United States Patent [19]

Derby

[11] **3,845,266**

[45] **Oct. 29, 1974**

[54] **MICROWAVE COOKING UTENSIL**

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[73] Assignee: **Raytheon Company**, Lexington, Mass.

[22] Filed: **July 9, 1973**

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

[56] **References Cited**

UNITED STATES PATENTS

3,271,552	9/1966	Krajewski	219/10.55
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Primary Examiner—J. V. Truhe
Assistant Examiner—Hugh D. Jaeger
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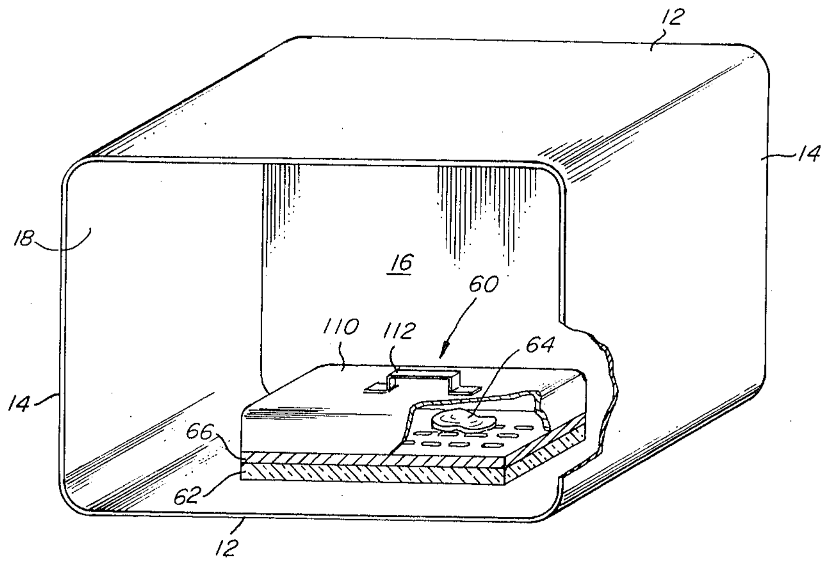
[57] **ABSTRACT**

A utensil is disclosed for microwave cooking including a load supporting means of a nonpermeable nondissipative material having a plurality of frequency responsive impedance matching energy transparent structures to expose a load to varying degrees of heating. Exterior load surfaces are differentially heated to achieve a browned and seared appearance in the areas of intense heating. Numerous configurations include slots, holes and slots, rectangular and diamond shaped openings. A body member having an energy transparent low loss region is provided to space the load from the oven enclosure conductive walls. A conductive cover is included in an alternative embodiment to enhance browning and searing.

14 Claims, 7 Drawing Figures



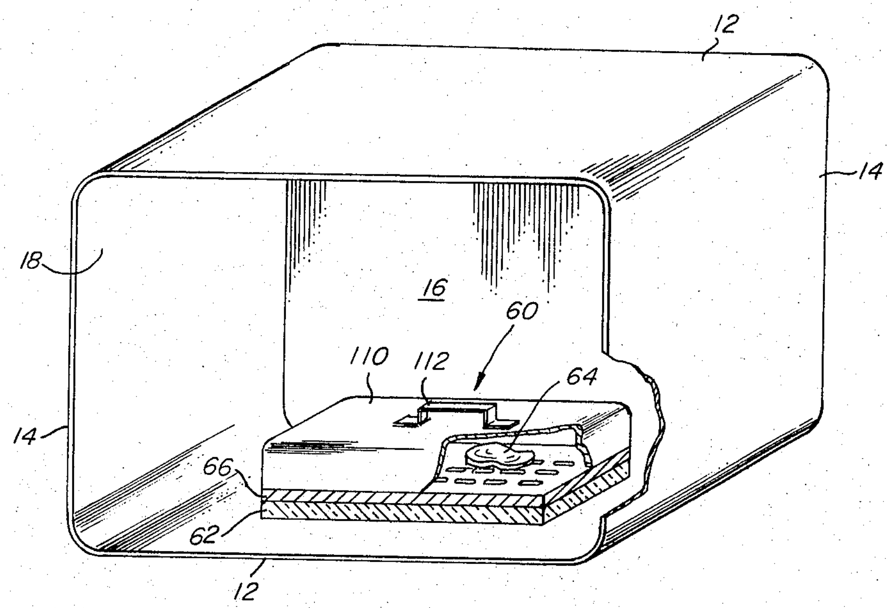

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FIG. 1

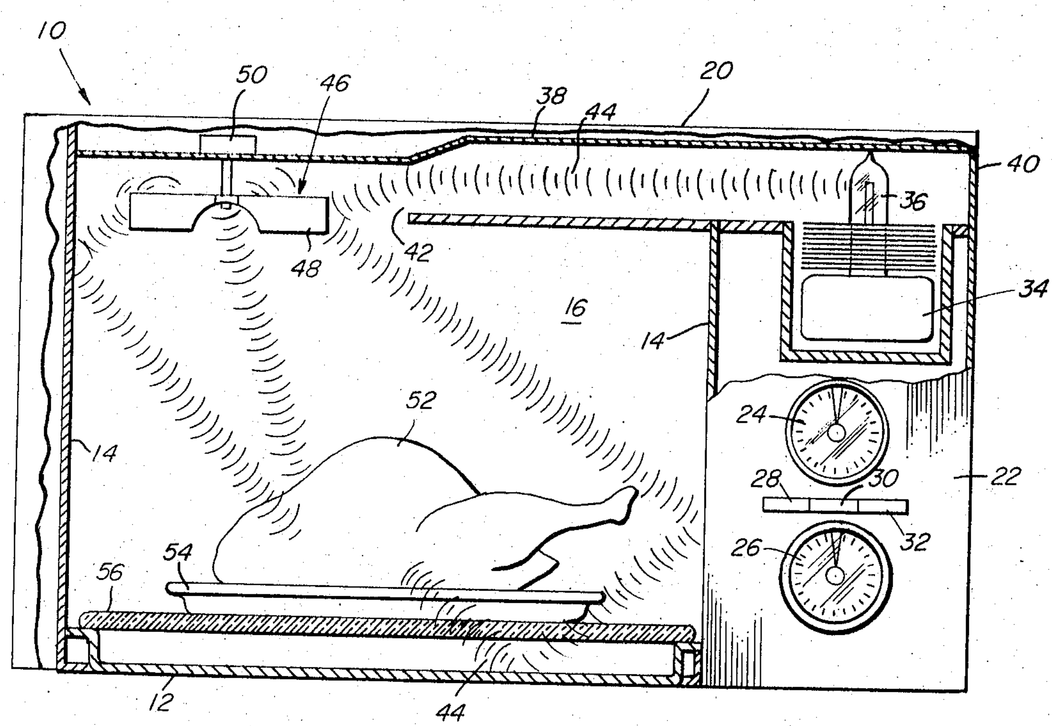
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FIG. 2

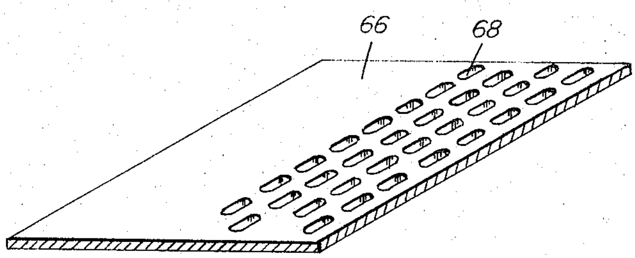

FIG. 3

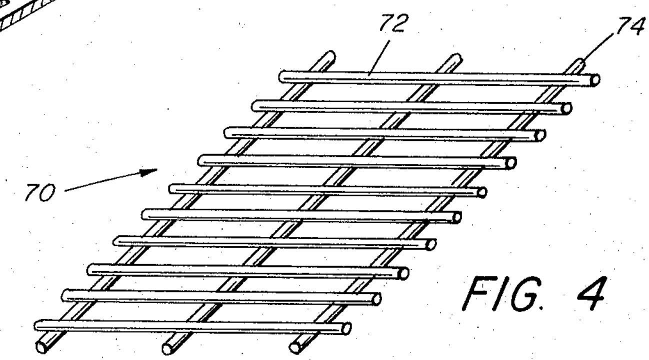

FIG. 4

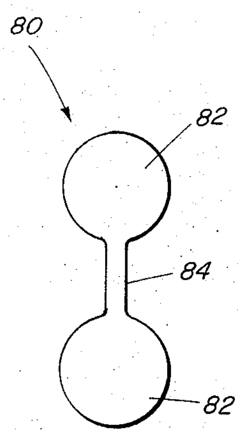

FIG. 5

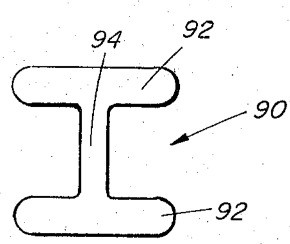

FIG. 6

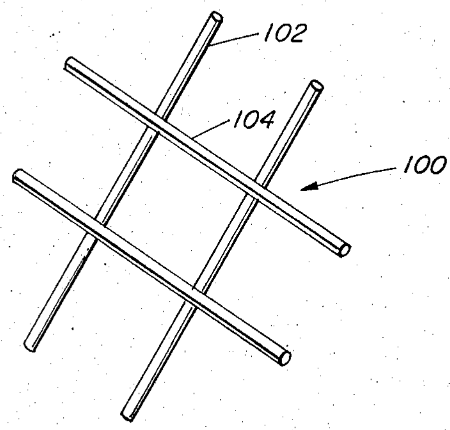

FIG. 7

MICROWAVE COOKING UTENSIL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a utensil for microwave cooking.

2. Description of the Prior Art

The preparation of food by microwave energy has become popular in recent years due to the fast preparation times available to the user. The microwave heating apparatus includes the magnetron which is operated at conventional domestic low frequency line voltages. The energy is fed within a conductive wall oven enclosure through a waveguide transmission line and the energy is distributed in a plurality of energy modes by such means as a mode stirrer. The frequencies of operation are assigned by federal regulatory bodies and, typically are 915 ± 13MHz and 2,450 ± 50MHz. For the purposes of the present description of the invention the term "microwave" is defined as electromagnetic energy radiation having wavelengths in the order of 1 meter to 1 millimeter and frequencies in the order of 300MHz to 300GHz.

The load placed in the oven enclosure becomes heated due to the interaction of the microwave fields within the material. In accordance with the so-called dielectric heating phenomena, the molecules tend to oscillate under the influence of the high frequency electromagnetic energy fields. The friction created by the molecular movement causes the material to be heated. All materials have varying energy propagating characteristics and, therefore, the depth of penetration and surface coloration vary which requires consideration, particularly, in the preparation of the edible product loads. Because of the depth-of-penetration limitations it is sometimes difficult to achieve a seared or browned surface on such materials as steaks, fowl, roasts and the like. Some microwave oven apparatus incorporate an electric or gas broiling element. Certain food additives may be coated on the load prior to cooking of selected materials having higher energy absorbing characteristics which will lead to a more rapid heating of the exterior surfaces while the remainder of the food load achieves the desired tenderness. Another factor to be considered is the selection of a cooking utensil since microwave energy is substantially shielded and reflected by conductive metallic materials and, therefore, microwave energy transparent materials, such as glass or plastic are preferred for microwave cooking.

Exemplary of some of the attempts in the prior art to evolve the browning and searing characteristics will now be enumerated. U.S. Letters Pat. 2,830,162, issued Apr. 8, 1958, to D. A. Copson, et al., and assigned to the assignee of the present invention, utilizes a container constructed of a ferromagnetic-like material with the container absorbing the microwave energy when heated. The material is responsive to the electromagnetic energy impinging thereon up to the Curie temperature point and, thereafter, it becomes substantially nonresponsive and pervious to the energy. The ferromagnetic materials sustain alternating electric and magnetic fields and, characteristically, have high energy loss at temperatures below the Curie point. Examples of such materials from which the food container is fabricated include alloys of manganese, tin, copper or manganese, aluminum and copper, as well as, alloys of

iron and sulphur, such as pyrrhotite. Additionally, ferroelectric materials such as zircomates of lead and barium and titanates of lead, barium and strontium may be utilized. The browning or searing surface conditions desired have been significantly improved by the disclosed utensils which, however, like the addition of the additional broiling elements, can be costly in the implementation.

Another example of prior art utensils is found in U.S. Letters Pat. 3,219,460 issued Nov. 23, 1965, to E. Brown which discloses a container of a dielectric material, such as paper, plastic or Pyrex, having an electrically conductive shielding material such as aluminum wrapped completely around the side and bottom surfaces. In addition, numerous designs include a crisscross, strip or other geometric pattern in aluminum foil covering the dielectric container to prevent the transmission of energy in certain compartments while permitting such energy to be readily introduced in other compartments to thereby provide for selective heating in the shielded and unshielded areas of the specific food products therein contained. Such microwave cooking utensils may also be costly and expensive in reduction to practice.

U.S. Letters Pat. 3,302,632 issued Feb. 7, 1967 to E. C. Fichtner also discloses a plastic-type material containing different foods in different cooking areas with the container having a microwave regulating material embedded in the walls to alter the microwave conductivity and permit microwave transmission in certain wall portions while providing different microwave cooking rates in other areas. In this embodiment certain materials, such as metallic particles, are embedded in selective compartments to alter the microwave transparency characteristics. Both of the embodiments using plastic materials with either an outer conductive coating or embedded metallic particles, lend themselves ideally to the preparation of frozen foods, such as TV dinners with the cost of the disposable container reflected in the relatively high cost of such prepared frozen meals.

Another method and apparatus for use in microwave cooking is disclosed in U.S. Letters Pat. 3,591,751 issued July 6, 1971 to C. E. Goltsos which discloses the use of a plurality of metal rods each having a length that is a multiple of a half wavelength of the microwave energy with the rods supporting, or being disposed, in close proximity to the food load. The requirement for the half wavelength metal rods causes these elements to become highly heated to red heat and to thermally transfer this heat to the supported food load by conduction. This prior art teaching may lead to rather cumbersome structures within the oven enclosure and, due to the high energy absorption by such elements, caution is required in the removal of the utensil to prevent unnecessary burns.

All the foregoing prior art embodiments designed to provide selective heating have been reasonably successful and will be found reduced to practice in numerous embodiments. A need, however, exists for a simple, less costly, microwave cooking utensil which will not be subject to cracking, due to overheating or uncontrolled temperature rise during operation and be relatively simple to use and store similar to conventional cooking utensils utilized with standard electric or gas cooking appliances.

SUMMARY OF THE INVENTION

In accordance with the invention a microwave cooking utensil is disclosed having a member of a microwave permeable material, such as glass or Pyrex or Pyroceram, having a thickness selected to provide for the coupling of energy reflected from the oven enclosure wall into the utensil. The article to be heated is supported on a member having a plurality of spaced energy frequency responsive impedance matching structures to permit coupling of energy into the load. The heating pattern results in browning and searing in the areas of intense energy transmission. The load supporting member comprises a nondissipating nonpermeable material having a perforated pattern or array of slots, holes and slots and the like achieve a desired microwave transparency. A cover of a conductive material may be provided, completely enveloping the load during operation, to further enhance the outer surface coloration. Since the utensil is primarily nonabsorbing and nondissipative very little thermal heating will be achieved. The transfer of energy relies principally on adjustment of the energy coupling characteristics to differentially heat the load to cause elevated temperatures through the microwave transparent structures. The utensil is easily removed, cleaned and stored.

BRIEF DESCRIPTION OF THE DRAWINGS

Details of the illustrative embodiments of the invention will be described with reference to the accompanying drawings, wherein:

FIG. **1** is an isometric view of an oven enclosure with the embodiment of the invention disposed therein;

FIG. **2** is a vertical cross-sectional view of a microwave oven apparatus with the distribution of the microwave energy within the oven enclosure shown diagrammatically;

FIGS. **3–7**, inclusive, represent embodiments of the load supporting member to achieve numerous heating patterns.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A typical microwave oven apparatus **10** is illustrated in FIG. **2.** Top and bottom conductive walls **12,** as well as sidewalls **14** define the oven enclosure **16** having an access opening **18** closed by means of door assembly (not shown) which may be side or bottom-hinged. A casing member **20** provided with a control panel member **22** surrounds the oven enclosure as well as the energy generator, controls and electrical apparatus. The control panel member **22** provides for mounting timers **24** and **26,** as well as start, stop and light buttons **28, 30** and **32.**

Magnetron energy generator **34** is of the well known type, as described in the text "Microwave Magnetrons," Radiation Laboratory Series, Vol. **6,** by G. B. Collins, McGraw-Hill Book Co., Inc., 1948 and U.S. Pat. No. 3,531,613 issued Sept. 29, 1970 to C. P. Domenichini, et al., and assigned to the assignee of the present invention. The generated energy is coupled to the oven enclosure by means of antenna **36** extending into the launching rectangular waveguide section **38.** The waveguide launching section is closed at one end by a terminating wall **40,** spaced a predetermined dimension from the antenna **36,** for optimum launching and direction of the energy. The opposing end of the waveguide launching section is provided with an open end **42.** The launched energy, diagrammatically represented by the waves **44,** is distributed within the enclosure in a multimode heating pattern accomplished by such well-known means as a mode stirrer **46** having a plurality of paddle members **48** actuated by motor **50.** The rotation of the stirrer results in the reflection of the energy waves which bounce off the conductive walls at the ceiling, back side and bottom of the oven enclosure. Load **52** is supported in a microwave energy permeable container **54** such as, a dish of a dielectric material which is in turn supported on a plate **56** of a similar material. The spacing of the glass plate **56** from bottom wall **12** provides for the reflections of the waves **44** from the bottom wall member to enter and be absorbed by the load **52.** The distribution and reflection of the waves **44** provides for substantially uniform energy distribution throughout the load **52** with a minimum of hot spots. The absorption of the microwave energy results in the conversion of a molecular movement within the load into heat for cooking. Substantially uniform cooking is achieved in this manner commencing from the outer surface into the interior of the load. In products where a searing or browning of the outer surfaces is desired such as in roasts, steaks or loads of a relatively large mass, the continued cooking with microwaves to achieve the outer surface coloration may result in the interior being overcooked and the loss of nutrient values. Taste as well as appeal is also improved by proper outer surface preparation.

Referring next to FIGS. **1** and **3** the utensil **60** embodying the invention is shown disposed within the oven enclosure **16** comprising a body member having a microwave permeable material region **62.** The thickness of this region is selected to provide a spacing between an exemplary load **64,** such as, illustratively, a steak, and bottom wall **12** to assure that the bouncing microwave energy waves will be coupled into the utensil. Region **62** is fabricated from any of the dielectric or ceramic materials which are transparent to the microwave energy or the utensil **60** may be provided with legs.

The load **64** is supported on a nonpermeable, nondissipative material surface **66** having a plurality of spaced frequency responsive energy transmission structures, such as perforation **68.** The array of perforations **68** is selected to provide for differential heating by intense transmission rather than absorption and conduction by the microwaves entering through the transparent opening **68** to thereby establish a searing or browning condition by reason of the penetrating concentrated energy. The load support surface **66** may be fabricated of stainless steel which is easy to clean; has a pleasing appearance and relatively long life. The spacings between the perforations **68** are selected to provide for the maximum coupling of the electromagnetic waves radiation within the enclosure into the load without materially heating the intervening portions of plate **68.** The transfer of energy is thereby accomplished not by thermal absorption and conduction by surface **66** but rather an arrangement where the spaces provide for little or no attenuation of the energy. This array is selected based on the anticipated varying dielectric constant load characteristics relative to the impedance characteristics of the waves within the enclosure at the operating frequency.

Referring to FIG. 4 another arrangement of the load supporting surface is shown comprising a grille 70 formed by a grid arrangement of elongated rods 72 and 74 interconnected in a mutually perpendicular manner. This arrangement would provide for intense heating by coupling energy in accordance with teachings in the microwave transmission art, such as delay lines of the ladder-type or meander lines.

In FIG. 5 the so-called dumbbell resonant iris arrangement 80 is shown comprising holes 82 and interconnecting slots 84. This arrangement is similar to that found in the waveguide transmission art to provide combined inductances and capacitances in iris members utilized as impedance matching structures for devices such as those shown and described in the text "Microwave Duplexers" Radiation Laboratory Series, Vol. 14 by L. D. Smullin and C. G. Montgomery, McGraw-Hill Book Co., Inc., New York, 1948, Page 70. Other examples of resonant openings are discussed in this text as well as the H-shaped arrangement 90 shown in FIG. 6 comprising parallel elongated slots 92 interconnected by a mutually perpendicular elongated slot 94. The provision of these resonant structures which are highly pervious to the microwaves assures the provision of the desired heating patterns in accordance with the invention.

In FIG. 7 a portion of a load support surface 100 is illustrated comprising diagonally arranged rods 102 and 104 in a substantially crisscross pattern to provide diamond shaped openings.

Cover 110 of a conductive material shown in FIG. 1 having a handle 112 provides for the further enclosing of the load supported on a surface having an array of microwave energy resonant structures comprising perforations, slots, square, diagonal or circular openings. The coupling of the energy through the body member region 62 or legs and surface 66 openings will be further amplified by this cover to enhance browning and searing. The cover will also prevent splattering on the oven walls.

There is thus disclosed an efficient microwave cooking utensil incorporating a nondissipative, nonpermeable support surface having a plurality of spaced energy transmission structures adapted to provide a selected differential heating pattern with a minimum of attenuation through the structure openings. The utensil is easy to clean, as well as, to store, and provides for substantial searing or browning by the intense penetration of the microwave energy in selected regions of the load. Since numerous modifications, variations and alterations will be evident of those skilled in the art, the foregoing description is intended to be interpreted broadly rather than in a limiting sense.

I claim:

1. In combination:

an enclosure;

means for energizing said enclosure with microwave electromagnetic energy;

energy coupling means for supporting a load within said enclosure;

said load supporting means comprising a means of a nonpermeable, nondissipative material having a plurality of spaced energy transmission structures arranged to provide areas of high energy penetration with substantially no attenuation to cause elevated temperatures to heat the load material exposed to said areas.

2. The combination according to claim 1 wherein said energy transmission structures comprise frequency responsive energy transparent areas arranged in a predetermined array in a major portion of said supporting means.

3. The combination according to claim 1 wherein said structures comprise perforations in said supporting means.

4. The combination according to claim 1 wherein said structures comprises slots in said supporting means.

5. The combination according to claim 1 wherein said structures comprise a circular opening and slot arrangement in said supporting means.

6. The combination according to claim 1 wherein said structures comprise openings having a rectangular configuration in said supporting means.

7. The combination according to claim 1 wherein said structures comprise openings having a diamond shaped configuration in said supporting means.

8. A utensil for cooking with microwave heating apparatus comprising:

a body member having a microwave energy transparent low loss region; and

a load supporting surface of a nontransparent, nondissipative material having a plurality of spaced frequency responsive impedance matching energy transmission structures arranged in an array to provide a transparency to couple said energy in a predetermined heating pattern.

9. A utensil according to claim 8 wherein said supporting surface is of a metallic composition.

10. A utensil according to claim 8 wherein said body member energy transparent region comprises a dielectric material.

11. A utensil according to claim 8 wherein said supporting surface comprises a grille including interconnected elongated metal rods having predetermined spacings for maximum energy transmission at the microwave apparatus operating frequency.

12. A utensil according to claim 8 wherein said supporting surface comprises a slotted metallic plate member with the slot dimensions and spacings being determined to provide maximum energy transmission at the microwave apparatus operating frequency.

13. A utensil according to claim 8 wherein said supporting surface comprises a metallic plate member having a plurality of slots with the dimensions and spacings being determined to provide maximum energy transmission at the microwave apparatus operating frequency.

14. A utensil according to claim 8 and a cover of a metallic material to enclose a load disposed on said supporting surface.

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