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Levinson

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[54] **METHODS OF HEATING AN ARTICLE IN A MICROWAVE OVEN**

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Related U.S. Application Data

[60] Division of Ser. No. 704,389, Feb. 9, 1968, Pat. No. 3,701,872, which is a continuation-in-part of Ser. No. 470,809, July 9, 1965, abandoned, and a continuation-in-part of Ser. No. 483,144, Aug. 27, 1965, abandoned.

[52] **U.S. Cl.** **219/10.55**

[51] **Int. Cl.** **H05b 9/06**

[58] **Field of Search** 219/10.41, 10.51, 219/10.55, 10.65

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[57] **ABSTRACT**

Methods of heating an article using microwave absorptive material, microwave absorptive combustible material, microwave nonabsorptive material, heat insulating material and/or heat conducting material are described.

A process and an implement for converting microwave energy into heat energy which includes a body having a plurality of resistive particles therein. Upon subjecting the particles to microwave irradiation, a plurality of electric arcs are generated throughout the particles, thereby resulting in the microwave energy being converted into heat energy, and the electric arcs serving as a load for the microwave irradiation source. The implement is particularly useful with microwave ovens.

13 Claims, 8 Drawing Figures

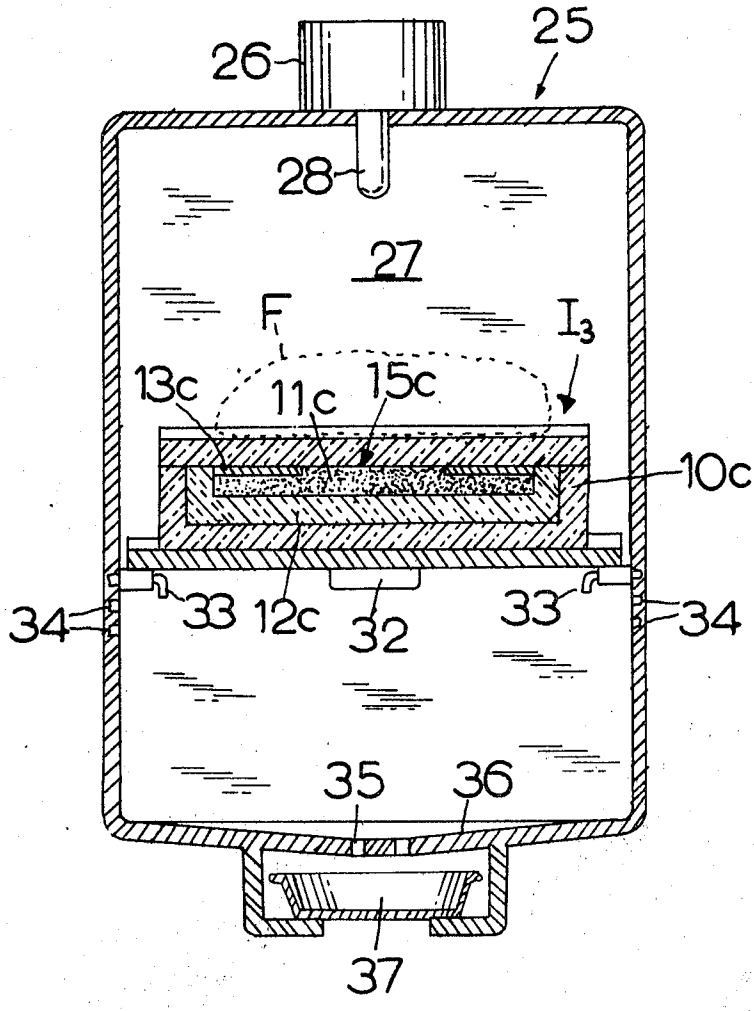


FIG. 1.

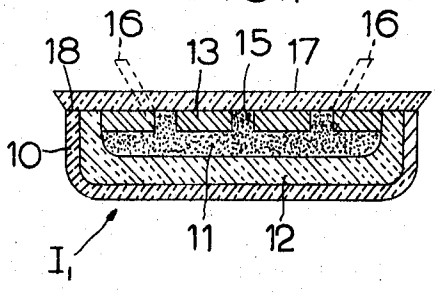


FIG. 2.

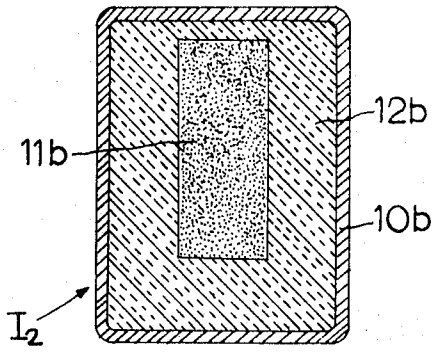


FIG. 3.

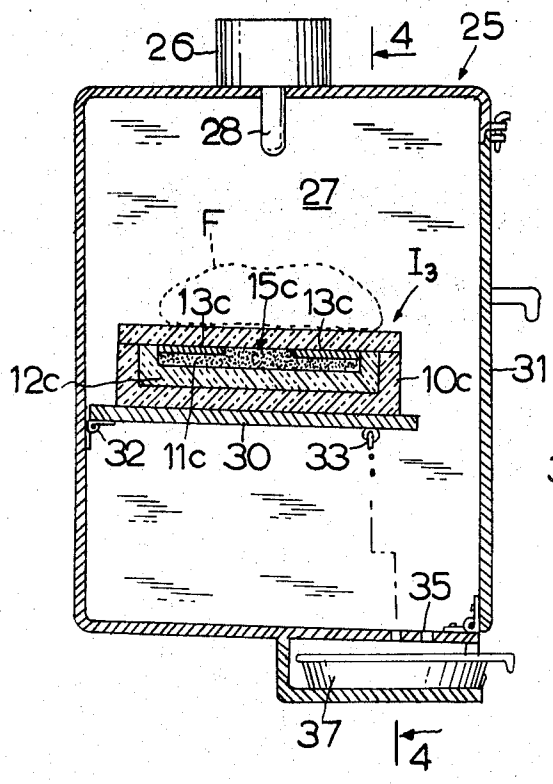


FIG. 4.

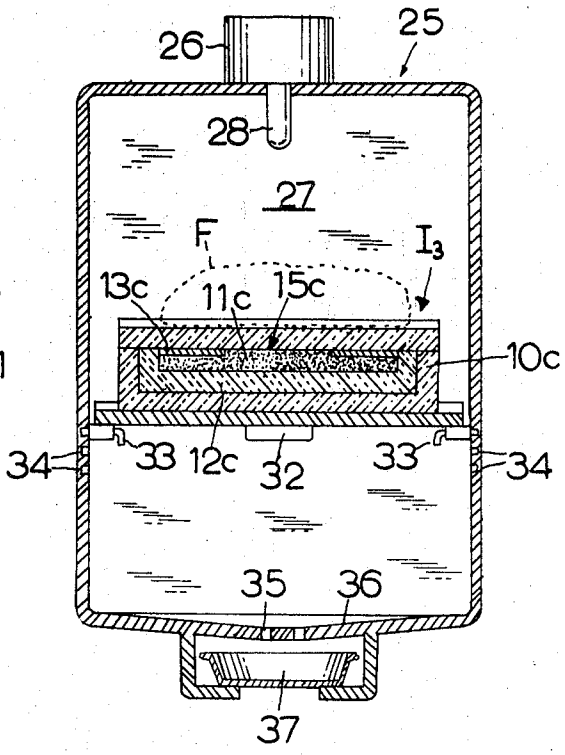


FIG.5.

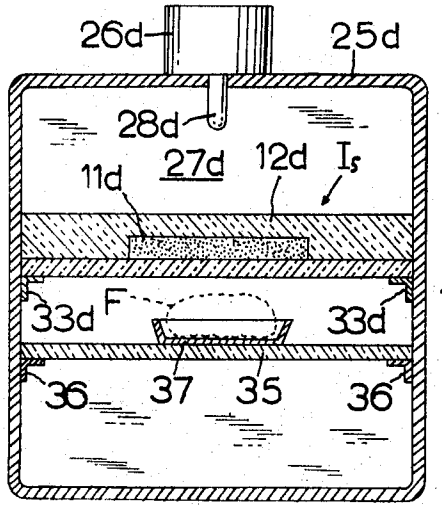


FIG.6.

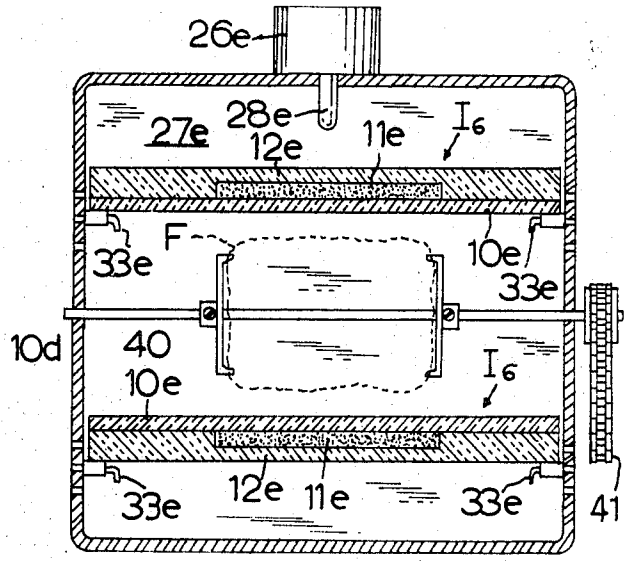


FIG.7.

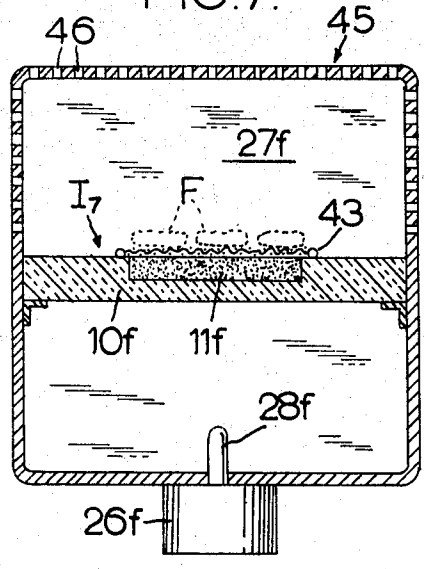
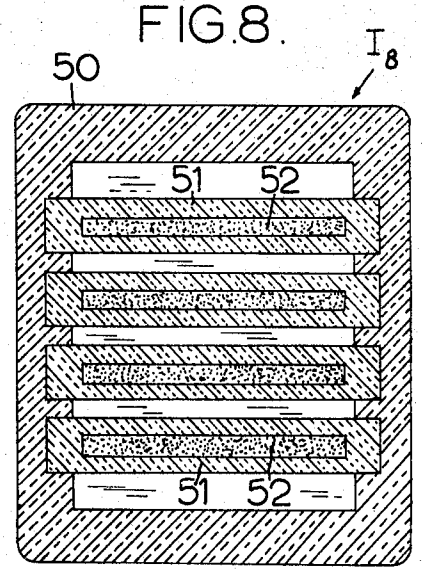


FIG.8.



METHODS OF HEATING AN ARTICLE IN A MICROWAVE OVEN

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a division of application Ser. No. 704,389 filed Feb. 9, 1968, now Pat. No. 3,701,872 which in turn is a continuation-in-part of Ser. No. 470,809, filed July 9, 1965 now abandoned and a continuation-in-part of Ser. No. 483,144 filed Aug. 27, 1965, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to an implement which in response to microwave irradiation is capable of processing and/or cooking a load. More particularly, this invention relates to an implement capable of converting microwave energy into heat energy which may thence be directed to an object to be processed.

Microwave ovens are extremely useful as cooking ovens; however, with conventional type microwave ovens, the searing, browning and crusting of foods constitutes a problem and requires either additional gas or electric heating elements in the microwave oven or the use of an externally located heating apparatus not related to the microwave oven. It is apparent that the heretofore methods employed for searing, browning and crusting are cumbersome, costly, time-consuming and generally unappealing to the users thereof.

Accordingly, one of the objects of this invention is a process for converting microwave energy into heat energy.

Another object of this invention is to provide an implement directly associated with microwave ovens so as to lend versatility to the cooking of foodstuffs. Advantageously, foodstuffs can be fried, roasted, grilled and baked with the desired crusting surface thereon.

Another object of this invention is to provide a microwave oven capable of cooking a foodstuff with a desired crusting surface thereon.

Still another object of this invention is to provide an implement for a microwave oven which, per se, is capable of acting as a dummy load for a microwave emitting source.

SUMMARY OF THE INVENTION

According to the objects of this invention, an implement, preferably taking the form of a cooling utensil or mocrowave oven shelf, is provided with a plurality of relatively small particles of resistive material therein. In response to receipt of microwave irradiation from a microwave source, a multitude of electric arcs are generated throughout the particles, thus resulting in the emitted microwave energy being converted into heat, and the electric arcs serving as a load for the microwave source.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and a fuller understanding of the invention may be had by referring to the drawings wherein:

FIG. 1 is a cross-sectional view of the implement taking the form of a cooking utensil;

FIG. 2 is a cross-sectional view of another embodiment of the implement taking the form of a "hot cube";

FIG. 3 is a cross-sectional side view of a microwave oven having incorporated therein another embodiment of the implement in the form of a shelf;

FIG. 4 is a view taken along line 4 — 4 of FIG. 3;

FIG. 5 is a cross-sectional side view of a microwave oven having incorporated therein another embodiment of the implement in the form of a shelf;

FIG. 6 is a cross-sectional front view of a microwave oven having incorporated therein another embodiment of the implement in the form of two shelves;

FIG. 7 is a cross-sectional side view of a microwave oven having incorporated therein another embodiment of the implement in the form of an electrical charcoal grill; and

FIG. 8 is a partial cross-sectional, plan view of another embodiment of the implement in the form of a grill-shelf.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the drawings, it will be apparent that the inventive implement may be constructed and utilized in various embodiments. According to one embodiment, as seen in FIG. 1, an implement I_1 is in the form of a cooking utensil and includes a body **10** which is permeable to microwave irradiation and preferable made of glass-ceramic type material, such as Pyroceram (manufactured by Corning Glass Works) or Cer-Vit (manufactured by Owens-Illinois). Located within body **10** is a bed or layer of particles **11** of a resistive material supported on an insulating medium **12** which may be of a material such as GR25 (manufactured by General Refractories Company). A good heat conducting element **13**, in the form of a plate, copper strips, rods, etc., is preferably located in contact with the particle bed **11**. The heat conducting element **13**, as illustrated in FIG. 1, preferably is a flat copper plate provided with openings **15-15** therethrough to permit the free random passage of microwave waves to and through the particles. In the event it is desired to utilize implement I_1 as a dummy load, per se, for a microwave emitting source, the heat conducting element **13** may be provided with a plurality of fins **16-16**, as seen in phantom, which extend from the implement structure to cause a free release of heat therefrom. A top processing surface **17**, made of a material similar to body **10**, is in contact with heat conducting element **13**, and is attached to the body at **18** by a suitable adhesive.

It has been found that the resistive particles **11** are, in actuality, a plurality of electrodes which support a plurality of spark gaps to discharge microwave energy therebetween. There are innumerable solid metals which will support an electric gap or arc. For example, the particles may be of a ferrite material having a high resistance to produce a relatively cool spark, when it is desired to use the implement as a household cooking utensil. On the other hand, a carbon material which possesses low resistance and produces a relatively hot spark may be utilized, when the implement is desired to be used in a refractory process for vapourizing metals. With the latter, ultra high heat temperatures may be obtained when considering carbon's melting point (approximately 6,500°F).

With respect to the heat insulation **12**, it is of a material, such as described above, which is permeable to microwave energy and not lossy or self-heating when exposed to microwave energy. The heat insulation has a dual purpose; firstly, to direct the heat to the workload and, secondly, when the implement is used as a cooking utensil, to protect the cook and confine the heat gener-

ated by the arcing from a table subsequently receiving the implement.

Regarding the body or casing **10**, it should be of a material, such as stated above, which is permeable to microwaves and not lossy or self-heating when exposed to microwave energy. The body is used to protectively contain the fragile heat insulating material and the loose plie or layer of resistive particles. Generally, the body or casing is constructed by sealing two portions together, one portion holding the particles and the other enclosing the particles and serving as a cooking surface.

With respect to heat conducting element **13**, it is of a material, such as stated above, which is capable of equalizing the heat generated. The heat conducting material may be of the same material as the resistive particles or of a material complementary thereto, such as copper having a low resistance and ferrite having a high resistance. It is apparent, however, that materials having a low melting point, such as aluminum, may not be used with materials having a high melting point, such as carbon, when temperatures in excess of the low melting point material are required.

In operation, the implement is located in a suitable microwave cavity (not shown) and exposed to microwave irradiation, the microwaves contacting the particles **11**. In response thereto, a plurality of electric arcs are generated throughout and between the particles **11** and the heat conducting element **13**. Within a relatively short time, the particle bed appears as a glowing bed of coal emitting a high degree of heat in excess of 1,000°F. The amount of heat generated is dependent upon the amount and size of the resistive particles, the quantity of the released microwave energy and the time. The microwave arcing tends to terminate the released microwave power and, as a result, precludes a sufficient degree of reflection of microwave power back to the source, thereby preventing any damage thereto. It is apparent that the higher the output power of the microwave generator, the more resistive particles required to properly terminate it.

FIG. **2** is illustrative of another embodiment of the implement, referred to as I_2, which takes the form of a "hot cube". Implement I_2 includes an outer coating **10***b* of a suitable microwave permeable material, such as glass-ceramic, epoxy and, in this instance, preferably cardboard. A simple heat insulating material **12***b*, such as sand concrete or castable refractory material, is located within the outer coating **10***b* and completely envelops a bed of resistive particles **11***b* of a material such as a relatively inexpensive high-grade iron ore.

After exposure to microwave irradiation, the heat stored within the hot cube releases and can be used advantageously as a warmer for articles or animals. For example, the hot cube may be easily inserted into insulating containers (not shown) whereupon the stored heat releases from the hot cube to heat or cook a foodstuff in proximity thereto. Similarly, the hot cube may serve as a body warmer for people. The duration of the released heat is commensurate with the size and type of insulation coupled with the quantity of microwave irradiation of the particle bed. Significantly, in view of this low cost of fabricating a "hot cube", such may be marketed as a disposable item.

While the implement has heretofore been discussed with respect to its use as a portable type article; namely a cooking utensil, hot cube, body warmer and the like, the implement also may take the form of a shelf or shelves in a imcrowave oven. As seen in FIG. **3** and **4**, there is illustrated a microwave oven **25** which is provided with a conventional microwave source **26**, such as a generator or magnetron, for supplying microwave energy into cavity **27** through waveguide **28**. An implement, generally referred to as I_3, takes the form of a shelf and includes a supporting element **30** for holding a ceramic type body **10***c*. Located within the body **10***c* is an insulating medium **12***c* having positioned thereon a plurality of resitive particles **11***c*. A heat conducting element **13***c*, having an opening **15***c* extending therethrough, is disposed in contact with the particles and the top portion **17***c* of body **10***c*, the top portion **17***c* being capable of receiving a foodstuff "F" thereon through closure **31**.

The supporting element **30** is pivotally adjustable at pivot **32** located near the rearmost portion of the oven and is provided with cooperating adjustable pins **33** near the foremost portion of the oven for insertion into various openings **34-34** for locking the implement-shelf I_3 in a desired angular position. As a result of the angular position of the implement-shelf I_3, any by-products of cooking, such as rendered fat, which results from the operation of the microwaves and implement as previously described, will pass by gravity through opening **35** of a downwardly converging bottom **36** into a portable container **37** for subsequent use or disposal.

As seen in FIG. **5**, there is illustrated another embodiment of the invention wherein the implement, referred to as I_5, takes the form of an upper shelf in an oven **25***d*. The oven is similar to the oven in FIGS. **3** and **4** with the exception that the implement-shelf I_5 is in an inverted position. As seen in FIG. **5**, the implement-shelf I_5 rests on supporting elements **33***d*–**33***d* and includes a bottom ceramic or quartz radiant panel **10***d*. An insulating medium **12***d* is provided on the top side of the shelf and houses a bed of resistive particles **11***d* therein. The insulating medium **12***d* herein takes on the added function of dividing the oven cavity so as to create a hot lower cavity and a relatively cooler upper cavity. A conventional bottom shelf **35**, premeable to microwave energy, is provided on supporting elements **36-36** for holding a utensil **37** with a foodstuff, f, thereon.

The operation is similar to that previously described with respect to the oven in FIGS. **3** and **4**. Typically, the microwave generator is turned on and the implement shelf I_5 is preheated until the radiant panel **10**d becomes hot, whereupon a foodstuff is placed under the radiant shelf. The foodstuff is cooked from both the microwave irradiation and the infra red radiation. Additionally, if an extra heavy, relatively darker crust is desired on the foodstuff, e.g. one which is cooked rare, the implement-shelf I_5 may be modified by conventional means to be movable, thus enabling the implement-shelf to be positioned into intimate contact with the foodstuff for a suitable period of time.

FIG. **6** discloses still another embodiment of the invention wherein the implement, referred to as I_6-I_6, takes the form of a pair of implement-shelves which may either be fixed or mobable with respect to each other. As seen therein, lower implement-shelf I_6 rests on adjustable supporting elements **33***e* and is provided with a bottom portion **12***e*, a bed of particles **11***e* and a top insulating portion **10***e* which cooperates with the bottom portion to encase the particle bed. Similarly, upper implement-shelf I_6 rests on adjustable supporting

elements 33*e* and is provided with a top portion 10*e*, a bed of resistive particles 11*e*, and a bottom insulating portion 12*e* which encases the particle bed in cooperation with the top portion. Optionally, a rotating spit 40 driven by a chain 41 connected to a motor (not shown) may be employed.

The implement shelves I_6-I_8 may be moved as desired, i.e., towards each other, either separately or together or into contacting or nearly contacting relationships with the foodstuff F to obtain additional crusting on opposite sides thereof, in a similar manner as discussed with respect to FIG. 5. It should be noted that while manual means are illustated to show relative movement of the shelves, suitable conventional mechanical or electromechanical means may be employed without departing from the invention.

FIG. 7 discloses still another embodiment of the invention and in its simplest structure, wherein the implement, referred to as I_7, takes the form of a microwave charcoal grill. Implement I_7 is comprised of a body 10f having a plurality of resistive particles 11f therein. Typically, a ceramic or metallic grill 43, illustrated with a foodstuff F thereon, may either be placed on or above the particle bed 11f.

A microwave irradiation source 26*f* is located in the bottom portion of the oven 25*f* and, when energized, emits waves through waveguide 27*f*. The top portion of the oven is provided with a grid 45 having relatively small openings 46-46. The openings 46-46 are sufficiently small so as to confine microwave energy therein, yet sufficiently large to permit the passage of air therethrough for disposal of by-products of combustion. Upon energization of the microwave source 26*f*, conversion of the microwave energy into heat energy results in a similar manner as hereinbefore described. It should be noted that if the resistive particles 11*f* are of a material, such as carbon, which will ignite when heated in the presence of air, the burning carbon, buring fat and the microwave energy will swiftly barbeque the foodstuff F.

FIG. 8 discloses still another inventive implement wherein the implement, referred to as I_8, is capable of taking the form of a grill-shelf which may be used as a substitute for implemnt shelf I_3, illustrated in FIG. 3. Here a ceramic frame 50 holds hollow ceramic or quartz tubes 51 filled with a plurality of resistive particles 52.

In operation, grill shelf I_8 is positioned in a microwave oven and preheated whereupon a foodstuff, such as a frozen steak, is placed thereon. With the aid of the energy from the microwave source, the steak is defrosted and cooked with a resultant grill pattern thereon which is similar to that obtained in prior art steak grilling, the gravy juice being collected in container 37. Additionally, the ceramic frame implement I_8 remains cool and can be easily transported with the steak thereon to a receiving table.

It is to be understood that the above described arrangements of the various implements are illustrative of the application of the principal of the invention, each implement employing, at least, a plurality of resistive particles therein capable of receiving and converting microwave energy into heat energy. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention is to be limited only by the spirit and scope of the appended claims.

I claim:

1. A method of heating an article in an oven chamber receptive to microwave energy comprising:
   - locating within said chamber a microwave absorptive member,
   - locating a heat conducting member in (a preselected relationship) contact with said absorptive member and between said microwave absorptive member and said article, and
   - exposing said microwave absorptive member to microwave energy until it absorbs and so converts said microwave energy (into) to heat energy and said heat conducting member conducts said generated heat energy to said article.

2. A method of barbecuing a foodstuff in an oven chamber receptive to microwave energy which comprises:
   - locating a microwave absorptive member within said oven chamber,
   - locating said foodstuff where said microwave absorptive member, when heated, will be in position to heat said foodstuff and where at least a portion of any conbustible heat rendered by-products of said foodstuff will contact said mocrowave absorptive member,
   - exposing said microwave absorptive member to microwave energy until it absorbs and so converts said microwave energy to heat energy to a temperature at least high enough to heat render combustible by-products from said article and high enough to kindle said combustible heat rendered by-products, and
   - additionally heating said foodstuff by the heat of rapid combustion of said kindled combustible heat rendered by-products.

3. A method of heating an article in an oven chamber receptive to microwave energy which comprises:
   - locating a microwave absorptive, combustible material in said oven chamber,
   - exposing said microwave absorptive, combustible material to microwave energy until it absorbs and so converts said microwave energy to heat energy and heats to its ignition temperature and is set on fire, and
   - locating said article in a predetermine position where said article will be heated by the dual heating of both the heat of combustion of said burning microwave absorptive, combustible material and, as it is released from said material, heat converted from said microwave exposure of said microwave absorptive, combustible material by said exposure of said material to microwave energy.

4. In a method, according to claim 3, the added step of:
   - locating a heat conductive member in contact with said article and between said article and said burning microwave absorptive, combustible material whereat to collect and conduct to said article heat energy released by said burning microwave absorptive, combustible material on said exposure to microwave energy.

5. A method of heating an implement and storing said heat within said implement while in an oven chamber receptive to microwave energy for subsequent use of

said heated implement at a location external said oven chamber which comprises:

locating said implement, said implement comprising a microwave absorptive member located within a microwave non-absorptive, heat insulating member, within said oven chamber,

exposing said implement to microwave energy for a predetermined time while said microwave energy absorptive material absorbs and so converts said microwave energy to heat energy, and

transferring said heated implement to a location exterior said oven chamber, and exposing, at said exterior location, an article to said stored heat as it is released from said heated microwave absorptive member by said heat insulating member.

6. A method of heating an article in an oven chamber receptive to microwave energy which includes the steps of:

exposing to microwave energy an implement, where said implement comprises a body which is at least partially microwave permeable and microwave non-absorptive enclosing a pocket of microwave energy absorptive material, within said oven chamber for a predetermined time while said pocket of microwave energy absorptive material absorbs and so converts said microwave energy to heat energy, and subsequently

locating said article to be heated on said heated body thereby heating said article from said heat energy as it is released from said microwave absorptive material.

7. In a method of heating an article, according to claim **6**, the added step of:

exposing said implement with said article thereupon for an additional predetermined time to microwave energy to heat the interior of said article by said direct exposure to microwave energy and heating the surface of said article in contact with said implement by the dual heating of both heat newly converted from said exposure to microwave energy within said article's surface and from heat newly converted and released from said pocket of microwave energy absorptive material.

8. In a method of heating an article, according to claim **6**, the added step of:

locating a microwave non-absorptive heat insulating material in a predetermined position with respect to said pocket of microwave absorptive material to contain, build up and direct said heat energy, which otherwise would not reach said article, onto said article.

9. A method of heating an article in an oven chamber receptive to microwave energy which includes the steps of:

locating a heating implement, within said chamber, said implement comprising:

a microwave-absorptive material,

a microwave-nonabsorptive, heating utensil, located in contact with an obverse surface of said microwave-absorptive material, heated by heat released by said microwave-absorptive material, and

a heat insulator located on the reverse side of said microwave-absorptive material to contain and direct heat released by said microwave-absorptive material which heat would otherwise not reach said heating utensil, onto said heating utensil;

exposing said heating implement to microwave energy for a predetermined time while said microwave-absorptive material absorbs and so converts said microwave energy to heat energy; and subsequently

locating said article on said heating utensil thereby heating said article from said heat energy as it is, in turn, released by said heating utensil.

10. A method of heating an article, according to claim **9**, where said heating utensil is a glass-ceramic cooking utensil and said article is a foodstuff.

11. A method of heating an article in a microwave oven which comprises:

exposing a body which has a plurality of spark gap electrodes therein to microwave energy thereby causing an electric discharge between adjacent electrodes and resulting in said microwave energy converting to heat energy, and

locating said article in predetermined relationship with said discharge path to subject said article to said heat energy and to heat said article thereby.

12. In a method of heating an article, according to claim **11**, where said body comprises heat insulating material which contains and directs heat which otherwise would not reach said article onto said article.

13. In a method of heating an article, according to claim **12**, which further includes:

locating a heat conductive element in contact with said article and between said article and said electric discharge whereupon said heat energy is more equally transferred from around said electric discharge to said article.

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