May 3, 1966 S. C. JOHNSON 3,249,731

OVEN

Filed Nov. 14, 1963

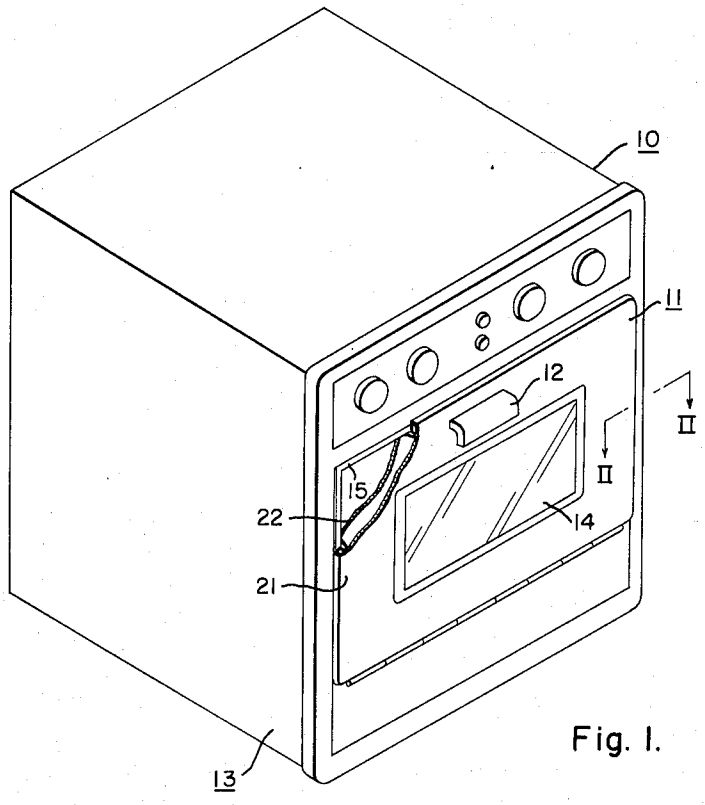

Fig. 1.

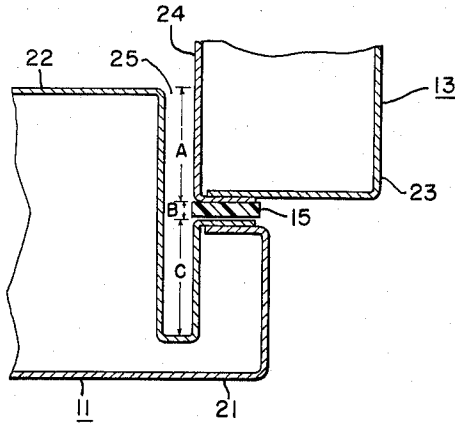

Fig. 2.

INVENTOR.
Stewart C. Johnson

BY

ATTORNEY

United States Patent Office 3,249,731 Patented May 3, 1966

3,249,731

OVEN

Stewart C. Johnson, Mansfield, Ohio, assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Filed Nov. 14, 1963, Ser. No. 323,720
7 Claims. (Cl. 219—10.55)

This invention relates to heating of materials in a housing supplied with microwave energy and concerns particularly containment of such energy about the edge of a door or the like.

Foodstuffs and other materials of so-called "lossy" dielectric may be heated by exposure to electromagnetic radiation in the microwave portion of the spectrum (from about one thousand to three hundred thousand megacycles per second, corresponding to wavelengths of from about thirty centimeters to one millimeter). Microwave generators operating in the midportion of this range are used to provide energy to cooking ovens or the like. The housing of such an oven is provided with a doorway or similar opening for the insertion and removal of the food and containers, and a door or other closure member is provided, which may contain a window for permitting visual observation of the interior. Not only must the window, if any, be designed to be opaque to the microwave radiation (though relatively transparent to visible light) the leakage of such radiation about the edge of the door must be eliminated or limited to a very small amount without unduly complicating the structure of the door or adversely affecting its operation.

A primary object of the present invention is provision of an effective microwave energy seal for the door or similar closure member of a microwave oven or the like.

Another object is reduction in the amount of adjustment, maintenance, and repair or replacement required in the sealing of a door for a microwave oven or the like.

A further object is interrelation of the door and interior wall of a microwave oven or the like to minimize microwave radiation at the seal therebetween and to absorb the relatively small amount of radiation at that location by the sealing means itself.

Other objects of the present invention, together with means and methods for attaining the various objects will be apparent from the following description and the accompanying diagrams of a preferred embodiment thereof.

FIGURE 1 is a perspective view, partly cut away, of a microwave oven embodying this invention; and

FIG. 2 is a sectional plan of a portion of the same apparatus, on a much larger scale, taken at II—II of FIG. 1.

In general, the objects of the present invention are accomplished, in apparatus for heating materials in an enclosure supplied with microwave energy and defined by a housing member having a conductive interior surface with an opening therein and a covering closure member for the opening, by means of a structural interrelationship of the respective members to provide a choke effect and a gasket therebetween absorptive to microwave radiation.

More particularly, the invention contemplates use of a covering closure member having a conductive portion overlapping but spaced from the surface of the housing member around the opening, the extent of overlap being equivalent to an odd number of quarter wavelengths of the microwave energy, one of the members having a recessed conductive portion communicating with the space between the overlapping portions, the depth of the recess being equivalent to an odd number of quarter wavelengths, and a gasket comprising lossy dielectric material on one of the members and interposed between the

respective members along one side of the junction between the space and the recess.

FIG. 1 shows in perspective a microwave oven **10** having a door **11** hinged at the bottom edge and provided with a handle **12** at the top. The door covers an opening or doorway in the front portion of the oven housing **13**. A window pane **14** occupies a portion of the door area. The upper left corner of the door is cut away to show a nonconductive gasket **15** of lossy dielectric, which constitutes a sealing strip between the door and the housing. A row of controls appears in a panel above the door; however, as they and the elements controlled by them are wholly conventional and do not enter into the present invention, neither the controls nor the elements controlled thereby are described or illustrated further herein.

FIG. 2 shows sectioned and on an enlarged scale a portion of the oven housing, door, and the intervening seal, as indicated on FIG. 1. It will be understood that the location at which this sectional view is taken is actually immaterial, the construction of the seal being essentially unchanged along the entire edge of the door or so much thereof as is of the construction indicated. The resilient gasket **15**, which has a rectangular cross-section is attached to either the door or the housing, as by a suitable adhesive or other suitable means.

The door **11** is shown as having an outer wall **21** and an inner wall **22**, and the housing **13** as having an outer wall **23** and an inner wall **24**. At least the interior surfaces of the inner walls of both the door and the housing are composed of electrically conductive material (e.g., aluminum or stainless steel), so as to contain the microwave energy, and the window is coated or screened (not shown) with similar material for the same purpose.

The inner walls of the door and housing overlap one another for a distance designated as A in FIG. 2, forming the initial portion of a channel **25** communicating with the oven interior; the terminal portion of the channel, designated as C is provided by a recess in the inner wall **22** of the door; and an intermediate portion, in line with the initial and terminal portions, is bounded on one side by the inner wall of the door and on the other side by the gasket **15**, the thickness of which is designated as B. A and C are preferably substantially equal to one another and to a quarter wavelength of the microwave energy supplied to the oven, and B is small with regard thereto. At a frequency of 2450 megacycles per second, which is a conventional microwave frequency for cooking ovens, a wavelength is about five inches.

The short circuit across the terminal portion of the channel **25** appears as a very high impedance in the vicinity of the gasket **15** and a low impedance across the channel entrance. Furthermore, the gasket is made up of lossy dielectric material, which is absorptive to the (small) amount of radiation that reaches it, such as a phenol-formaldehyde or urea-formaldehyde thermoset resin (e.g., the material known as "Micarta") with or without iron or other metal particles embedded therein. Other suitable gasket materials will come readily to the minds of persons skilled in the art. The gasket thickness should be great enough to provide a substantial absorptive mass in the width available, without unnecessarily increasing the spacing of the door from the housing. The preferable gasket thickness is from about one-tenth to one-fourth inch, and the width from about a half inch to two inches. The width of the channel **25** should be less than a quarter wavelength, preferably considerably less, but more than the gasket thickness.

While the distance A or C (or both) could be made an odd multiple of quarter wavelengths, to do so would increase the amount of wall material used and would decrease the ratio of useful oven volume to total space

required, which generally is undesirable. The channel may be reoriented, at least in part, while still functioning as desired, with appropriate redesign of the door and housing. Any change therein or in shape or size of the door or its relation to the oven wall should be made only with due allowance for the dimensional requirements, dependent upon the wavelength of the microwave energy supplied. Other modifications from the structure of the disclosed preferred embodiment may be made without departing from the claimed invention.

The claimed invention is:

1. In apparatus for heating materials in an enclosure supplied with microwave energy and defined by a housing member having a conductive interior surface with an opening therein, a covering closure member for the opening having a conductive portion overlapping into but spaced from the surface of the housing member around the opening, the extent of overlap being equivalent to an odd number of quarter wavelengths of the microwave energy, said closure member having a recessed conductive portion communicating with the space between the overlapping portions and constituting a straight line continuation of said space, the depth of the recess being equivalent to an odd number of quarter wavelengths, and a gasket comprising lossy dielectric material on one of the members and interposed between the respective members along the outside of the junction between the space and the recess, said gasket extending entirely around said opening to prevent conductive contact between said respective members along said outside of said junction.

2. In apparatus for heating materials in a housing supplied with microwave energy, having a conductive interior surface and having a doorway to the exterior, a door adapted to close the doorway and having a portion intruding into the housing in the closed position, the intruding portion being surrounded by but spaced from the housing surface, the extent of overlap of the housing surface and the door in the intrusion direction being equivalent to an odd number of quarter wavelengths of the microwave energy, the door having a recessed conductive portion communicating with the housing by way of the space between the intruding portion and the housing surface and constituting a straight line continuation of said space, the depth of the recess being equivalent to an odd number of quarter wavelengths, the peripheral portion of the door and the housing adjoining one another along the outside of the junction between the recessed portion and the communicating space and being spaced from one another by a gasket comprising a lossy dielectric extending entirely around said doorway to prevent conductive contact between said door and said housing along said outside of said junction.

3. In apparatus for heating materials in a housing supplied with microwave energy, having a conductive interior surface and having a doorway to the exterior, a door adapted to close the doorway and having a portion intruding into the housing in the closed position, the intruding portion being surrounded by the housing surface but spaced therefrom less than a distance equivalent to a quarter wavelength of the microwave energy, the extent of overlap of the housing surface and the intruding portion of the door being equivalent to an odd number of quarter wavelengths, the door having a recessed conductive portion communicating with the housing by way of the space between the intruding portion and the housing surface and constituting a straight line continuation of said space, the depth of the recess being equivalent to an odd number of quarter wavelengths, the peripheral portion of the door and the housing adjoining one another along the outside of the junction between the recessed portion and the communicating space and being separated from one another only by a gasket comprising a lossy dielectric extending entirely around said doorway to prevent conductive contact between said door and said housing along said outside of said junction.

4. In apparatus for heating materials in a housing supplied with microwave energy, having a conductive interior surface and having a doorway to the exterior, a door adapted to close the doorway and having a portion intruding into the housing in the closed position, the intruding portion being surrounded by but spaced from the housing surface, the extent of overlap of the housing surface and the intruding portion of the door being equivalent to an odd number of quarter wavelengths of the microwave energy, the door having a recessed conductive portion communicating with the housing by way of the space between the intruding portion and the housing surface and constituting a straight line continuation of said space, the depth of the recess being equivalent to an odd number of quarter wavelengths, the peripheral portion of the door and the housing adjoining one another along the outside of the junction between the recessed portion and the communicating space and being separated from one another by a gasket thin with respect to a quarter wavelength and comprising a lossy dielectric extending entirely around said doorway to prevent conductive contact between said door and said housing along said outside of said junction.

5. In apparatus for heating materials in a housing supplied with microwave energy, having a conductive interior surface and having a doorway to the exterior, a door adapted to close the doorway and having a portion intruding into the housing in the closed position, the intruding portion being surrounded by but spaced from the housing surface, the extent of overlap of the housing surface and the intruding portion of the door being equivalent to an odd number of quarter wavelengths of the microwave energy, the door having a recessed conductive portion communicating with the housing by way of the space between the intruding portion and the housing surface and constituting a straight line continuation of said space, the depth of the recess being equivalent to an odd number of quarter wavelengths, the peripheral portion of the door and the housing adjoining one another along the outside of the junction between the recessed portion and the communicating space and being separated from one another by a gasket comprising a lossy dielectric including a thermoset resin extending entirely around said doorway to prevent conductive contact between said door and said housing along said outside of said junction.

6. In apparatus for heating materials in a housing supplied with microwave energy, having a conductive interior surface and having a doorway to the exterior, a flanged portion on the housing surrounding the doorway and terminating in a flange generally parallel to the doorway, a door adapted to close the doorway and having a portion intruding into the housing in the closed position, the intruding portion being surrounded by but spaced from the housing surface, the extent of overlap of the housing surface and the intruding portion of the door being equivalent to an odd number of quarter wavelengths of the microwave energy, the door having a recessed conductive portion communicating with the housing by way of the space between the intruding portion and the housing surface and constituting a straight line continuation of said space, the depth of the recess being equivalent to an odd number of quarter wavelengths, the recessed portion terminating in an outwardly directed flange parallel to and spaced from the housing flange, and a gasket consisting essentially of lossy dielectric material extending entirely around said doorway to prevent conductive contact between said door flange and said housing flange and filling the space between the two flanges in the closed position of the door, that space being thin with respect to a quarter wavelength.

7. In apparatus for heating materials in a housing supplied with microwave energy, having a conductive interior surface and having a doorway to the exterior, a flanged portion on the housing surrounding the doorway

and terminating in a flange generally parallel to the doorway, a door adapted to close the doorway and having a portion intruding into the housing in the closed position, the intruding portion being surrounded by but spaced from the housing surface, the extent of overlap of the housing surface and the intruding portion of the door being equivalent to a quarter wavelength of the microwave energy, the door having a recessed conductive portion communicating with the housing by way of the space between the intruding portion and the housing surface and constituting a straight line continuation of said space, the depth of the recess being equivalent to a quarter wavelength, the recessed portion terminating in an outwardly directed flange parallel to and spaced from the housing flange, and a gasket consisting essentially of lossy dielectric material extending entirely around said doorway to prevent conductive contact between said door flange and said housing flange and filling the space between the two flanges in the closed position of the door, that space being thin with respect to a quarter wavelength.

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RICHARD M. WOOD, *Primary Examiner.*

L. H. BENDER, *Assistant Examiner.*