of the antenna members 31 and 41. The ends of the feed member 71 extend beneath the mid-portion of the connecting members 51 and 61 and aligned openings are provided through the ends of the feed member 71 and the associated connecting members 51 and 61, the aligned openings receiving suitable fasteners therethrough, such as screws, to interconnect the members 51, 61 and 71.

Connection is also made between the antenna 30 and the top wall 12, four conductive connections being provided and four non-conductive or insulated connections being provided. A first conductive connection is made between the midpoint of the antenna member 31 and the top wall 12 by means of a conductive slug 35 formed of any suitable electrically conductive material such, for example, as aluminum. The lower end of the slug 35 has a tapped opening therein in alignment with an opening in the antenna member 31 and adapted to receive a suitable fastener, such as the screw 37, therein (see particularly FIG. 5). The upper end of the slug 35 also is provided with a tapped opening and is positioned in alignment with an opening in the top wall 12 for the reception of a suitable fastener, such as the screw 36, therein. A like conductive connection is made between the midpoint of the antenna member 41 and the top wall 12 by an electrically conductive slug 45 having the lower end thereof secured to and in electrical connection with the antenna member 41 and having the upper end thereof secured to and in electrical connection with the top wall 12. A similar conductive connection is made between the midpoint of the connecting member 51 and the top wall 12 by an electrically conductive slug 55 having the lower end thereof secured to and in electrical connection with the connecting member 51 and the underlying end of the feed member 71, and having the upper end thereof secured to and in electrical connection with the top wall 12. A like conductive connection is made between the midpoint of the connecting member 61 and the top wall 12 by an electrically conductive slug 65 having the lower end thereof secured to and in electrical connection with the connecting member 61 and the underlying adjacent end of the feed member 71 and having the upper end thereof secured to and in electrical connection with the top wall 12.

The insulated connections between the antenna 30 and the top wall 12 are made by four insulators 52, 53, 62 and 63, all formed of a suitable electric insulating material such as the ceramic "Steatite." More specifically, the insulator 52 has a threaded opening in the lower end thereof and in alignment with openings in the antenna member 31 and the connecting member 51 for the reception therein and therethrough of a suitable fastener, such as the screw 57 (see FIG. 5 also); the upper end of the insulator 52 is likewise provided with a threaded opening which is in alignment with the opening in the top wall 12 for the reception therein and therethrough of a suitable

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fastener, such as the screw 54, for mounting the insulator 52 and the connected parts upon the top wall 12. The insulator 53 is constructed and mounted like the insulator 52 and interconnects the overlying portions of the antenna member 41 and the connecting member 51 to the top wall 12. The insulator 62 also has a construction and is mounted like the insulator 52 and serves to interconnect the overlying portions of the antenna member 31 and the connecting member 61 to the top wall 12. The insulator 63 is likewise constructed and mounted in the same manner as the insulator 52 and serves to connect the overlying portions of the antenna 41 and the connecting member 61 to the top wall 12.

The microwave energy used in operating the microwave heating oven 10, more particularly, the energy coupled to the antenna 30 described above, is derived from a suitable source that is diagrammatically illustrated at 90 in FIG. 1 of the drawing. One preferred source of microwave energy is a crossed-field electric discharge device in the form of a multiple cavity magnetron device of the type illustrated and described in the co-pending application of James E. Staats, Serial No. 105, 983, filed April 27, 1961. The magnetron device described in that application is particularly well suited for incorporation in electrical cooking apparatus such as the microwave heating oven 10 of the present invention. More particularly, this magnetron device is designed to oscillate at an ultra-high frequency of about 915 mc., employing anode-cathode voltages in the general range 250 to 1000 volts D.C., with corresponding R.F. power outputs in the general range 80 to 2400 watts. Specifically at a plate voltage of about 290 volts D.C., this magnetron device has a continuous R.F. power output of about 100 watts at the ultra-high frequency of 915 mc.; at a plate voltage of about 570 volts D.C., this magnetron device has a continuous R.F. power output of about 700 watts at the ultra-high frequency of 915 mc.; and at a plate voltage of about 1000 volts D.C., this device has a peak R.F. power output of about 2400 watts at the ultra-high frequency of 915 mc.

By using the control and power supply systems illustrated and described in the copending application of James E. Staats, Serial No. 181,144, the above-described magnetron device can be readily operated from the usual household 3-wire Edison network of 236 volts, single-phase, 60-cycles, A.C. More specifically, the power supply system disclosed in this application includes a "voltage doubler and rectifier circuit" which produces from the 236 volts A.C. of the Edison network the relatively high D.C. output voltage of 570 volts that can be supplied to the magnetron device which oscillates to supply ultra-high frequency energy at about 915 mc., the R.F. power output of the magnetron device being approximately 700 watts.

The microwave energy so generated is conducted from the source 90 to the antenna 30 within the wall structure 11 by means of the transmission line 80. Preferably the transmission line 80 is of the general construction and arrangement of that disclosed in the copending application of Louis H. Fitzmayer, Serial No. 135,582, filed September 1, 1961, now Patent No. 3,172,987, granted March 9, 1965; whereby the transmission line 80 includes an outer conductor 81 and an inner conductor 82 (see FIG. 2) which connects with a terminal 83 that is connected to an electrical input terminal 72 mechanically secured to and in electrical connection with the midpoint of the feed member 71 (see FIG. 4).

An important feature of the present invention resides in the fact that the microwave energy is introduced into a non-resonant cooking cavity by means of a plurality of resonant dipole antenna elements coupled in the proper phase relationship for establishing a uniform composite field in the non-resonant cooking cavity. An important advantage of using the non-resonant cooking cavity is derived from the fact that the introduction of dielectric materials to be heated into the cooking cavity does not affect

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its resonance, and therefore minimum field distortion and decoupling effects are encountered. As a result, the microwave heating oven of the present invention can efficiently heat a wide variety of dielectric materials all without the need for resorting to complicated and relatively inefficient mode stirring structures.

The cooking cavity defined by the conductive wall structure 11 is non-resonant in the sense that the dimensions of the oven cavity are related to the wavelength of the microwave energy from the generator 90 so that the oven cavity is free of resonant modes at the operating wavelength. When the cooking cavity is box-like in shape, and specifically, when the cooking cavity is an orthohexahedron, as illustrated in the drawing, the resonant wavelength thereof can be directly calculated from the equation:

$$\lambda = 2 \left[\left(\frac{1}{X} \right)^2 + \left(\frac{m}{Y} \right)^2 + \left(\frac{n}{Z} \right)^2 \right]^{-1/2} \quad (1)$$

In accordance with the present invention the dimensions X, Y and Z are chosen so that when they are substituted in Equation 1 above, none of the resonant wavelengths of the corresponding cooking cavity correspond to the wavelength of the microwave energy source 90; furthermore, the presence of an object to be heated within the cooking cavity has a "pulling" effect, whereby it is desirable that the operating frequency of the microwave energy source 90 should be displaced from the nearest resonant frequency of the cooking cavity about 5% of the wavelength of the microwave energy from the source 90. In other words, the cooking cavity may have any combination of dimensions X, Y and Z except those which possess resonant wavelengths within 5% of the frequency of the microwave generator 90. Cooking cavities having dimensions substantially larger than the wavelength of the source 90 tend to possess a large number of resonant frequencies or modes which are very close together, i.e., separated by less than 10% of the wavelengths involved, whereby it is further desirable that the X and Y dimensions be the same order of magnitude as the wavelength of the microwave energy source 90. One particular illustration of a combination of dimensions useful in accordance with the present invention and being non-resonant is obtained when: the X dimension is of the same order of magnitude as the wavelength of the microwave energy from the source 90, the Y dimension is substantially equal to the X dimension, and the Z dimension is not greater than one-half the X dimension.

The antenna 30 illustrated in the drawing is of the plane reflector array type and the maximum gain is obtained when the distance between the antenna and the top wall 12, i.e., the distance D in FIG. 5, is within the range from about 5% to 15% of the wavelength of the microwave energy from the source 90, the preferred spacing being about 10% of the wavelength of the source 90 or slightly less. In order to obtain the most uniform field for heating and cooking purposes, the cooking surface should be placed at least one-quarter wavelength from the antenna, and accordingly, the distance H in FIG. 3 should be at least one-quarter of the wavelength of the source 90 so that the cooking surface which is disposed a short distance upwardly from the bottom wall 13 will be at a point of maximum uniformity of the heating field.

The antenna 30 as illustrated in FIG. 4 includes a plurality of resonant dipole elements all coupled in proper phase relationship for establishing a uniform composite field within the cooking cavity. More specifically, as illustrated in FIG. 4, the cooking cavity is approximately square and has X and Y dimensions substantially equivalent to a wavelength of the microwave energy source 90. The principal antenna members 31 and 41 are each disposed one-quarter wavelength from the adjacent grounded wall, the antenna member 31 being placed parallel to the rear wall 17 and spaced about one-quarter wavelength therefrom, and the antenna member 31 being placed

parallel to the front wall 16 and spaced about one-quarter wavelength therefrom. The connecting members 51 and 61 in turn are disposed one-quarter wavelength from the adjacent parallel grounded walls, i.e., the connecting member 51 being disposed parallel to the side wall 14 and spaced therefrom about one-quarter wavelength and the connecting member 61 being disposed parallel to the side wall 15 and spaced therefrom about one-quarter wavelength. The longitudinal axis of the feed member 71 is disposed along the line spaced one-half wavelength from the walls 16 and 17 and parallel thereto and the ends of the feed member 71 terminate at points spaced approximately one-quarter wavelength from the adjacent side walls 14 and 15, respectively.

It will be seen therefore that the slug 35, for example, is disposed one-quarter wavelength from each of the insulators 52 and 62 which are in turn disposed one-quarter wavelength from the side walls 14 and 15 respectively. The slug 45 is similarly positioned one-quarter wavelength from each of the insulators 53 and 63 which are in turn positioned one-quarter wavelength from the side walls 14 and 15, respectively. The slug 55 is positioned one-quarter wavelength from the input connection 72 and one-quarter wavelength from each of the insulators 52 and 53. The slug 65 is likewise positioned one-quarter wavelength from the feed connection 72 and one-quarter wavelength from each of the insulators 62 and 63. The antenna 30 therefore is of branched configuration, is symmetrical with respect to the oven cavity and includes a plurality of dipole antenna elements each of which radiates into the non-resonant cooking cavity and in proper phase relationship to provide a uniform field of microwave energy therein, the electric field being diagrammatically illustrated by the dashed lines in FIGS. 2 and 3 and indicated with the arrows marked with the letter E. The resultant field is substantially uniform throughout a large area disposed centrally of the cooking cavity and uniformly decreases to zero at the outer edges of the bottom wall 13.

As has been pointed out above, the X and Y dimensions of the cooking cavity are preferably not equal to one wavelength of the microwave energy from the source 90, and in the preferred embodiment of the invention are actually slightly less than one wavelength of the microwave energy source 90, whereby the antenna members 31 and 41 have a physical length which is slightly less than a wavelength of the source 90; and likewise, the connecting members 51 and 61 and the feed member 71 have physical lengths that are slightly less than one-half the wavelength of the source 90. The various dipole elements of the antenna 30 are, however, reactively loaded, and more particularly capacitively loaded by the ceramic insulators 52, 53, 62, and 63 which have the effect of electrically increasing the apparent length of the various antenna members so that the various antenna dipole sections are resonant at the frequency of the microwave source 90 although physically contained within the wall structure 11 which has dimensions X and Y less than the wavelength of the microwave energy from the source 90.

In accordance with one preferred operative example of the improved microwave heating oven 10 of the present invention, the microwave energy source 90 operates at the governmentally assigned frequency of 915 mc., corresponding to a wavelength of approximately 12.9 inches. The X dimension of the cooking cavity is equal to the Y dimension and is 12 inches. The Z dimension of the cooking cavity is exactly one-half of the X dimension, namely, 6 inches. Such an orthohexahedron cooking cavity having the dimensions $X=12$ inches, $Y=12$ inches, and $Z=6$ inches has a plurality of resonant wavelengths as calculated by Equation 1 above, the three longest resonant wavelengths being 17.15", 11.12" and 10.6". Each of these three resonant mode wavelengths are removed from the generator wavelength of 12.9"

more than 5%, whereby the cooking cavity having the dimensions stated will be non-resonant, i.e., will be free of resonant modes at the operating wavelength of 12.9".

The antenna members 31 and 41 each have a length of 12 inches, i.e., a length slightly less than one wavelength of the source 90, a width of 1 inch, and a thickness of 0.045 inch; the connecting members 51 and 61 and the feed member 71 have lengths of 6½ inches, widths of 1 inch and thicknesses of 0.045 inch. However, the capacitive loading of the antenna 30 by means of the four ceramic insulators 52, 53, 62 and 63 provides an apparent electrical length for the various dipole antenna elements so that the dipole elements are resonant at the wavelength of the microwave energy from the source 90. Furthermore, the distance D in FIG. 5 is about 1.0 inch to obtain the maximum gain from the antenna 30, and the distance H in FIG. 3 is slightly less than 5.0 inches and is, accordingly, slightly greater than one-quarter wavelength of the microwave energy from the source 90.

Consequently, the antenna 30 will be resonant at the wavelength of the microwave energy from the source 90 and will provide a uniform symmetrical pattern with the radiation from each dipole element in proper phase relationship to provide a uniform heating field in the center of the cooking cavity, the uniform field extending throughout the greater portion of the volume of the wall structure 11. The resonant antenna 30 moreover, will feed energy to the non-resonant cooking cavity so that the microwave heating oven 10 can accept a wide variety of dielectric materials for heating therein with a minimum of distortion of the electric field and a minimum of decoupling effects. As a result, a large amount of energy is quickly and uniformly transferred from the source 90 to dielectric materials placed in the oven cavity so that, for example, pre-cooked frozen dinners can be heated in six minutes and refrigerated dinners can be heated in four minutes.

It will be understood from the above operative example that the microwave heating oven is compact in size, can be readily operated from the standard household electric power supply, and heats evenly and consequently with low operating cost a wide variety of dielectric materials.

In view of the foregoing, it is apparent that there has been provided an improved microwave heating oven which comprises a non-resonant cooking cavity, and also there has been provided in the non-resonant cooking cavity an antenna that is resonant at the wavelength of the microwave energy from the connected source.

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. A microwave heating oven comprising conductive wall structure defining an oven cavity and having a doorway therein communicating with said oven cavity and provided with a door movable between open and closed positions with respect to said doorway, an antenna arranged within said oven cavity, and a source of microwave energy adapted to operate at a predetermined wavelength and operatively coupled to said antenna, the dimensions of said oven cavity being related to said predetermined wavelength of the microwave energy of said source so that said oven cavity is free of resonant modes at said predetermined wavelength and so that the wavelengths of the resonant modes of said oven cavity are displaced by at least about 5% from said predetermined wavelength.

2. A microwave heating oven comprising conductive wall structure defining an oven cavity and having a doorway therein communicating with said oven cavity and

provided with a door movable between open and closed positions with respect to said doorway, an antenna arranged within said oven cavity, and a source of microwave energy operatively coupled to said antenna, said oven cavity having substantially the configuration of a simple tetragonal, wherein the X dimension is substantially equal to the Y dimension and wherein the Z dimension is not greater than $\frac{1}{2}$ the X dimension, wherein the X dimension is of the same order of magnitude as the wavelength of the microwave energy of said source, and wherein said dimensions have values such that said oven cavity is non-resonant at the wavelength of the microwave energy of said source.

3. A microwave heating oven comprising substantially box-like conductive wall structure including top and bottom walls and a pair of side walls and front and rear walls, said wall structure defining an oven cavity therein, one of said walls having a doorway therein communicating with said oven cavity and provided with a door movable between open and closed positions with respect to said doorway, an antenna arranged within said oven cavity adjacent to and below said top wall, said antenna cooperating with said adjacent top wall to provide a radiating device of the plane reflector array type, and a source of microwave energy operatively coupled to said antenna, the dimensions of said oven cavity being related to the wavelength of the microwave energy of said source so that said oven cavity is non-resonant at the wavelength thereof.

4. The microwave heating oven set forth in claim 3, wherein said antenna is spaced from said top wall a distance equal to from about 5% to about 15% of the wavelength of the microwave energy of said source.

5. The microwave heating oven set forth in claim 3, wherein said antenna is spaced from said bottom wall a distance at least equal to 25% of the wavelength of the microwave energy of said source.

6. A microwave heating oven comprising substantially box-like conductive wall structure including top and bottom walls and a pair of side walls and front and rear walls, said wall structure defining an oven cavity therein, one of said walls having a doorway therein communicating with said oven cavity and provided with a door movable between open and closed positions with respect to said doorway, an antenna arranged within said oven cavity adjacent to and below said top wall, said antenna cooperating with said adjacent top wall to provide a radiating device of the plane reflector array type, and a source of microwave energy operatively coupled to said antenna, said oven cavity having substantially the configuration of an orthohexahedron, wherein the X dimension is of the same order of magnitude as the wavelength of the microwave energy of said source and is substantially equal to the Y dimension and wherein the Z dimension is not greater than $\frac{1}{2}$ the X dimension, and wherein said dimensions have values such that said oven cavity is non-resonant at the wavelength of the microwave energy of said source.

7. A microwave heating oven comprising substantially box-like conductive wall structure including top and bottom walls and a pair of side walls and front and rear walls, said wall structure defining an oven cavity therein, one of said walls having a doorway therein communicating with said oven cavity and provided with a door movable between open and closed positions with respect to said doorway, an antenna arranged within said oven cavity and disposed substantially in a plane positioned adjacent to and below and substantially parallel with said top wall, said antenna including two substantially symmetrical arm structures and an electrical input terminal therebetween, whereby said antenna constitutes a dipole antenna and cooperates with said adjacent top wall to provide a radiating device of the plane reflector array type, and a source of microwave energy operatively coupled to said electrical input terminal, the dimensions

of said oven cavity being related to the wavelength of the microwave energy of said source so that said oven cavity is non-resonant.

8. The microwave heating oven set forth in claim 7, wherein said electrical input terminal is disposed below the central portion of said top wall, one of said arm structures is of branched configuration and is positioned below one side of said top wall, and the other of said arm structures is of branched configuration and is positioned below the other side of said top wall.

9. The microwave heating oven set forth in claim 7, wherein each of said arm structures includes an antenna section having a length equivalent to one-half of the wavelength of the microwave energy of said source and is disposed from said electrical input terminal a distance equivalent to one-quarter wavelength of the microwave energy of said source.

10. A microwave heating oven comprising substantially box-like conductive wall structure including top and bottom walls and a pair of side walls and front and rear walls, said wall structure defining an oven cavity therein, said front wall having a doorway therein communicating with said oven cavity and provided with a door movable between open and closed positions with respect to said doorway, a source of microwave energy, the dimensions of said oven cavity being related to the wavelength of the microwave energy of said source so that said oven cavity is non-resonant, an antenna arranged within said oven cavity and disposed substantially in a plane positioned adjacent to and below and substantially parallel with said top wall, said antenna including two substantially symmetrical antenna members extending generally parallel to said front and rear walls and having a length equivalent to the wavelength of the microwave energy of said source, and an electrical input terminal operatively coupled to said source of microwave energy and disposed below the central portion of said top wall between said antenna members and operatively coupled thereto.

11. The microwave heating oven set forth in claim 10, wherein said antenna further includes two substantially symmetrical arm structures disposed between said electrical input terminal and said antenna members.

12. A microwave heating oven comprising substantially box-like conductive wall structure including top and bottom walls and a pair of side walls and front and rear walls, said wall structure defining an oven cavity therein, said front wall having a doorway therein communicating with said oven cavity and provided with a door movable between open and closed positions with respect to said doorway, a source of microwave energy, the dimensions of said oven cavity being related to the wavelength of the microwave energy of said source so that said oven cavity is non-resonant, an antenna arranged within said oven cavity and disposed substantially in a plane positioned adjacent to and below and substantially parallel with said top wall, said antenna including two substantially symmetrical antenna members extending between said side walls and having lengths equivalent to the wavelength of the microwave energy of said source and spaced apart a distance equivalent to one-half the wavelength of the microwave energy of said source, connecting members connecting adjacent portions of said antenna members at points spaced a distance equivalent to one-quarter wavelength of the microwave energy of said source from the adjacent side wall, and an electrical input member interconnecting the midpoints of said connecting members and operatively coupled to said source of microwave energy.

13. The microwave heating oven set forth in claim 12, wherein the distance between said side walls and the distance between said front and rear walls are slightly less than the wavelength of the microwave energy of said source, and means is provided capacitively loading said antenna members to impart thereto an electrical length

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greater than the mechanical length thereof so that the electrical length thereof is equivalent to the wavelength of the microwave energy of said source.

14. A microwave heating oven comprising conductive wall structure defining an oven cavity and having a doorway therein communicating with said oven cavity and provided with a door movable between open and closed positions with respect to said doorway, a source of microwave energy adapted to operate at a predetermined wavelength, an antenna arranged within said oven cavity and operatively coupled to said source and resonant at said predetermined wavelength, said antenna including two substantially symmetrical arm structures disposed substantially symmetrically with respect to the side walls of said oven cavity, whereby said antenna constitutes a dipole antenna, the dimensions of said oven cavity being related to said predetermined wavelength of the microwave energy of said source so that said oven cavity is free of resonant modes at said predetermined wavelength.

15. A microwave heating oven comprising substantially box-like conductive wall structure including top and bottom walls and a pair of side walls and front and rear walls, said wall structure defining an oven cavity therein, said front wall having a doorway therein connecting with said oven cavity and provided with a door movable between open and closed positions with respect to said doorway, a source of microwave energy having a predetermined operating wavelength, an antenna arranged within said oven cavity and disposed substantially in a

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plane position adjacent to and below and substantially parallel with said top wall and operatively coupled to said source, said antenna including two substantially symmetrical antenna members extending between said side walls, the distance between said side walls and the length of said antenna members being of the same order of magnitude as the wavelength of said source but differing in mechanical length therefrom, the dimensions of said oven cavity being related to said predetermined wavelength so that said oven cavity is free of resonant modes at said predetermined wavelength, and means reactively loading said antenna members to impart thereto an electrical length equal to the wavelength of said source to cause said antenna to be resonant at said predetermined wavelength.

16. The microwave heating oven set forth in claim 15, wherein the distance between said side walls is slightly less than the wavelength of the microwave energy of said source, and said reactive loading means capacitively loads said antenna members to impart thereto an electrical length greater than the mechanical length thereof so that the electrical length thereof is equivalent to the wavelength of the microwave energy of said source.

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