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Valles

[11] **3,846,608**

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[54] **HIGH TEMPERATURE RESISTANT DOOR SEAL FOR A MICROWAVE OVEN**

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[73] Assignee: **Litton Systems, Inc.**, San Carlos, Calif.

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[52] **U.S. Cl.** .... **219/10.55**, 49/479, 87/6, 174/35 GC, 219/397, 277/230

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

[58] **Field of Search** .... 174/35 GC, 356 MS; 277/230, 234, 235 R, 235 A; 219/10.55, 396, 397, 413; 29/193; 49/479; 87/6

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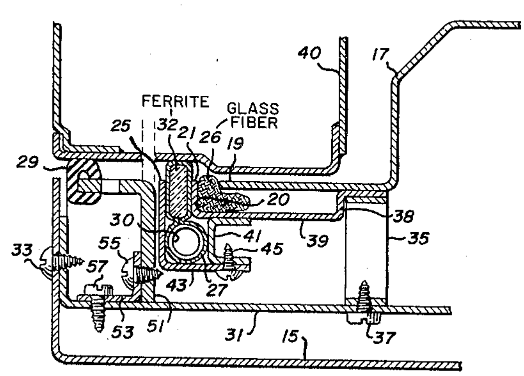
[57] **ABSTRACT**

A microwave energy door seal includes a choke seal and a high temperature resistant dissipative seal, with the dissipative seal being located adjacent the door passage for the choke seal. Further a second dissipative type seal is located on the door spaced from the high temperature resistant dissipative type seal. The high temperature resistant seal comprises a ferrite ensleeved in a glass fiber braid mounted to the door or opposite oven frame with spring means for holding it in place as well as biasing the ensleeved ferrite into abutting contact with an oven member surface.

23 Claims, 8 Drawing Figures



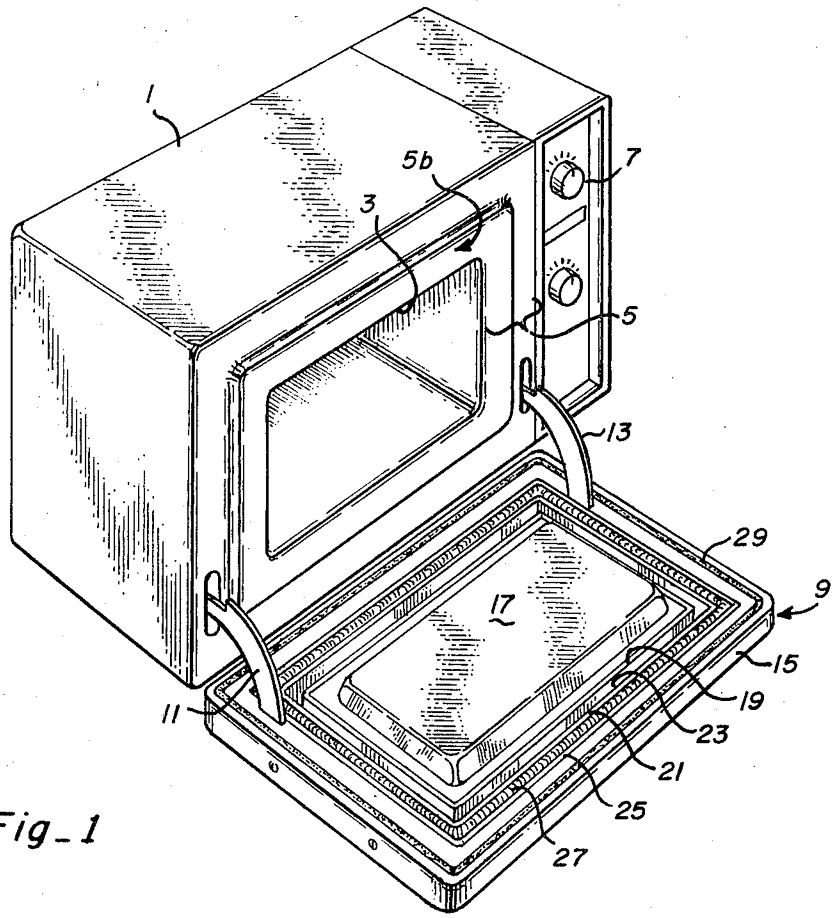

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Fig_1

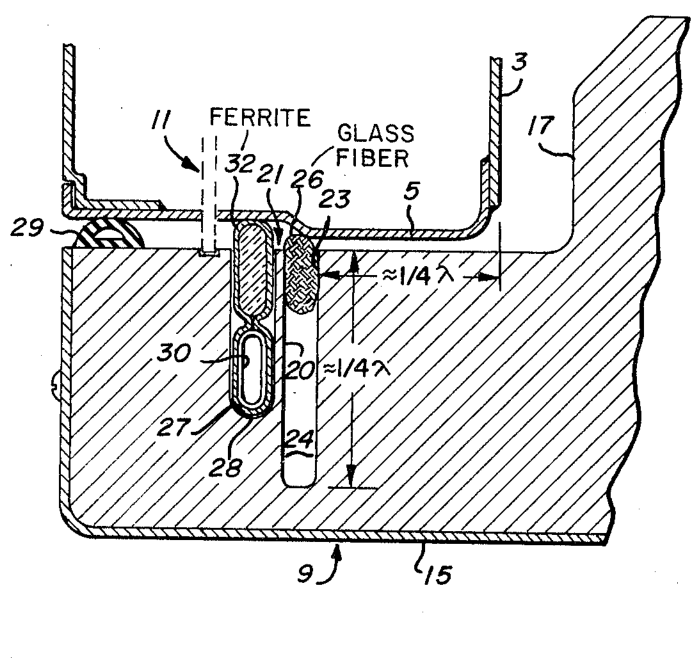
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Fig_2

Fig_3

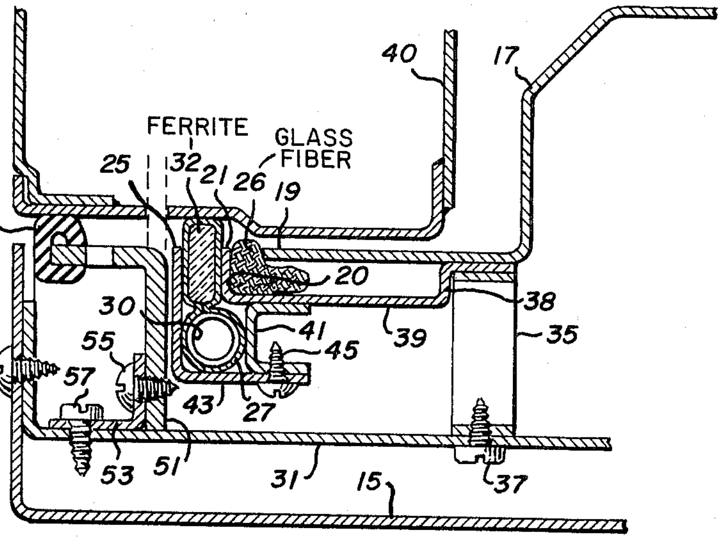


Fig_5

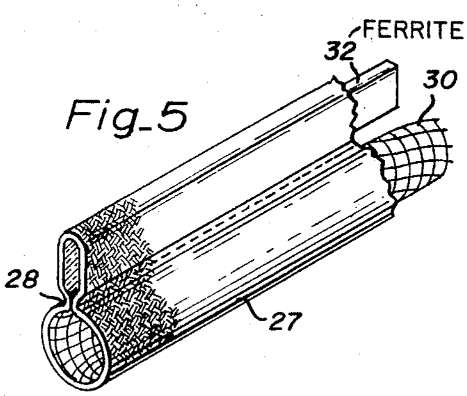


Fig_6A

Fig_6B

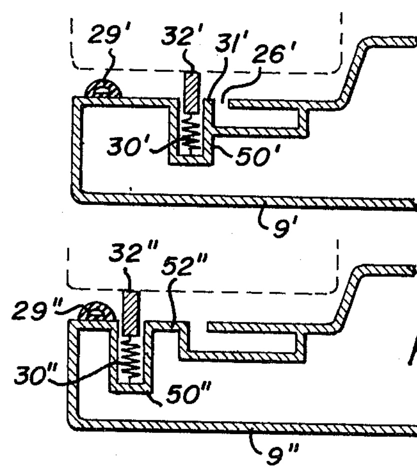
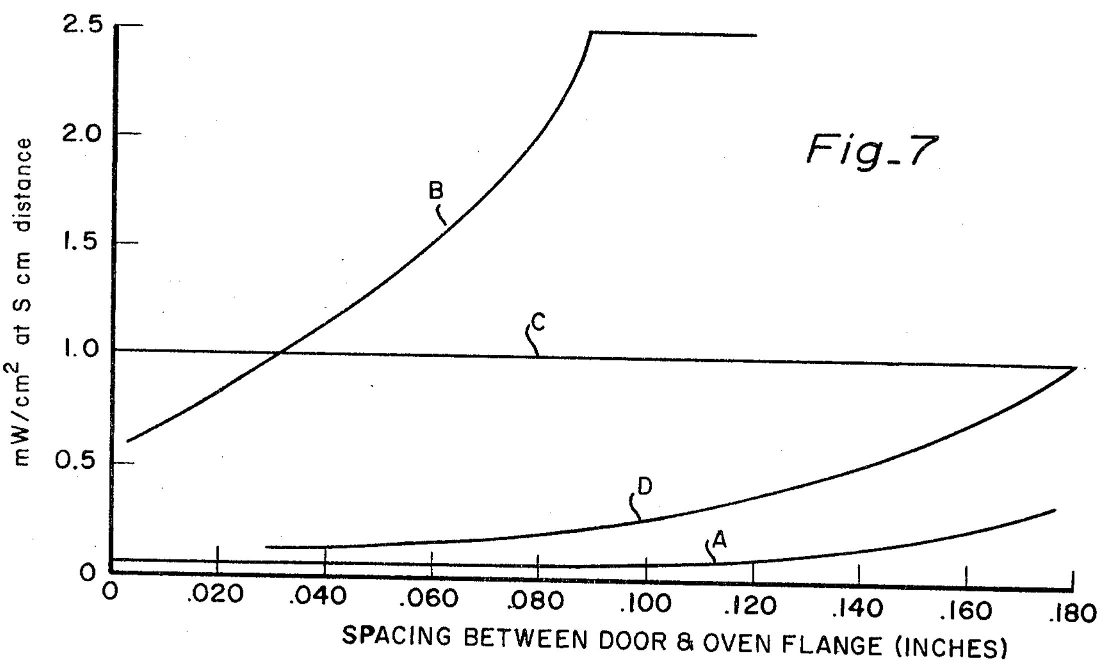


Fig_7



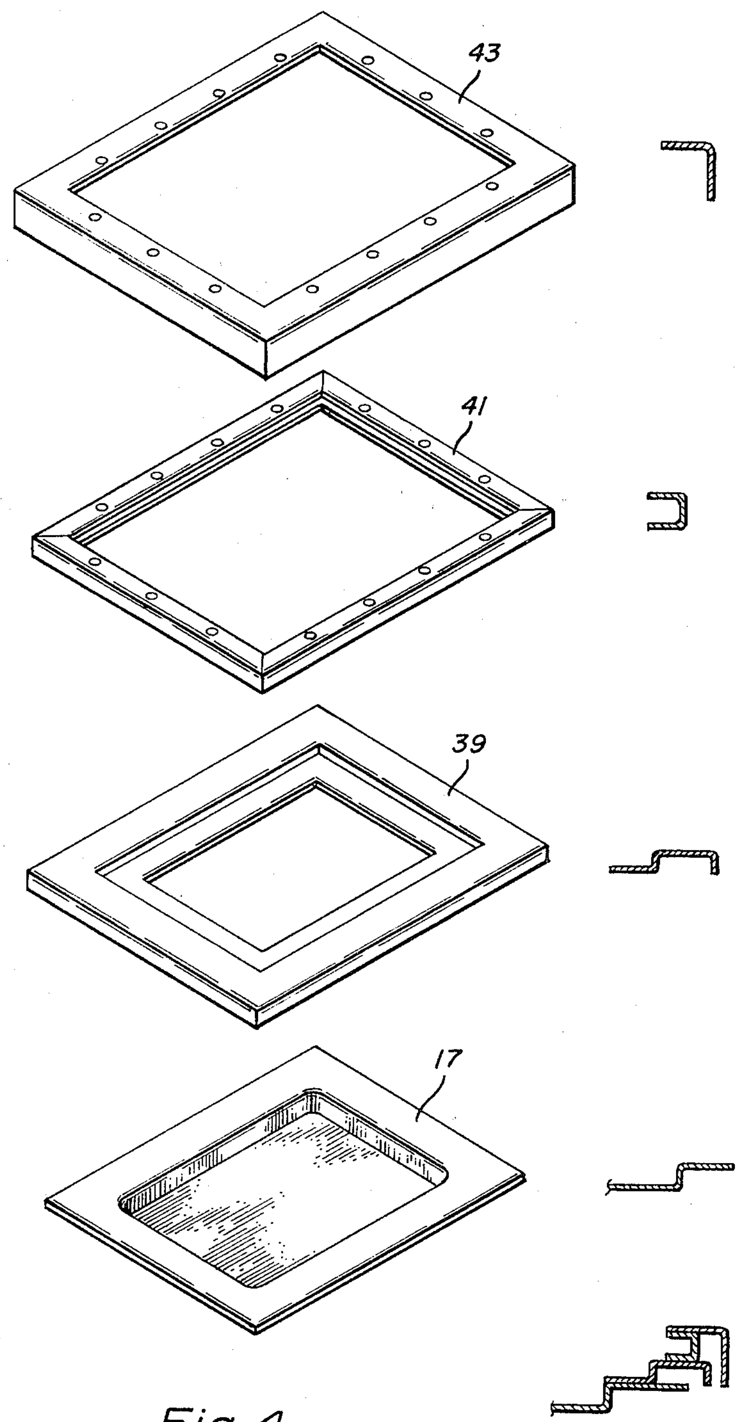


Fig_4

HIGH TEMPERATURE RESISTANT DOOR SEAL FOR A MICROWAVE OVEN

BACKGROUND OF THE INVENTION

Certain enclosures require seals to prevent high frequency radiation, such as microwave frequency energy, from leaking through physical gaps between a movable enclosure door which closes the entrance of the enclosure and the enclosure frame. This requirement for effective microwave energy door seals is most predominant in the microwave oven, a cooking appliance in which foodstuffs are cooked or heated by exposure to microwave energy. Typically the microwave oven includes a metal walled container or enclosure which in turn contains a metal walled cooking chamber, an annular frame portion at the front surrounding the cooking chamber which extends between the chamber and, for example, the outer wall of the enclosure, and a movable door which in its closed position covers the entrance to the cooking chamber as well as a major portion or all of the annulus. For this purpose various types of microwave energy seals have been employed either separately or in combination, in order to meet the rigid requirement that microwave leakage between the door and oven chamber be on the order of **1.0** milliwatt or less, measured at a distance of 5 centimeters from any portion of the oven door, when the oven is in operation. Familiar types of door seals include what is referred to as the "choke seal," contact seal, and dissipative seal. The choke seal is based upon the analogy to a short-circuited microwave transmission line or choke stub, as variously termed, of a length equal to one-half wavelength at the operating frequency. The dissipative seal relies upon the principle of absorbing and dissipating incident microwave energy radiation, and a contact seal relies on the principle of providing a metal barrier, a tight metal-to-metal contact between the door and frame to eliminate any gaps between the movable door and the enclosure through which leakage might occur. Various past door seal designs include combinations of one or more of these individual door seals based on the premises that two seals perform better than a single seal, three seals perform better than two seals, etc., until at some point the additional cost of an additional seal exceeds the expected improvement in decreasing leakage.

As an example, in U.S. Pat. No. 3,196,242 to DeVries, graphite material, a microwave absorptive material, is distributed about the periphery of the oven door as a seal to dissipate microwave frequency leakage. Ironfield, U.S. Pat. No. 3,182,164, shows and teaches various embodiments of a "choke seal," and Schall, U.S. Pat. No. 2,956,143, discloses a metal-to-metal contact seal and a lossy rubber seal. And as is found in Moreno, "Microwave Transmission Design Data," Dover Publications, reprinted 1958, page 169, the combination of a choke seal and a lossy rubber seal spaced therefrom is disclosed as a means of preventing microwave energy leakages between waveguide joints. Although these seals serve their purposes satisfactorily, further developments in cooking appliances dictate that the microwave oven be combined with a conventional electric oven that includes pyrolytic cleaning devices which are found in the conventional types of "self-cleaning" electric ranges. As is known, pyrolytic oven cleaning devices operate on the principle of heating the oven to a very high temperature so as to completely vaporize any grease or other dirt on the oven walls. Obviously vaporization conveniently eliminates the need for manual or chemical removal of greases and stains from the oven chamber walls. The high temperatures at which the pyrolytic cleaning devices operate impose new requirements on door seals: the door seal must prevent leakage of microwave energy and withstand high temperatures. Thus the loss loaded conductive rubber seal if exposed to such high temperatures will decompose. And various other types of lossy materials must be evaluated to determine whether they are physically damaged or whether they may lose their microwave energy absorptive characteristics if heated to those high temperatures.

OBJECTS OF THE INVENTION

Accordingly it is an object of my invention to provide an improved microwave energy door seal for a microwave oven that is not subject to damage through exposure to very high temperatures.

It is another object of my invention to provide an improved microwave oven door seal which is capable of withstanding the high oven temperatures characteristic of pyrolytic cleaning devices.

It is an additional object of my invention to provide a door seal that provides unusually good results in minimal leakage.

And it is a still further object of my invention to provide a construction for a dissipative seal which is simple to construct, assemble, and install.

BRIEF SUMMARY OF THE INVENTION

The microwave oven door seal means of my invention includes a choke seal, characterized by a first conductively bounded chamber having a passage in the door annulus with such passage spaced a predetermined distance from the oven chamber, a dissipative seal characterized by an open chamber adjoining the chamber of the choke seal and bounded by a metal wall common to the first chamber spacing the two chambers by approximately one-one sixtieth wavelength (0.03-inch) and a ferrite element protruding from said opening in said chamber with underlying spring means within said second chamber for urging said ferrite member into abutment with the oven frame.

In accordance with another aspect of my invention the ferrite member and the spring are enclosed in a single glass fiber sleeve and the sleeve is divided into two compartments, suitably by a seam. The glass fiber sleeve is pervious to microwave energy, introduces a gap between the ferrite and the oven frame, and is thermally insulative to serve as a heat block.

The invention is further characterized by a second dissipative seal, characterized by a carbon loaded rubber gasket, which forms a surround on the inner annulus of the door located more proximate the outer periphery of the door than the aforementioned seals.

The foregoing and other objects and advantages of my invention as well as the elements characteristic of my invention, including equivalents and substitutions therefor, are better understood by giving consideration to the detailed description of the various embodiments of the invention, which follows, taken together with the illustrative figures of the drawings.

DESCRIPTION OF DRAWINGS

In the drawings:

FIG. **1** illustrates an external view of the improved door seal of my invention;

FIG. **2** illustrates in partial section one embodiment of my invention;

FIG. **3** illustrates in partial section another embodiment of my invention;

FIG. **4** illustrates an exploded view of some door elements which appear in the section of FIG. **3**;

FIG. **5** illustrates a novel construction of a dissipative type door seal of my invention;

FIGS. **6a** and **6b** provide a symbolic outline representation of two different door seals, one of which represents my invention; and

FIG. **7** is a graph depicting the results obtained in a practical embodiment of my invention represented by FIG. **5** and FIG. **2**.

DETAILED DESCRIPTION

A microwave oven **1** is illustrated in perspective in FIG. **1**. The oven includes a cavity **3**, which is bordered at the front by a frame or annulus **5**, and a control panel **7**, and an oven door **9**, shown ajar.

The inner surface of oven door **9** is visible in FIG. **1** and permits a view of some external portions of the door seals formed within the door proper, which is hereinafter explained and disclosed in greater detail. The door is supported to the oven frame by two hinges, **11** and **13**, which are of a conventional structure and allows the door to swing out to the fully opened position illustrated. Although I illustrate a swing-out type of door support, it is understood that the operation of the door seals hereinafter described are independent of the particular way in which the oven door is attached to the oven and that the invention is equally applicable to oven doors which are hingedly mounted to a side wall and open outwardly to the right or to the left. Likewise as is known to those skilled in the art, any one or more of the described door seals may be installed or formed in the annulus or frame portion **5** and in which the door surface is employed as an electrically conductive surface.

Conventionally oven **1** forms an enclosure or container which houses all the conventional elements of the microwave oven, including the power supply and microwave energy source, not illustrated. Typically the microwave source generates a frequency of 2,450 MHz. The oven contains a cooking chamber or cavity **3** which is open at the front, in which the foodstuffs to be cooked are set in place. Typically the oven cavity is a metal walled inner container having dimensions greater than one-wavelength at the operating frequency of the enclosed microwave source. The cavity has, suitably, a porcelainized or vitreous enamel surface finish. Suitable openings into this chamber, not visible in the figure, such as the opening for admitting microwave energy, the Cal-rod browning elements installed on the upper chamber wall, and the pyrolytic self-cleaning elements, are enclosed in the chamber but are not visible in the figure nor are they necessary to an understanding of the invention. The frame portion or annulus **5** extends between oven cavity and the outer oven walls. A portion of the annulus $\mathbf{5}_b$ is elevated. The control panel portion **7** which contains the numerous switches, timer control knobs, etc., conventional in the microwave oven, appears on the right side in the figure for purposes of perspective completeness only since the details thereof are not necessary to the understanding of the invention and are not further described.

The microwave oven illustrated to place my invention in its context is the familiar countertop or portable variety. It is understood, however, that the invention is utilized in and forms part of the conventional built-in type ovens in which the microwave oven is built into a conventional electric range, the latter of which is more likely to contain pyrolytic self-cleaning elements. The important relevant physical element is the annulus **5** and the oven chamber **3** since it is these elements which cooperate with the door mounted elements to form the door seal.

Door **9** is constructed of various parts including an outer panel **15** and an inner panel **17**. As illustrated in the figure, the inner panel **17** has a protruding portion which protrudes into the oven cavity **3** slightly when the door is in the closed position. Although I illustrate the protrusion to be constructed of metal, it is also within the scope of the invention to install in this protruding portion a glass window suitably protected with a nonradiating metal grill of any conventional and known structure.

A flange edge **19** and the second flange edge **21** border an opening **23** which forms the passage to a first chamber or cavity, not visible in this figure, which functions as a choke type of seal, hereinafter illustrated and explained in greater detail. Another opening exits between flange edge **21** and another flanged edge **25** and a protruding braided glass fiber strip **27** is located in that opening. As is hereinafter brought out in greater detail, the glass fiber strip encloses a ferrite material and protrudes from another chamber, not illustrated in this figure, in which the braided material is situated. This ferrite material functions as a seal. Finally, a resilient carbon loaded rubber strip **29** extends around the inner annulus of the door most adjacent the outer periphery of the door to form a gasket-like seal.

The various structural elements comprising the door seal extend entirely around the periphery of the door inner annulus exposing to view what appears to be a series of concentric rectangles of a "picture-frame" shaped geometry and each of these elements is located in the annular inner door portion aligned so as to overlie annulus **5** of the oven frame proper when the door is in the closed position.

The foregoing explains the arrangement and the external features of the elements of the door seals visible on the outside surfaces of the inner surface of the door together with the relationship thereof to the abutting or underlying annulus **5** of the oven. A better understanding of the structures forming the seals is obtained by considering partial sections of doors such as is found in the details of two different structures hereinafter presented in FIG. **2** and in FIG. **3**.

It is noted in connection with the description of the figures which are hereinafter described, the numerical designation of the elements employed are the same numbers used to refer to those same elements found and described in connection with the description of FIG. **1**. The door construction in FIG. **2** utilizes a solid piece of material, for illustrative purposes, such as cast aluminum, and has the outer panel **15** attached. The annulus of the oven frame **5** as well as the chamber wall of oven cavity **3** and the outer wall of the oven are shown in dotted lines for purposes of illustrating the relationship of the door frame to the door. The door section illustrated in this figure is positioned with the door slightly ajar. The pliant loss loaded rubber gasket seal 29 is situated on the inner side 17 of the door. In this sectional view, a first chamber 24 is fashioned from a deep groove of approximately one-fourth wavelength in length and one-twentieth wavelength in width. The opening 23 of chamber 24 is positioned approximately one-fourth wavelengths from the portion of the door annulus which overlies the most adjacent side wall of oven chamber 3. Of course, this groove extends completely around the door panel in a rectangular picture-frame geometry, as was described and visible in FIG. 1. At the frequency of 2,450 MHz one wavelength is approximately 4.8 inches in length. A strip of glass fiber material, 26, is installed in the upper end of the passage 23 to function as a dirt seal. The glass fiber material is pervious to microwave frequency energy but forms a barrier to particles of dirt and grease.

The second chamber, 28, is similarly fashioned by a deep groove in the door which extends around the door in a picture-framelike geometry. The second chamber shares a common narrow wall 20 terminating in flange edge 21 with the first chamber. Suitably the edge 21 is no more than one-one sixtieth wavelength in width so as to space the two chambers as closely together as is possible by less than one-twentieth wavelength (0.240 inches). Other choices within a desired range for this spacing may be 0.02 inches to 0.20 inches, 0.02 inches to 0.24 inches, and 0.025 inches to 0.05 inches. The second chamber also encloses a spring, 30, at the bottom end and a rectangular ferrite strip 32. Spring 30 is suitably a tubular braided spring such as is available from the Bentley-Harris Company and this exerts a radially outward force. In turn, the spring and ferrite strip are ensleeved in the braided glass fiber sheath 27. The door hinge 11, partially illustrated, is shown attached to the inner side 17 of door 9.

When the door 9 is in the closed position the rubber seal is compressed between the door frame and door to provide a tight seal. Spring 30 forces the ensheathed ferrite 32 into abutment with the door frame annulus 5. It is noted that the glass fiber braid 27 slightly spaces and prevents ferrite 32 from actual contact with the door frame annulus.

Inasmuch as the glass fiber is pervious to microwave energy and essentially nondissipative, it is equivalent to a slight gap between the door and frame. Likewise if the door annulus 5 is covered by a porcelainized coating that in itself is equivalent to a further physical gap.

As is evident to one skilled in the art, a solid door made of cast aluminum is very expensive and is, in a sense, impractical. At best it is useful to illustrate the elements of the invention without the complications of flanges and other structural assemblies hereinafter introduced to the reader. Thus a more practical embodiment of the invention is illustrated in the partial section of the door illustrated in FIG. 3. The door in this practical embodiment includes a plurality of interconnected panels and is internally hollow. The outer panel 15 and the inner door panel 17 are interconnected through a support bracket, such as main door member 31. Door member 31 is joined to panel 15, suitably by screws, such as screws 33. Door member 31 is also joined to inner panel 17 by a mounting hat or bracket 35, the latter of which is attached to main door member 31 suitably by a screw 37, and to inner panel 17 together with an intermediate flange 39 sandwiched therebetween by a weld. Metal flange 39 is of a picture-framelike rectangular structure and includes an upwardly projecting lip 20 which terminates in edge 21, and a second upwardly projecting lip 38 which is in contact with panel 17. In cross section, bracket 39 resembles a channel and part of this channel is covered by a portion of inner panel 17.

It is noted that the edge 19 of inner panel 17 is spaced from edge 21 to form a passage 23, and the bracket 39 together with the overlying portion of panel 17 forms a metal walled chamber cavity which functions as a "choke" type seal. Suitably this cavity is approximately one-fourth wavelength in length and one-twentieth wavelength wide. The passage 23 is located approximately one-fourth wavelength from the adjacent wall 40 of cooking cavity 3 so that the total distance to the short-circuited (metal walled) end 38 of the chamber is about one-half wavelength. A strip of braided glass fiber 26 is conveniently inserted into and is situated in the chamber physically filling or "plugging" the entrance to this chamber and forms a dirt seal. A rectangular picture-framelike metal bracket or channel assembly 41 having a U-shaped cross section is attached to the underside of bracket 39, as shown at one stem of the U, suitably by spot welds, so that the base of the U is a slight distance from lip 20 of bracket 39. Another bracket 43, of a picture-framelike geometry, having an L-shaped cross section, is joined to bracket 41 near an end of the base stem of the L, suitably by screws, such as screw 45, as illustrated, and with the other stem of the L extending up to the plane of door panel 17. The upper edge 25 of the L-shaped bracket is spaced from the edge 21 of bracket 39 to similarly define a passage and the inner sides of bracket 45, the base of bracket 41, and bracket 39 define a second chamber which extends about the door annulus which shares in common at least one wall portion 20, terminating in edge 21, with that of the first chamber. The second chamber includes an enlarged portion on the bottom end. An elongated braid spring 30 is installed in the enlarged portion of this chamber and a ferrite dissipative material 32 is installed in the front end of the chamber substantially plugging or filling the chamber entrance. Both the spring and the ferrite material are sheathed in a braided glass fiber sheath 27. The diameter of spring 30 is larger than the passage formed between edges 21 and 25 of the bracket sides. Thus during assembly the spring is radially compressed and pushed into its position in the chamber whence the spring restores to its full diameter. Thus this seal assembly is retained in place in the door and can be removed only by exerting a sufficient pulling force on the sheath. Still another rectangular bracket 51, having an L-shaped cross section, is supported by main door member 31 by means of various L-shaped brackets, 53, joined to member 31 by screws 55 and 57. The rubber gasket strip 29 is a graphite loaded rubber material. It is shaped so as to have a hook-like underlying portion. This hook-like portion is inserted within the space 62 and grips bracket 31 to hold the rubber seal in place on the door.

To illustrate this practical construction of the elements and this geometrical relationsip more closely, I provide the exploded view of FIG. 4. In FIG. 4 four of the door elements are illustrated including inner door panel **17,** the metal bracket **39,** the support bracket **41** and bracket **43.** Each of the elements is of a rectangular picture-frame geometry and are of appropriate dimension so as to fit together to form the chambers and passages within the door as observed in cross section in FIG. **3.**

The construction details of the ferrite dissipative seal assembly is illustrated in FIG. **5.** As is there shown, the braided glass fiber sheath **27** is divided into two elongate compartments by a seam **28.** The lowermost compartment contains the elongated wire mesh spring **30,** which is exposed in the figure for clarity of illustration. The upper compartment contains the ferrite **32** which is also exposed in this illustration. The ferrite **32** is an elongated rectangular strip. A plurality of these ferrite strips are inserted end to end into the second compartment. Obviously only a portion of the seal is illustrated and a length sufficient to extend around the annulus portion of the door is used. The ferrite material withstands the high temperatures to which it is exposed in the oven, and the glass fiber braided strip is an excellent thermal insulator, and hence in the combination in the oven it serves the additional purpose of providing a thermal seal or "heat block."

In operation the oven chamber is exposed to microwave frequency radiation, typically of a frequency of 2,450 megahertz. As is known, the "choke seal" is designed and dimensioned as an analogy to a waveguide transmission line, and as is known the input electrical impedance characteristic of a one-half wavelength short-circuited waveguide transmission line to microwave frequency fields at that frequency is ideally zero ohms, or in other words a "short-circuit." Hence ideally the input electrical impedance to the physical gap between the door and oven is very very low so as to effectively shunt or bridge the field currents across the physical gap. Since the input physical gap extends all around the inner periphery of the door it may be more accurate to analogize to a series of such transmission lines connected together. However one skilled in the art views the "choke seal," it is expectedly not perfect and does allow some leakage current to flow. This leakage is incident upon the dissipative seal ferrite **32.** The dissipative seal converts the incident microwave energy to heat as a characteristic of the material much as is done by the foodstuffs being cooked in the oven chamber. Since there is only a minute amount of leakage energy there is only a minute amount of heat generated in the first dissipative seal. Inasmuch as the fiberglass sheath **27** enclosing the ferrite **32** is pervious to microwave energy, there is provided a further path for microwave energy to pass if it is not fully dissipated in seal **32.** The third seal **29** is made of graphite loaded pliant rubber and is hence a dissipative type of door seal. With the door closed the rubber is somewhat compressed between the door and oven frame and eliminates any gaps.

Ideally any microwave energy which leaks past the first dissipative seal is absorbed in this second dissipative seal. However as is hereinafter described in connection with the discussion of the results of one practical embodiment of the invention, some minute permissible level of leakage does occur and is measurable.

FIG. **6$_a$** illustrates a simplified symbolic drawing of the cross-section of part of the door and door seal of the invention, and FIG. **6$_b$** similarly illustrates a similar but not identical door and door seal which does not incorporate the invention. Thus FIG. **6$_a$** shows the oven door **9'**, the choke seal chamber having an entrance **26'**, a second chamber **50'** containing the spring **30'** and the protruding ferrite **32'**. The loss loaded rubber seal **29'** is attached to the inner annulus of the door near the door's outer periphery. The first chamber and second chamber **30'** have the wall **51'** in common, and the width of that wall is less than approximately one-twentieth wavelength. For purposes of this illustration the glass fiber sheath enclosing the spring and the ferrite are omitted. As is evident, this cartoon schematic is representative of the details of the structure illustrated in both FIG. **2** and FIG. **3.** The structure represented in FIG. **6$_b$** likewise illustrates the door **9''**, a choke seal chamber having an entrance **26''**, a second chamber **50''** housing a spring **30''** and protruding ferrite **32''**. The loss loaded rubber perimeter seal **29''** is attached to the inner annulus of the door. The first and second chambers do not have a common wall, but are separated by an edge **52''** which is greater than one-twentieth wavelength in length.

The difference between FIG. **6$_a$** and FIG. **6$_b$** is that in FIG. **6$_a$** the two chambers have a thin wall **51'** in common, which spaces the chambers by a distance of only one-fiftieth wavelength or less, whereas in the schematic of FIG. **6$_b$** the two chambers are separated a greater distance by an annulus portion of the door **52'**.

Reference is now made to FIG. 7 which illustrates graphically the radiation in units of milliwatts measured at a distance of 5 centimeters from the door to oven boundary as a function of the gap spacing between the door seals on the movable door and the annulus or frame of the oven container in an oven operating to provide 2,450 MHz microwave energy in the cooking chamber. These measurements were accomplished on a door constructed in accordance with the teachings of FIG. **3** and represented by schematic FIG. **6$_a$** with the distance between the chambers, i.e., the thickness of wall **21''** being 0.030 inches, to obtain the results in Curve A, and with the door modified to conform to the schematic illustration of FIG. **6$_b$**, where the ferrite seal was moved an additional three-eighths inch away from the first chamber, to obtain the results of Curve B. To form the physical gaps various thicknesses of nonconductive or substantially nondissipative material, such as mylar, is inserted between the door and the annulus of the oven container. Such material was a plurality of ¼ inch thick square spacers to cover only a portion of the door perimeter. Curve C is a straight line and represents radiation of one milliwatt per square centimeter measured at a distance of **5** centimeters, which is the maximum radiation permitted by current U.S. Government regulations. As is apparent from Curve A, the level of the leakage radiation for all gap spacings is substantially lower than the maximum permitted by Government standard. As is also apparent from Curve B, in the case of the door seal in which the ferrite dissipative seal is spaced a greater distance from the choke seal, the leakage radiation is substantially higher initially and exceeds the Government standard for a great number of gap spacings. In practice the door configuration represented by the schematic of FIG. **6$_a$** is substantially better than any door seal arrangement known to applicant. Curve D illustrates the results when a 3 inch × 4 inch paper pad, of various thicknesses, simulating an entrapped hot pad, was inserted between the door and the oven across the door annulus including the dissipative seals, without allowing microwave energy leakage above the Government standard. This indeed was unexpected to me and is in my opinion significant. From a technical standpoint, I did not perceive that the arrangement of the three seals or their juxtaposition provided the synergistic effect which apparently has been demonstrated by the results. I can only speculate that the narrow edge of the common metal wall separating the choke and ferrite seals concentrates any leakage fields in the ferrite material where it is better absorbed as a possible reason for such unexpected and substantially improved results. In addition to having a microwave door seal that meets present Government standards and withstands pyrolytic oven temperatures, the present seal in my opinion advances the art in that even very large gaps, such as one-eighth inch, do not produce energy leakage that I regard as significant, being below the Government limit as shown in Curves A and D. As is known, ovens shipped from the factory must conform to the leakage standards set by the Government. On the other hand, if the oven is not maintained properly in use, certain increases in leakage necessarily result. Instructions in present oven clearly specified that the user should clean the annulus of the oven and door to prevent the build-up of dirt and grease, which due to their accumulation can result in a gap between the door and the oven container, and microwave energy in amounts above the desired standard would leak. With a rather large public there are always a number of persons whose personal habits may preclude the implementation of such instructions and who choose to assume the risk of disregarding warnings.

With the present invention it is apparent that substantial amounts of grease build-up, dirt or other material can accumulate between the door and the oven chamber, and even so, only acceptable levels of leakage occurs. In effect, the door seal of the invention provides such significant results that it can even protect those additional persons against their own improvidence and lack of good judgment in failing to follow instructions and warnings in the care and use of the microwave oven.

It is clear from the foregoing construction and mode of operation of the door seals that the function of the door seal is independent of whether its structure is supported by or formed within the movable door, such as door **9** in FIG. **1**, or is instead supported by or formed in the annulus **5** surrounding the entrance to the oven chamber in FIG. **1**. Clearly in accordance with the teachings of my invention and as is known in the prior art, suitable seals may be mounted or formed in the annulus **5** region and the inner annular door portion may instead be a solid conductive metal surface. Likewise, any one of the seals may be mounted on the oven chamber annulus and the remaining ones of the door seals mounted on the inner annular door portion. This is simply a reversal of parts between different portions of the closure members consisting of the door and the frame. It is clear that my invention is intended to cover the door seal arrangements as described in the appended claims, irrespective of their position, i.e., door or frame support, and it is desired that my claims be so construed to include this equivalent.

It is believed that the preceding description of the preferred embodiments of my invention disclose my invention in sufficient detail to enable one skilled in the art to make and use my invention. However it is expressly understood that my invention is not to be limited to those particular details inasmuch as various modifications, additions and equivalents suggest themselves to one skilled in the art upon reading this specification.

Accordingly my invention is to be broadly construed within the full spirit and scope of the appended claims.

What I claim is:

1. In a microwave oven having a heating chamber within which foodstuffs to be heated by exposure to microwave energy radiation are received, an entry opening at an end of said chamber to provide access to said chamber, an annular border region surrounding said entry opening, and a movable door operable between an open and closed position to prevent exit of microwave energy radiation, said door including a middle door portion to cover said entry opening to said chamber and an annular border region about said middle door portion which covers, at least in part, said annular border region surrounding said heating chamber entry opening to form opposed annular regions, and microwave energy seal means to prevent radiation leakage from physical gaps between said annular door portion and annular border region; the improvement in said combination wherein said microwave energy seal means comprises:

a choke type seal which includes a first elongated continuous electrically conductive walled cavity of predetermined depth located behind one of said annular border regions and extending about said entry opening; and

a narrow opening in said first cavity located in said one of said annular border regions and extending entirely about said entry opening and spaced a predetermined distance from said entry opening for providing microwave energy pervious path between said cavity and from about said opposed annular regions;

a dissipative seal which includes a second elongated cavity underlying one of said annular regions and extending about said entry opening, a narrow opening in said second cavity located in said one of said annular regions and extending about said entry opening and spaced a predetermined distance therefrom for providing a passage between said annular region and said second cavity,

microwave energy dissipating means located partially within, extending about, and protruding from said narrow opening in said second cavity,

spring means located within and extending about said second cavity for providing a force on said dissipative means in a direction outwardly of said second cavity to force said dissipative means outwardly from said opening in said second cavity and apply a pressure to the opposed one of said annular regions;

a third seal which includes a compressible strip of electrically lossy material located on one of said annular regions and extending about said entry opening for compressive engagement between said annular door region and said annular border region surrounding said chamber; and

wherein said opening in said first cavity is spaced from said opening in said second cavity by a predetermined distance within the range of 0.02 and 0.24 inch and is located more proximate said entry opening than said opening in said second cavity and wherein said opening in said second cavity is located more proximate said entry opening than said third seal.

2. The invention as defined in claim **1** wherein said dissipative seal further comprises an elongated sleeve of high temperature resistant pliant microwave energy pervious material, said sleeve being divided into two elongated compartments and wherein each of said microwave energy dissipating means and said spring means are located within said sleeve.

3. The invention as defined in claim **2** wherein said microwave dissipative material comprises a ferrite.

4. The invention as defined in claim **3** wherein said spring comprises a wire mesh tubular spring.

5. The invention as defined in claim **2** wherein said sleeve material comprises braided glass fiber fibers.

6. The invention as defined in claim **4** wherein said wire mesh tubular spring has a predetermined cross-sectional diameter and wherein said predetermined diameter is greater than the width of said narrow opening in said second cavity.

7. The invention as defined in claim **1** wherein said predetermined distance between said opening in said first cavity and said opening in said second cavity comprises approximately 0.03 inch.

8. The invention as defined in claim **6** wherein said predetermined distance between said opening in said first cavity and said opening in said second cavity comprises between 0.025 inch and approximately 0.050 inch.

9. The invention as defined in claim **1** wherein said one of said annular regions, which said second elongated cavity underlies, comprises said annular border region on said door.

10. The invention as defined in claim **9** wherein said one of said annular border regions in which said first cavity is located behind, comprises said annular border region of said door.

11. The invention as defined in claim **10** wherein said one of said annular region on which said third seal is located, comprises said annular border region of said door.

12. The invention as defined in claim **6** wherein said one of said annular regions, which said second elongated cavity underlies, comprises said annular border region on said door.

13. The invention as defined in claim **12** wherein said one of said annular border regions in which said first cavity is located behind, comprises said annular border region of said door.

14. The invention as defined in claim **13** wherein said one of said annular region on which said third seal is located, comprises said annular border region of said door.

15. The invention as defined in claim **6** further comprising a dirt seal, said dirt seal comprising a high temperature resistant material pervious to microwave frequency energy and relatively impervious to dirt particles, said dirt seal located in said opening in said first cavity.

16. The invention as defined in claim **15** wherein said compressible strip of electrically lossy material comprises a rubber having a substantially lower temperature resistance than said sleeve and said ferrite.

17. The invention in a dissipative seal which comprises:

a door for a microwave oven;

a cavity in said door extending thereabout in a continuous loop;

a narrow opening in the surface of said door, said opening extending about said door in said same continuous loop;

an elongated sleeve of braided glass fiber material, said sleeve being divided into two elongated compartments and extending about said cavity;

an elongated tubular mesh spring installed in one of said compartments and ferrite material installed in the other of said compartments, and wherein the diameter of said tubular mesh spring is greater than the width of said opening, said tubular mesh spring being located within said cavity and said ferrite material and a portion of said sleeve protruding from said opening.

18. In a microwave oven having a cooking chamber for receiving foodstuffs to be heated, outer walls forming a container within which said oven chamber is located and a front wall portion between said outer walls and said cooking chamber to form an annular region about said cooking chamber, and a movable door for closing the front end of said chamber, said door having an annular region which overlaps said annular region of said container when said door is in the closed position, the improvement therein comprising:

a first conductively walled chamber located within said door, said chamber having a passage opening in said annular region and spaced a predetermined distance from said cooking chamber for providing a microwave energy leakage-inhibiting effect;

a second chamber, said second chamber having a restricted portion and an opening therein in said annular portion of said door, said second chamber having a metal wall in common with said first chamber, said wall having an edge exposed in said annular portion, said wall having a thickness in the range of 0.02 to 0.20 inch;

microwave energy absorbing material located in said second chamber and protruding therefrom for abutment with said annular container portion and spring means located in said chamber for biasing said microwave energy absorbing material against movement into said chamber; and

a loss-loaded rubber strip forming a gasket between said annular portions of said door and said container.

19. The invention as defined in claim **18** wherein each of said annular portions of said door and said oven container include a coating of vitreous enamel material.

20. The invention as defined in claim **19** further comprising a sleeve of high temperature resistant pliant material and wherein each of said spring means and said microwave energy absorbing means are positioned within said sleeve.

21. The invention as defined in claim **20** further comprising seam means for dividing said sleeve into two compartments and wherein said microwave energy-absorbing material is located in a first compartment and said spring means is located in a second compartment.

22. The invention as defined in claim **21** wherein said sleeve material comprises braided glass fiber.

23. The invention as defined in claim **22** further comprising a strip of glass fiber material positioned within said entrance of said first cavity for providing a barrier to dirt particles while permitting passage of microwave energy therebetween.

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