

United States Patent

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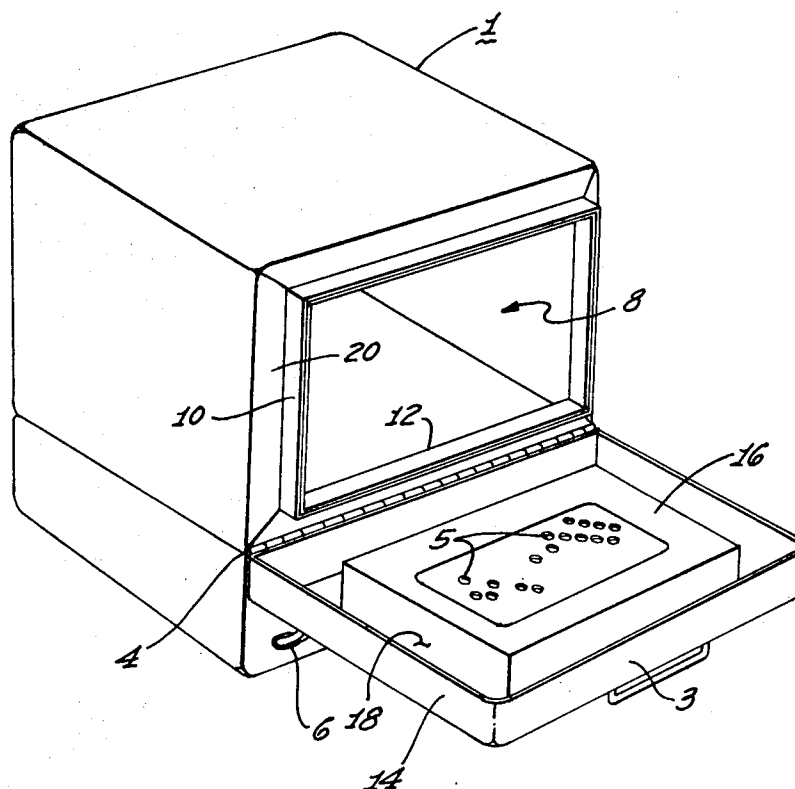
[54] **MICROWAVE OVEN HAVING MESHING
 MICROWAVE DOOR SEAL**
9 Claims, 4 Drawing Figs.

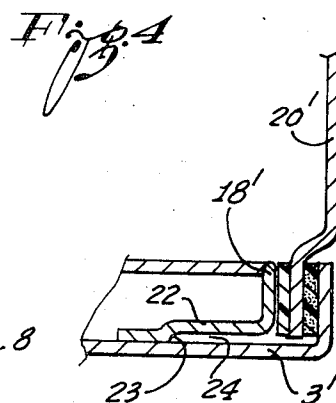
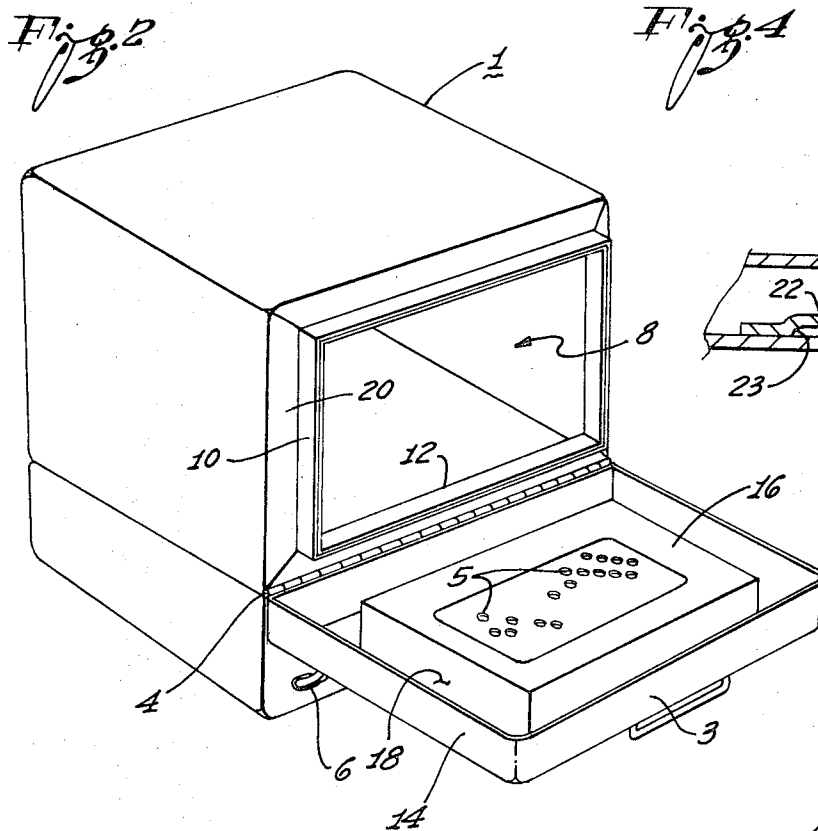
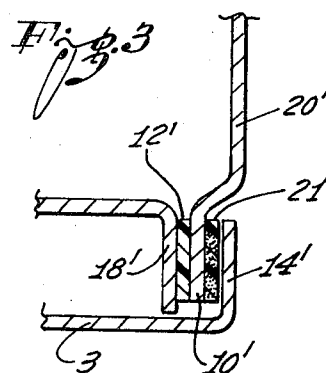
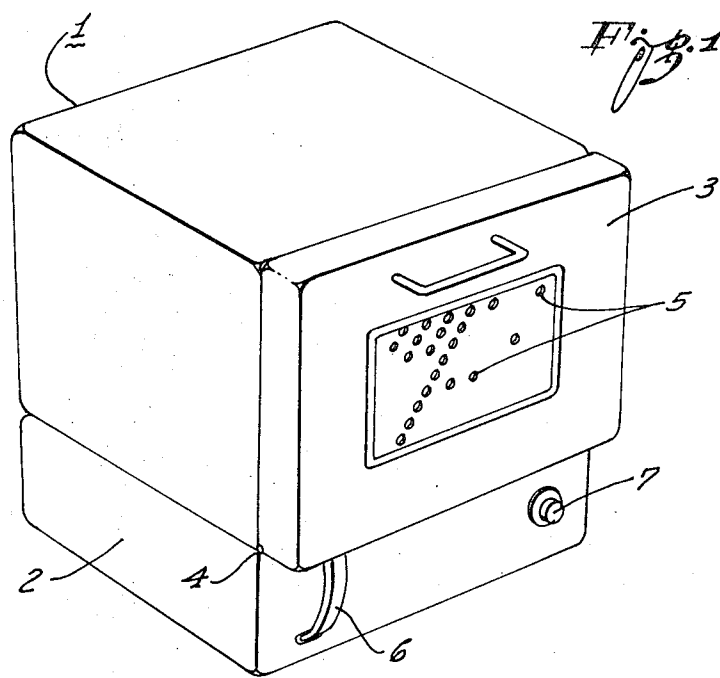
[52] U.S. Cl. **219/10.55**
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 [50] Field of Search **219/10.55**

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ABSTRACT: A microwave oven includes an oven cavity portion having an opening for permitting the insertion of food stuffs and a door to close the oven during heating. An elongated strip formed from and recessed from the oven walls surrounds the oven opening. The oven door includes an inwardly projecting rim portion which fits within the recess and overlaps substantially the strip portion when the door is in the closed position; and a second conductive strip or surface, which in like manner overlaps the strip portion, extends about the inner surface of the oven door spaced from the rim. This forms a channel within which fits the first conductive strip when the door is in the closed position. In each instance the spacing between the conductive surface and the conductive strip and the spacing between the conductive strip and the rim is less than one-tenth of the wavelength of the microwave energy used in the oven for heating purposes. In addition, a narrow lining of dielectric is positioned between the conductive surface and the conductive strip.





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MICROWAVE OVEN HAVING MESHING MICROWAVE DOOR SEAL

This invention relates to microwave ovens and, more particularly, to a microwave oven having an improved microwave seal formed between the oven door and cavity which prevents leakage of microwave energy.

Improvements in microwave heating or cooking apparatus have resulted in the availability of many different oven constructions capable of providing proper heating of food stuffs by radiation with microwave energy. Briefly, microwave heating may be said to rely upon the molecular agitation in or absorption by the substance caused by exposure to energy of microwave frequency. In contemporary microwave ovens the food stuffs are placed in an oven cavity closed by a hinged door. The door covers the oven entrance and confines the microwave energy fed into the oven cavity. As would be expected, where a door is provided for any closure there is always some clearance or gap between the edges of the door and the closure. The extent of such cracks is of course dependent upon the tolerances used in construction. To prevent any residual microwave energy from leaking or escaping out such cracks or gaps in an oven door it is customary to provide an electrical seal of one type or another around the door edges, a function similar to insulating a house door to prevent entry of wintry drafts of air.

As a practical matter present microwave oven designs of many oven manufacturers provide a good RF seal between the door and the cavity. However, the result is often to provide a bulky door or opening or to provide special gadgetry such as heavy door spring to ensure by exerting large door or seal pressure the desired amount of sealing. Considered together, the oven and seal the structures are either complicated, or, if simple, require more expensive techniques for manufacturing the oven, or special schemes requiring excessive manipulation during opening and closing of the oven door.

There is another instance in which microwave energy can leak possibly from the oven. For example, there are times when the oven door is open during heating before the microwave source has been disabled by the interlock, as for example when the "cook" intuitively decides that his or her foodstuffs are sufficiently heated. A normal safeguard provided in all ovens is the system of interlocking or "interlock" between the oven door and the generator or source of microwave energy. With such an interlock circuit any movement of the door from the closed to the open position automatically shuts off or disables the microwave generator, if not all ready disabled.

However, as with any other type of mechanical system there is always some tolerance similar to "backlash" between the door movement, interlock, and the disablement of the microwave generator. For example, it is theoretically desired that the interlock operate immediately no matter how slight the door is opened. As a practical matter this is difficult or impossible to achieve and to maintain; and accordingly, in some systems of interlock or in other systems after they have worn sufficiently there is always a possibility that some extra leakage occurs should the door be opened a small distance, perhaps on the order of one thirty-second of an inch or less, during which time the interlock system has not disabled the microwave source. Of course during the normal continued movement of the door to its open position the interlock system always operates and disables the microwave source. It has been found that such small leakage is essentially harmless and may be disregarded. However, there is a desire in this day and age to reduce wherever possible any exposure to any radiation whatsoever.

Accordingly, it is an object of the present invention to provide an improved microwave seal for a microwave oven door;

It is a further object of the invention to provide a microwave oven door construction in which microwave energy remains sealed in the oven even though there may be a limited amount of door movement;

It is a still further object of this invention to provide a microwave oven door construction in which the microwave

energy remains sealed in the oven even though there is a limited amount of door warping or misalignment due to use or manufacturing tolerances; and,

It is an additional object of the invention to provide a microwave oven door seal which is not dependent upon seal or door closing pressure.

Briefly, the invention is characterized first by an elongated strip about the oven opening formed from and recessed from the major portions of the side and tip walls of the oven cavity together with an inwardly projecting rim portion on the oven door which fits within the recess and overlaps substantially said strip portion when said door is in its closed position. In addition, the door further contains an elongated conductive surface extending around and projecting toward said oven opening so that said strip fits between the last mentioned conductive surface and the rim portion of the door when said door is in the closed position. Further in accordance with another aspect of the invention, a narrow lining of dielectric material is incorporated, positioned between, and lines the space between said conductive surface and said strip and is supported on said strip or door.

Further in accordance with another aspect of the invention a lining of microwave attenuative material is fitted in between said rim portion and said strip portion.

The foregoing and other objects of the invention together with other advantages and features believed to be characteristic of the invention both as to its organization and method of operation are better understood from the following detailed description taken together with the figures of the drawings in which:

FIG. 1 illustrates one embodiment of the invention;

FIG. 2 is a perspective of the embodiment of FIG. 1 with the door in the open position revealing fully the microwave seal;

FIG. 3 is a segmental cross section schematic that shows the construction of the microwave seal; and

FIG. 4 schematically shows in cross section a segmental schematic of another embodiment of the invention.

The microwave oven of FIG. 1 includes an oven cavity 1 constructed of electrically conductive metal walls seated atop and firmly joined to a container or power pack 2, as may be variously termed. Container 2 houses all essential components of a conventional power supply and microwave energy source so that the assembly of oven cavity and power unit is of a modular approach. Inasmuch as that circuitry is of any suitable type and is not necessary to an understanding of the invention, it is not described in detail. A microwave passage, not illustrated, permits the passage of microwave energy from container 2 into oven cavity 1. The oven unit includes conventional controls such as the timer 6 and interlock 7 which are conventional in structure and operation and which need not be described in detail.

Hinge 4 swingably mounts a door 3 to oven cavity 1. Door 3 includes a panel 5 which consists of a grill containing small holes. These holes are substantially smaller in diameter than one-tenth the wavelength of the frequency of the microwave energy used in the oven, suitably 2450 megahertz. They present a very very high impedance to microwave energy of that frequency and, consequently, there is no leakage of that energy through panel 5. Primarily, the holes permit the operator to directly observe any objects placed in oven cavity 1 as they are heated; and, in addition, permit an exit for the escape of heat or moisture. It is noted that, alternatively, panel 5 may be eliminated and a solid wall of conductive material substituted without affecting operation of the oven. The walls of oven cavity 1 are formed of sheet metal, such as thin sheet steel or aluminum. Accordingly, the inside surface of the sheet metal borders the inside of the oven cavity, while the outside surfaces thereof essentially define the upper exterior of the microwave oven. The provision of this wall construction with the remaining seal structure hereinafter described promotes an oven construction which is very light and eliminates the use of separate inner and outer walls separated by insulation as has been past practice.

In FIG. 2 oven door 3 is pivoted about hinge 4 to an open position which exposes the opening 8 in oven cavity 1 through which the objects to be heated are placed into or withdrawn from the cavity. An elongated narrow rim or strip 10 surrounds or defines the boundary of cavity opening 8. Strip 10 is formed in portions from adjoining ones of the sheet metal cavity walls and is recessed a predetermined distance from the major surfaces of those walls. This depression or recession of strip 10 results in a cross-sectional area for opening 8 slightly smaller than the corresponding cross-sectional area inside oven cavity 1.

An elongated strip or lining 12 of dielectric material, suitably plastic, is fastened in any conventional manner along the inside surface of strip 10. The oven door is bordered by an inwardly projecting rim portion 14 at right angles to the plane of door 3. When the door is in the closed position, as is illustrated in FIG. 1, rim 14 substantially overlaps strip 10. In addition, only a small clearance is provided between strip 10 and rim 14 with the door in the closed position, small being substantially less than one-tenth the wavelength of the microwave energy. Moreover, with the door in the closed position the outer surfaces of the oven walls and the rim 14 of the oven door are dimensioned and arranged to provide a smooth appearance or "flush fit".

Attached to the inner side of door 3 is a panel supporting member 16. panel support projects inwardly from the outer surface of door 3 and along its sides forms a bordering portion or inner conductive surface 18 of a predetermined depth and which is inwardly projecting from the door surface. Surface 18 is spaced from and substantially parallel to rim 14. Preferably the spacing between surface 18 and wall strip portion 10 with dielectric strip 12 attached provides between a snug fit therebetween and a clearance of .05 inch and the distance between surface 18 and strip 10 is less than one-tenth λ . Moreover, there is substantial overlap between strip 10 and conductive surface 18 when the door is in the closed position. Ideally the degree of overlap between those two elements permits limited movement of the door relative to oven cavity 1 while maintaining a good microwave seal therebetween. As is apparent, the FIGS. are exaggerated in dimension to assist one to better understand the invention.

An added degree of understanding of the invention is gleaned from the cross-sectional segmental schematics of FIGS. 3 and 4. These FIGS. represent schematically the juncture between oven door 3 and the oven cavity 1 with the door in the closed position. Considering FIG. 3 it is seen that the schematic is representative of the structure of the mating between door edge and cavity on each of the top and vertical sides of the oven construction. For clarity, the numerals used to identify the elements used in these FIGS. correspond with those of FIG. 1 and 2 and are primed. The wall strip 10' is formed from and recessed from the surface of the wall, a sidewall 20' being used in this illustration. Strip 10' fits between the inwardly projecting rim 14' of door 3' and the door supported conductive surface 18'. It is apparent that each of elements 18', 10', and 14' are overlapping. The liner 12' of dielectric material fits between surface 18' and strip 10' and is supported by the latter.

In practice the distance between surface 18' and strip 10' is so small relative to the wavelength of the frequency microwave energy, less than one-tenth λ , that by itself the passage appears as a very high capacitance and prevents significant leakage. The dielectric appears to provide proper electrical loading and hence reduces further the possibility of leakage. Note that if the door 3' is closed so tightly that the end of strip 10' door 3' there would be no leakage because there is a fully conductive boundary. With the positions shown in the FIG. the impedance factor described insures the seal. This duality of the construction affords extra protection.

Moreover, should any energy happen to pass through the dielectric it must follow a circuitous path around strip 10' and rim 14'. Again due to the small spacing between those elements, small relative to the wavelength of the microwave ener-

gy used in the oven, the path provides a low impedance that bypasses the electric field, and so reduces the possibility of leakage.

Exemplary dimensions chosen for some of the elements in the disclosed embodiment of the invention are as follows: the walls of the oven cavity are constructed of .020 galvanized steel, the door is constructed of 1/16-inch aluminum sheet, the conductive surface supporting the panel attached to the door is .020 galvanized steel. The main surface of the panel support is spaced approximately one-half inch from the main door panel, while the conductive surface 18' parallel to rim 14' is spaced about nine thirty-seconds of an inch from the strip 10'. The depth of recess of strip 10' is approximately five thirty-seconds of an inch measured from the inside surfaces. The width of strip 10' is about two thirty-seconds of an inch and the width of rim 14' is about thirty thirty-seconds of an inch with the width of the surface parallel thereto slightly larger. The dielectric liner 12' can be a plastic material of a one-sixteenth inch thickness. Each of these dimensions may be described in fractions of a wavelength of the microwave frequency which is suitably 2450 megahertz.

As further illustrated in FIG. 3, the described door seal may be further enhanced by the inclusion of a liner of microwave attenuative material 21, suitably a carbon loaded plastic. Liner 21 fully eliminates any possibility of leakage from the oven cavity. The attenuative liner may be fastened to the outer side of wall strip portion 10' in the same manner as dielectric liner 12'. The attenuative strip 21 is located in between rim portion 14' and strip 10' and is suitably one-sixteenth of an inch in thickness.

As is apparent, many minor variations are possible in accordance with the spirit of the disclosed invention. For example, it is possible or desirable to use either a snug fit between each or any of the two liners and the two elements which sandwich same; or alternatively conductive surface 18' may have a .05 inch clearance between its surface and dielectric 12' or any permissible variation thereof. Further, it is possible to substitute a wire braid or to use a wire braid material in addition at the juncture of any two adjoining strip, rim, or surface portions adjoining the disclosed door seal. Obviously the use of a wire braid material simply acts to reflect incident microwave radiation. Moreover, if it is desired, a plastic tape can be fitted around the end of rim 14' which can extend over the whole oven cover.

An additional refinement is illustrated in the segmental schematic of FIG. 4. Inasmuch as many of the elements illustrated in FIG. 4 are identical to those shown in FIG. 3, they are not further discussed. However, in FIG. 4 the conductive surface 18' is modified so that it contains a section 22 spaced from and parallel to the main door panel 3' and at its end 23' matched to 3'. The end 23' forms an electrical short circuit. The length of the formed passage 24 is chosen so that with the additional distance to the inner door surface the total electrical length resembles a half-wavelength short circuited transmission line. Such a transmission line presents a very low electrical impedance to microwave energy presented at its input. In this case the low impedance is designed to be presented at the entrance of the door seal path; i.e. near the end of conductive surface 18', and, electrically, the cavity will appear to be a conductive surface.

To describe some of the important functions of the invention reference is again made to the schematic of FIG. 3. At the time the operator opens oven door 3', rim 14' and conductive surface 18' moves away from wall strip 10'. However, since the microwave door seal so formed consists of elements which to a great extent overlap, slight movement to open the door does not break the seal, but merely reduces the amount of overlap between the described elements. Thus, during the initial door opening procedure the basic configuration of the door seal remains intact. This is significant in the instance when the door is being opened at a time when the microwave source is operating to supply high frequency fields within the oven cavity. Since the interlock circuitry must disable that

source, theoretically, before the door is opened even a crack. As described previously, the interlock is a mechanical device which has some "play" or "backlash" and hence cannot be relied upon for infinite accuracy in monitoring very small door movements say less than one sixty-fourth of an inch. Accordingly, with the dimension for the door seal elements, as previously set forth, there is almost one-half of an inch of permissible movement at the top of the door before the seal is fully broken. With such a leeway the operation of the interlock circuit is insured and the tolerances of an interlock circuit used in conjunction with this oven need not be held to the same high tolerances as required by other ovens. Accordingly, even momentary exposure of the operator to significant radiation is avoidable.

In concluding this description it is noted that should an oven be dropped, the oven cavity may become warped or the door may become misaligned relative to the cavity opening. In the instance of such damage there is a possibility of creating small gaps through which the microwave energy may, to an extent, leak during operation since with such slight damage it is still possible to close the door which prevents the interlock circuit from disabling the microwave source. However, in the construction of the invention set forth herein it is apparent that should any misalignment occur between the door and the cavity which would render the door seal inoperative, it is apparent that wall strip 10' would abut rim 14' or surface 18' and prevent the door from fully closing. Effectively with door closure prevented the interlock circuit prevents operation of the microwave source and the operator must have the damage repaired before further oven use is possible.

It is to be understood that the above-described arrangements are intended to be illustrative of the principles of the invention and not by way of limitation since numerous other arrangements and equivalents suggest themselves to those skilled in the art which do not depart from the spirit and scope of my invention.

Accordingly, it is expressly understood that the invention is to be broadly construed within the spirit and scope of the appended claims.

I claim:

1. A microwave oven having an oven cavity to provide a space for receiving objects to be heated by exposure to microwaves of a wavelength λ , an opening in said cavity through which said objects may be inserted or withdrawn from said oven cavity; and a door for closing said opening to prevent leakage from said cavity of microwave energy during heating of said objects; said oven including: first and second sidewalls, a back wall, and a top wall each of which has a major inner surface area bordering said edges cavity and an outer surface bordering the outside of said microwave oven, and a bottom wall for said oven cavity; each of said walls being of a metallic sheet material; a strip portion formed from at least said side and top walls and extending there around at the front of said oven cavity, said strip portion being recessed a predetermined distance from the major outer surfaces of said respective walls and having an edge facing said door when said door is in its closed position, said oven door having a rim portion about at least its side and top edges inwardly projecting therefrom a predetermined distance, said rim portion being received within said recess in said top and sidewalls overlapping and spaced by less than one-tenth λ from said elongated strip portion when said door is in its closed position; whereby said door forms with the outer wall surface of said top and sidewalls the appearance of a flush fit therebetween and any space between said strip and rim portion inhibits leakage of microwave energy from said cavity, conductive surface means on the inner side of said door forming a second elongated strip parallel to said rim portion and spaced therefrom a predetermined distance, said predetermined distance being greater than the depth of recess of said wall strip portion so that said wall strip portion is both positioned between said door rim and said second strip and overlaps said wall strip when said door is in its closed position and spaced

from the latter by less than one-tenth λ , a liner of dielectric material positioned between said wall strip and said door strip when said door is in its closed position; said dielectric material being supported by either said wall strip or door strip portions and snugly fitting therebetween when said door is in the closed position to inhibit leakage of microwave energy from said oven cavity.

2. The invention as defined in claim 1 further comprising: an elongated liner of microwave attenuative material positioned between said elongated strip portion of said walls and said door rim when said door is in the closed position, said attenuative material being supported by either one of said rim portion or elongated strip portion.

3. The invention as defined in claim 1 wherein said conductive surface means includes a recessed portion forming a passage between said surface means and the inside of said door to form therebetween a quarter-wavelength RF choke at the juncture of said door and said opening to further inhibit the leakage of microwave energy.

4. A microwave oven having an oven cavity adapted to receive foodstuffs to be heated by microwave energy of a wavelength, λ , said oven cavity having walls comprising a thin metallic sheet material, and a door hingedly mounted along one edge and adapted to be pivoted between an open and closed position to uncover or cover respectively an opening in said oven cavity; an improved meshing microwave seal formed between said door and said oven walls for preventing the leakage of microwave energy from the oven cavity during heating, said microwave seal comprising: an outwardly projecting elongated metallic strip extending about said opening in said oven cavity formed in and recessed by a predetermined depth from the major surfaces of the top and sidewalls of said opening at the front end thereof; said door having a rim portion which extends at least around the top and sides of said door inwardly projecting from said door and positioned in said recess overlapping said strip and flush with said oven walls when said door is in its closed position; said door further having an elongated conductive surface projecting toward said cavity opening and spaced from said strip by less than one-tenth λ on the side of said conductive strip opposite said rim portion when said door is in its closed position.

5. The invention as defined in claim 4 further comprising a lining of dielectric material positioned between and lining said conductive surface and said strip portion and supported by either.

6. The invention as defined in claim 5 further comprising a lining of microwave attenuative material positioned between said rim portion and said elongated strip and extending about at least the side and top borders of said walls when said door is in its closed position, said attenuative liner being supported by either said rim or said strip.

7. The invention as defined in claim 5 wherein said dielectric material is of a thickness substantially equal to the clearance between said strip and said conductive surface; whereby said door fits snugly into place when in the closed position.

8. A microwave oven having an oven cavity adapted to receive foodstuffs to be heated by microwave energy of a wavelength, λ , said oven cavity having walls comprising a thin metallic sheet material, and a door hingedly mounted along one edge and adapted to be pivoted between an open and closed position to uncover or cover respectively an opening in said oven cavity; an improved meshing microwave seal formed between said door and said oven walls for preventing the leakage of microwave energy from the oven cavity during heating, said microwave seal comprising: a metallic strip extending about and projecting outwardly from about the opening in said oven cavity recessed by a predetermined depth from the major surfaces of the top and side metal walls of said opening at the front end thereof; said door having a rim portion which extends at least around the top and sides of said door inwardly projecting from said door toward said opening and positioned in said recess overlapping said strip and flush

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with said oven walls when said door is in its closed position; said door further having an elongated conductive surface projecting toward said cavity opening and spaced from said strip by less than one-tenth λ on the side of said conductive strip opposite said rim portion when said door is in its closed position.

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9. The invention as defined in claim 8 further comprising a lining of dielectric material positioned between and lining said conductive surface and said strip portion and supported by either.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,544,751 Dated December 1, 1970

Inventor(s) Benjamin V. Valles

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 68, between the words "strip 10'" and "door 3'" insert the word -- abutts --. Column 5, line 50, cancel the word "edges" and substitute therefor -- oven --.

SIGNED AND
SEALED
FEB 9 1971

FEB. 9, 1971

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, Jr.
Commissioner of Patents