

July 4, 1967

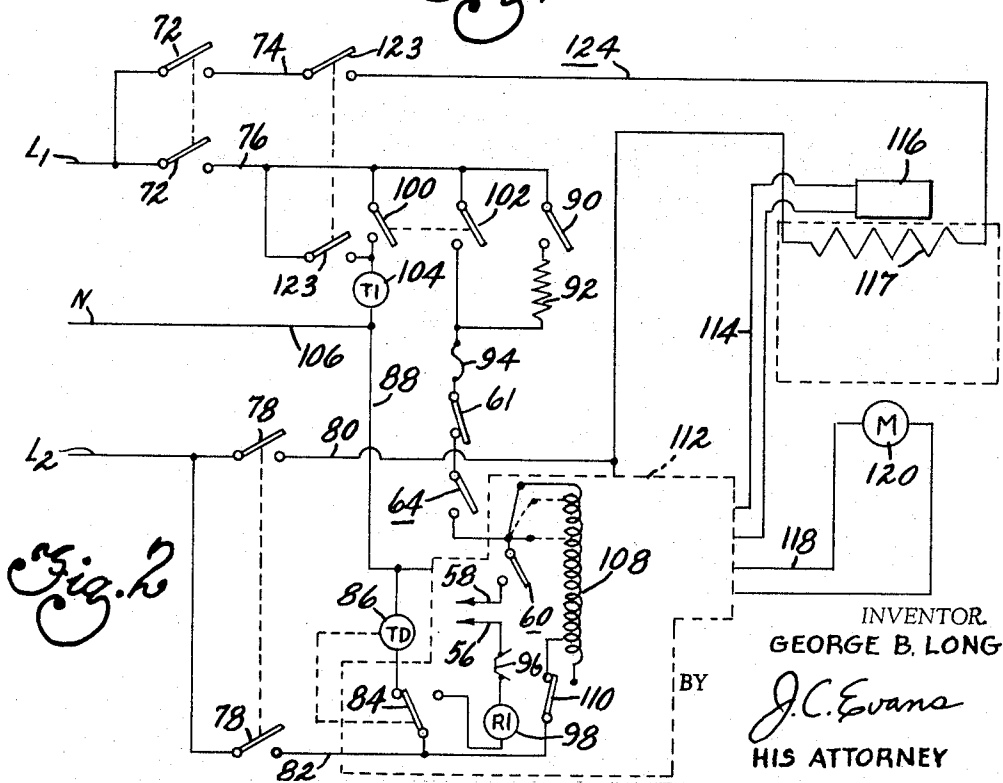
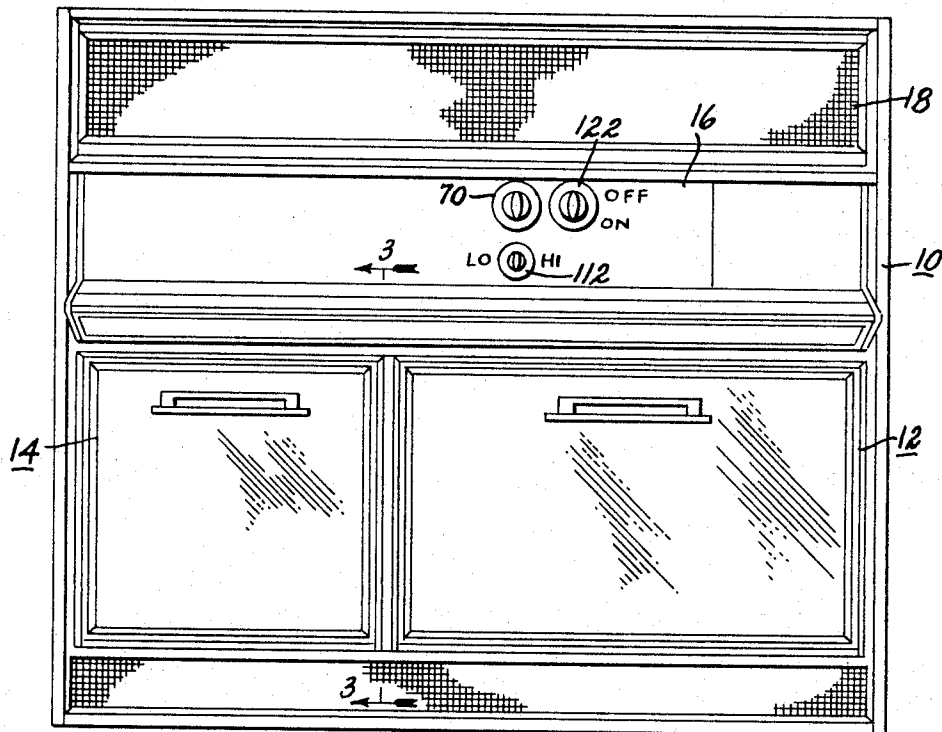
G. B. LONG

3,329,795

MICROWAVE OVEN

Filed Aug. 28, 1964

3 Sheets-Sheet 1



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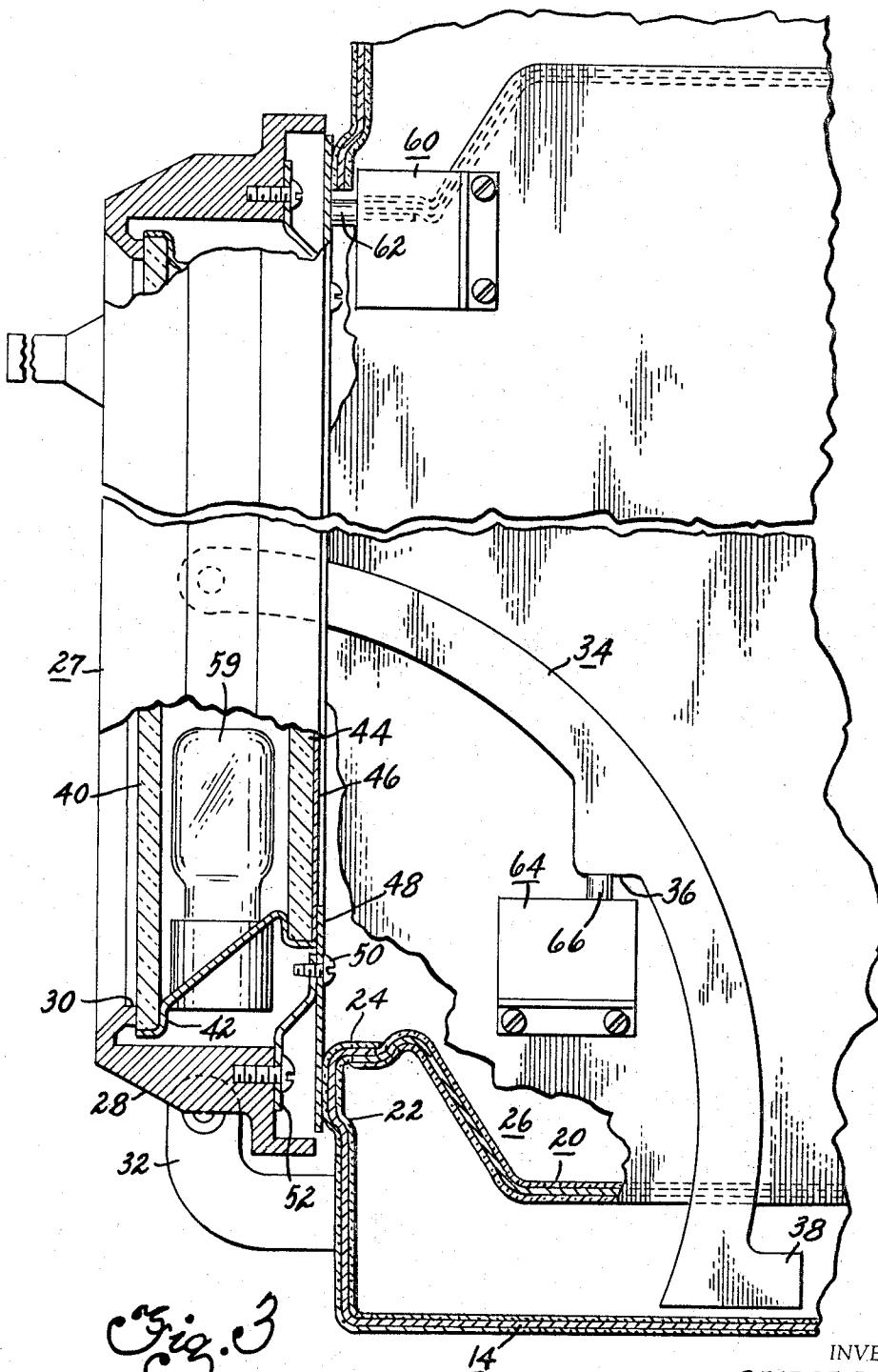


Fig. 3

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3 Sheets-Sheet 3

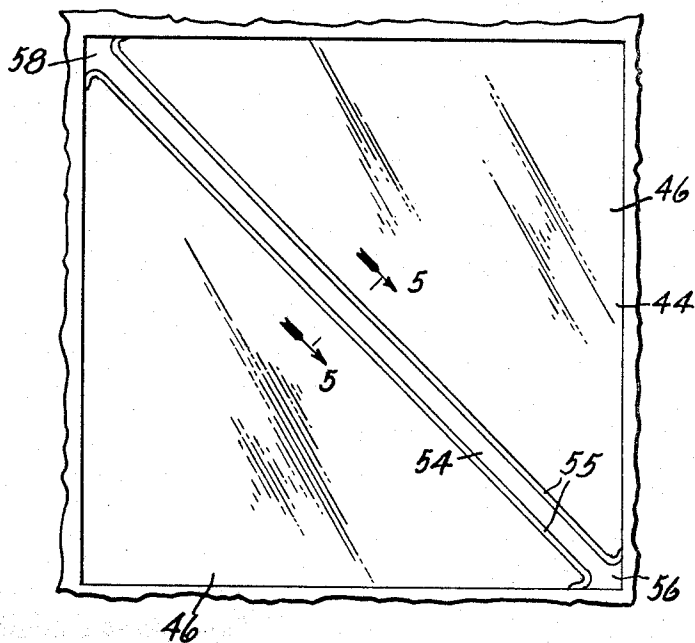


Fig. 1

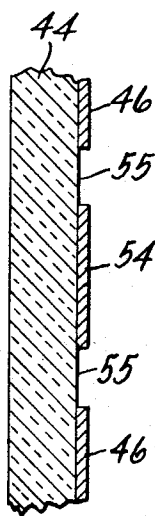


Fig. 5

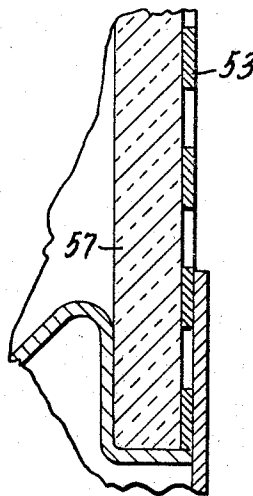


Fig. 6

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1

3,329,795

MICROWAVE OVEN

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13 Claims. (Cl. 219-10.55)

This invention relates to oven structures having a source or microwave cooking energy therein and more particularly to a microwave detecting and safety system for indicating that the door of the oven is not completely shielding against the escape of radio frequency waves from the oven and for turning off the microwave generator under such conditions.

One problem in the development of a completely suitable domestic microwave oven assembly has been that created by the fact that microwave energy is relatively undetectable by the user of the appliance and can by either inadvertence or mechanical defects in the structure escape from interiorly of the oven structure. The mechanical defect problem is particularly prevalent in arrangements where the door closure portion of the structure is constructed to include a see-through door closure design. Such door closures typically have a frangible see-through shield that when cracked might allow the escape of microwave energy from the cooking cavity.

To prevent escape of such energy when the door closure is inadvertently opened during cooking, most domestic microwave cooking appliances include a switch that has an actuating plunger in the door opening collar movable upon door closure opening to a position to open the power supply circuit to the microwave generator in the oven. Such a switch, however, can be accidentally actuated to its circuit closing position whereby the microwave generator will be re-energized to generate an unnecessary radio frequency mode within the oven enclosure.

An object of the present invention, therefore, is to improve microwave oven structures by the provision therein of a plurality of microwave generator power supply switches including a first switch that is responsive to microwave leakage clearances between a door closure element and the oven liner for de-energizing the generator and a second switch that opens the power circuit of the microwave generator when the door closure element is moved into its open position whereby the first switch can be accidentally closed without energizing the microwave generator.

A further object of the present invention is to improve microwave oven structures having domestic use by the provision therein of a see-through door closure member including a frangible see-through microwave shield including an electrically conductive portion that detects a break in the frangible member that will allow the escape of microwave energy and is responsive to such a break to de-energize the microwave generator power circuit.

A further object of the present invention is to provide an improved see-through door closure for a microwave oven structure including a frangible transparent pane having a thin conductive layer of material thereon for blocking the escape of microwave energy while being transparent within the optical range to allow observation of the interior of the oven wherein the conductive layer includes a portion thereof electrically insulated from all other portions thereof for detecting cracks in the frangible member that might allow the escape of microwave energy; and by the provision of circuit means connected with said first electrically conductive portion for opening the power circuit for the microwave generator upon the occurrence of such cracks.

2

A further object of the present invention is to provide an improved door closure structure for shielding against the escape of microwave energy from interiorly of a domestic microwave oven by the provision therein of a frangible transparent member having microwave shield means thereon that completely covers the planar extent of the viewing area in the door closure and pilot indicator means located exteriorly of the frangible member including ionizable particles that are energized by the escape of microwave energy through the frangible member to indicate the escape by a luminescent signal; and to provide circuit means in association with the pilot indicator means including photosensitive means for opening the power circuit for the microwave generator upon detecting the luminescent signal indicating an escape of radio frequency waves.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein preferred embodiments of the present invention are clearly shown.

In the drawings:

FIGURE 1 is a view in front elevation of a domestic wall oven assembly;

FIGURE 2 is a diagrammatic view of a circuit for controlling the operation of a microwave oven part of the assembly in FIGURE 1;

FIGURE 3 is an enlarged view in vertical section, partially broken away and partially in section, being taken substantially along the line 3-3 of FIGURE 1;

FIGURE 4 is a fragmentary view in front elevation of a viewing window portion of the door closure of an electronic oven;

FIGURE 5 is an enlarged view in vertical section taken along the line 5-5 of FIGURE 4; and

FIGURE 6 is a fragmentary view in vertical section of another embodiment of the door closure assembly shown in FIGURE 3.

Referring now to the drawings in FIGURE 1, a built-in type cooking appliance 10 is illustrated including side-by-side ovens 12, 14 having a control panel 16 located above that extends completely across the width of the appliance 10. Above the panel 16 is located a vent opening 18. In the illustrated arrangement the oven 14 is an oven assembly of the type including a microwave generator unit as a source of cooking energy. If desired, a suitable source of radiant energy may also be included therein such as an electrical resistance element that supplements the cooking action of the microwave generator unit by producing baking and broiling effects on objects being treated. The details of the oven 14 are more specifically set forth in copending United States application, Ser. No. 360,980 of Homer W. Deaton, filed Apr. 20, 1964, with it being understood that the oven illustrated in the copending application is merely representative of a typical microwave oven that is suitable for association with the present invention.

In FIGURE 3 a liner 20 of the oven 14 is illustrated including a forwardly facing continuous flange or collar 22 that forms an access opening 24 to an oven cavity 26 formed by the side walls, top, rear wall and bottom portions of the liner 20. In the illustrated embodiment of the invention the liner 20, including the flange portion or collar 22 thereof is covered by a layer of porcelain enamel of the grade used for domestic oven liners.

In the illustrated arrangement, the access opening 24 is closed by a door closure assembly 27 that includes a peripheral frame portion 28 formed continuously to define a viewing opening 30 therein. The frame 28 is operatively connected to the liner 20 by a lower hinge member 32 and an upper hinge member 34 on either side thereof.

3

In the illustrated arrangement the upper hinge 34 is representatively illustrated as having one end thereof connected on the inner surface of the flange 28 and opposite end thereof directed between one side of the liner 20 and an outer wall of the oven assembly. The upper hinge member 34 has a cam surface 36 thereon intermediate its ends and the innermost end of the member 34 is hooked at 38 whereby, when the door 27 is moved to an open position, the hook portion 38 will engage a stop element as is well known in the art to maintain the door in a horizontally open position.

Referring now more specifically to the door closure assembly 27, the opening 30 therein is closed by a see-through window that serves to shield against the escape of microwave energy from the oven cavity 26 when the door is closed while allowing visual observation of articles being cooked. More specifically, the opening is closed by a first exterior pane 40 of transparent material such as glass, transparent plastic or the like that is supported within an offset lip portion at one side of a continuous window supporting member 42 that is directed continuously around the opening 30 within the frame 28. The window supporting member 42 has a lip on the opposite side thereof that supportingly receives an inside shield member 44 of transparent material having the inner surface thereof coated by a layer 46 of electrically conductive material that is transparent within the optical range. One example of glass having a layer of electrically conductive material is a tempered electrically conductive optically transparent glass manufactured by Corning Glass under the trade name EC Optical Glass. In practicing the invention, it is preferable that the integral electrically conductive coating on the face of the member 44 has electrical characteristics in the order of 20 to 50 ohms per square inch to block the escape of microwave energy. Such an arrangement has been found suitable for blocking against the escape of microwave energy exteriorly of the oven cavity 26 while being sufficiently optically transparent whereby a user can see interiorly of the oven. In the illustrated arrangement, in addition to the shielding action of the interior shield member 44, the door closure assembly 27 includes a flexible metallic flange 48 thereon that is secured by suitable fastening means such as screws 50 to a support member 52 on the frame 28. The flexible flange 48, more particularly, is formed continuously around the frame 28 so as to overlap the porcelainized flange or collar 22 of the oven liner 20 whereby when the door 27 is closed, the flange 48 will be located in spring biased engagement with the smooth porcelainized surface of the collar 22. Such an interrelationship between the flange 48 and the collar 22 has been found to be unusually suited for preventing the escape of radio frequency modes peripherally of the door closure 27. A further feature of the flange 48 and porcelainized collar 22 is that they act to suppress microwave arcing between the door closure 27 and the liner 20 in a highly effective manner.

The illustrated door closure assembly 27 is representative of an economical arrangement for both shielding against the escape of radio frequency modes and a desired see-through assembly wherein the shielding action is effected by use of frangible transparent shield members.

One aspect of the present invention, therefore, is the provision of means in association with the frangible transparent shield member 44 for detecting cracks and operable upon the detection of such cracks to open the power circuit to the microwave generator of the assembly 14. More specifically, the layer of electrically conductive material 46 on the inner shield member 44 includes a portion 54 extending diagonally across the face of the member 44, as best illustrated in FIGURE 4. A space 55 on either side of the diagonal portion 54 electrically insulates it from the remainder of the electrically conductive layer 46, as best illustrated in FIGURES 4 and 5. At either end of the diagonal strip 54 suitable

4

leads 56, 58 are provided to be electrically connected in the power circuit of the microwave generator in the assembly 14 whereby, if the frangible inner shield member 44 is cracked, either in a vertical or horizontal direction, the crack will migrate across the face of the frangible member 44 to eventually break the diagonal conductor strip 54 and thereby open the power circuit to the microwave generator until necessary repairs are made to the frangible microwave shield. In practicing this aspect of the invention, the insulating spaces 55 on either side of the conductor strip 54 are in the order of one-quarter inch so that microwave cooking energy waves are blocked. Minor faults or very small fissures in the shield member 44 of a size that will not permit the escape of microwave energy will be effectively limited in their migration whereby the oven assembly 14 will remain operable unless the frangible interior shield 44 is cracked or broken to a relatively substantial degree as discussed above.

In the embodiment of FIGURE 6 a grid 53 of silver aluminum is fired on one face of a frangible transparent shield member 57 like member 44 in the first embodiment. In this case the grid 53 serves to block microwave energy and, if desired, can include a portion electrically insulated from other parts of the grid that detects cracks similarly to conductor strip 54 in FIGURE 4.

Another safety aspect in the disclosed embodiment of the invention is the provision therein of a pilot indicator for giving a visual indication of microwave leakage through the shield member 44. As shown in FIGURE 3, a glow tube 59 is mounted on the support 42 between shield members 40, 44. This tube contains neon or other ionizable luminescent gas that will glow upon detecting such leakage to warn the user of a dangerous mechanical failure in the shielding action of the door closure assembly 27. If desired, a photosensitive switch 61 can be included in the power supply of the microwave generator as shown in FIGURE 2 that will sense ionization of the glow tube 59 to cut off the power supply in response to microwave leakage.

Another feature of the present invention is the provision of a plural interlocking switch arrangement that maintains a desired microwave sealing effect about the periphery of the door closure assembly 27. In the illustrated arrangement, a first microwave leak detecting switch assembly 60 is illustrated as being secured on one side of the liner 20, as best shown in FIGURE 3, so that an outwardly biased plunger 62 thereon is directed forwardly and exteriorly of the liner collar 22 to be biased against the microwave sealing flange 48 when the door is closed. The switch 60 is relatively sensitive and in cases where the door closure assembly 27 is bent or distorted in use so that the sealing flange 48 thereon no longer biasingly seals the collar 22, the plunger 62 will detect such clearance to open the microwave generator power supply circuit when the inner door seal is displaced from zero to one thirty-second inch opened from the porcelainized surface on the collar 22. The microwave leakage switch 60 thereby serves as a very sensitive means for detecting potential microwave escape clearance about the door closure 27 and is responsive to detecting such opening to de-energize the power supply circuit until the situation is alleviated.

Relatively insensitive door switches are often arranged in this manner to turn on oven lights and to shut off microwave generator power circuits when the door is fully opened, but they fail to take care of peripheral door leakage clearances. While the present microwave leakage switch 60 also serves to cut off power on door opening, in addition thereto, a safety switch 64 is operatively associated therewith including a plunger actuator 66 thereon that is engaged by the cam surface 36 on one of the hinges 34 as shown in FIGURE 3. When the door is open the cam surface 36 moves away from the plunger 66 that is free to move outwardly of the switch housing

5

64 to thereby open the power supply circuit for the microwave generator.

By virtue of the safety switch 64 a user of the assembly 14 can safely move relative to the outwardly extended plunger 62 on the microwave leakage switch 60 without having to worry about depressing it and thereby inadvertently energizing the power circuit for the microwave generator when the door closure assembly 27 is opened. When the door is returned to its closed position both switches 60 and 64 are positioned to close the power circuit for the generator.

To better understand the safety aspects of the conductor strip 54, glow tube 59 and plural microswitch arrangement, reference is now made to the control circuit of FIGURE 2. When an electronic cooking operation is to be commenced, the door closure 27 is moved into its closed position to cause the microwave leakage switch 60 and the safety switch 64 to be closed. In the circuit illustrated in FIGURE 2, these switches are included in a network connected across lines L_1 , L_2 of a conventional three-wire power supply including the lines L_1 , L_2 and a line N. Following door closure a manually rotatable knob 70 on panel 16 of a timer is moved into a desired time position to close a pair of timer switches 72 in parallel conductors 74, 76 connected to L_1 . Movement of the timer knob 70 also closes a pair of timer switches 78 in parallel conductors 80, 82 connected to line L_2 . In a typical cooking operation, once the switches 72, 78 are closed an initial microwave warmup occurs that includes closing a time delay switch 84 by a time delay mechanism 86 electrically connected across lines N, L_2 by a conductor 88. Following or during movement of the timer knob 70 into an operative timer position and during closure of the time delay switch 84 to effect microwave energization, the timer knob 70 is pushed inwardly to close a momentary switch 90. Closure of time delay switch 84 and momentary switch 90 completes a relay circuit from line L_1 through switch 72, conductor 76, switch 90, a resistor 92, fuse 94, switches 64, 60, the lead 58 to the diagonal conductor strip 54, thence from the conductor lead 56 through a high temperature magnetron cutout element 96, a relay coil 98, switch 84, conductor 82 and switch 78 to line L_2 .

Once the relay coil 98 is energized, relay switches 100, 102, are closed whereby a timing circuit is completed from L_1 through switch 72, conductor 76, relay switch 100, a synchronous timer motor 104 and a conductor 106 to N. Closure of the switch 102 completes a microwave generator power circuit from line L_1 through switch 72, conductor 76, relay switch 102, fuse 94, switches 64, 60, the input terminal of a primary coil 108 and thence through the output terminal of the coil through a selector switch 110 movable into "high" and "low" power positions upon rotation of a knob 112 on the control panel 16. The primary coil 108 is only one portion of a typical microwave oven power supply 112 of a type well known to those skilled in the art. Such a power supply 112 typically includes an output circuit 114 for energizing a microwave generator 116 and another output circuit 118 for energizing a drive motor 120 for a mode stirring device as more specifically set out in the copending Deaton application.

In some cases, it may be desirable to supplement the cooking action of the microwave generator 116 by a radiant energy heating source 117. In this case, a user rotates the timer 70 into a desired operative position and turns on the radiant energy source by moving a knob 122 to an on position to close a pair of selector switches 123. This completes the timer circuit between lines L_1 and N through the timer motor 104. At the same time a resistance element energization circuit 124 is completed between lines L_1 and L_2 . If concurrent microwave and radiant energy cooking is desired, the user merely has to depress the knob 70 to close momentary switch 90 for energizing the magnetron 116.

By virtue of the diagonal conductor 54, any break in the frangible interior shield 44 will open the power sup-

6

ply circuit by interrupting it between leads 58 and 56 as illustrated in FIGURE 2. This will interrupt the power supply circuit to the microwave generator 116 during all phases of operation of the illustrated control circuit or any other equivalent circuit.

Likewise, in cases where the door has been distorted so that the peripheral microwave flange 48 no longer continuously biasingly engages the porcelain surface of the liner collar 22, the switch 60 will be moved to an open position to open the power supply circuit 114 again during all phases of the operation of the control circuit. Moreover, by the provision of the safety switch 64, when the door is open, a user cannot inadvertently close the microwave leakage switch 60 to re-energize the power circuit 114 since the switch 64 is always in an open position when the door is open and, moreover, since the switch 64 is located in a relatively inaccessible location, it cannot be inadvertently operated to negate this safety aspect.

While the glow tube or pilot indicator mentioned above is intended primarily to serve as a visual indication of leakage in the microwave cooking oven assembly, it will be appreciated that the photo-sensitive switch 61 can be included in the circuit illustrated in FIGURE 2 to interrupt the microwave generator power supply when the shielding effect of the frangible shield member 44 is no longer present.

While the embodiments of the present invention as herein disclosed constitute preferred forms, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. In a microwave oven, the combination of, a microwave generator, a power supply circuit for said generator, an inner liner including a continuously formed collar forming an access opening to the interior of the oven, a door closure assembly including a flexible continuously formed peripheral flange adapted to biasingly sealingly engage said continuous collar when said door closure assembly is in its closed position, first switch means for detecting clearances between said peripheral microwave sealing flange and said collar and operable to de-energize the power supply for said generator upon the occurrence of a predetermined microwave leakage clearance, second switch means located interiorly of said oven between said inner liner and the outer shell of said oven, and linkage means operated by opening movement of said door closure assembly to operate said second switch means to de-energize said generator power supply when said door closure assembly is in an open position whereby said first switch means can be inadvertently operated to a circuit energizing position without energizing said microwave generator when said door closure assembly is opened.

2. In a microwave oven, the combination of, an inner liner forming an oven cavity, a microwave generator for directing a radio frequency mode interiorly of said oven cavity, said liner including a continuous collar for forming an access opening to said oven cavity, door closure means for shielding against the escape of microwave energy through said access opening when said assembly is in a first position, a power supply for said microwave generator, a plurality of switch means for selectively de-energizing said microwave generator, one of said switch means responding to a predetermined clearance between said door closure means and said liner collar for de-energizing said generator to prevent leakage of microwave energy through said predetermined clearance and another of said plurality of said switch means being operated following a second predetermined clearance between said door closure means and said liner collar for de-energizing said microwave generator power supply irrespective of the operation of said one of said switch means.

3. In the combination of claim 2, said door closure means for shielding against microwave escape including a flexible outwardly directed continuous peripheral flange that biasingly engages said liner collar when said door closure assembly is in its first predetermined position,

said one switch means including a plunger actuator biased against said peripheral flange and movable into a first position for detecting said predetermined clearance between said flange and said collar to eliminate leakage of microwave energy around the periphery of the door closure means.

4. In a microwave oven, the combination of, an inner liner forming an oven cavity, a source of microwave energy, a power supply circuit for said source of microwave energy, said liner including a continuous collar forming an access opening to said oven cavity, a door closure assembly for shielding against the escape of microwave energy from said oven cavity, said door closure assembly including a viewing field for observing articles within said oven cavity, said viewing field being covered by a frangible optically transparent shield member, electrically conductive means on one face of said frangible shield member for blocking microwave energy, a first portion of said electrically conductive material being electrically insulated from the other portions of said electrically conductive material, said first portion of said electrically conductive material forming a part of said microwave generator power supply circuit and being responsive to a predetermined break in said frangible shield for opening said power supply circuit to de-energize said microwave generator to thereby prevent the escape of microwave energy from the interior of said oven cavity.

5. In the combination of claim 4, said first portion of said electrically conductive means being directed diagonally across the planar extent of said frangible shield member to detect breaks therein extending vertically or horizontally or intermediate the vertical and horizontal through the planar extent thereof.

6. In the combination of claim 5, said first portion of said electrically conductive means being spaced from the other portions of said electrically conductive means throughout the extent of said first portion of said material a predetermined distance sufficient to interrupt the migration of small fissures in said shield member while blocking microwave energy.

7. In the combination of claim 4, said electrically conductive means including a grid of fired-on metallic conductive material forming a continuous conductor portion of said power supply circuit for the microwave generator, said grid extending substantially completely across said shield member to intersect fractures therein extending vertically, horizontally or intermediate the vertical and horizontal.

8. In a microwave oven, the combination of, an inner liner forming an oven cavity, a source of microwave energy, a power supply circuit for said source of microwave energy, said liner including a continuous collar forming an access opening to said oven cavity, a door closure assembly for shielding against the escape of microwave energy from said oven cavity, said door closure assembly including a viewing field for observing articles within said oven cavity, said viewing field being completely covered by a frangible optically transparent shield member, and an electrically conductive grid of fired-on metal on one face of said frangible shield member for blocking the escape of microwave energy through said frangible shield member, a first portion of said electrically conductive grid being electrically insulated from the other portions of said grid, said first portion of said grid forming a part of said microwave generator power supply circuit and being responsive to fragmentation of said frangible shield of a predetermined degree for opening said power supply circuit to de-energize said microwave generator to thereby prevent the escape of microwave energy from the interior of said oven cavity.

9. In a microwave oven structure, the combination of, an inner liner forming an oven cavity, a microwave generator for directing a radio frequency mode interiorly of said oven cavity, said liner including a continuous collar forming an access opening to said oven cavity, a

door closure assembly for shielding against the escape of microwave energy from said oven cavity, said door closure assembly including a see-through frangible shield member having a layer of electrically conductive material thereon for blocking the escape of microwave energy, and a pilot indicator of ionizable material located exteriorly of said shield member in said door closure assembly for detecting microwave energy that passes through fractures in said frangible shield member, said pilot indicator giving a visual warning indication upon detecting a predetermined level of microwave energy leakage.

10. In the combination of claim 9, a power supply circuit for said microwave generator, and means responsive to energization of said pilot indicator for interrupting said microwave generator power circuit.

11. In a microwave oven, the combination of, an inner liner forming an oven cavity, a microwave generator for directing a radio frequency mode interiorly of said oven cavity, said liner including a continuous collar for forming an access opening to said oven cavity, door closure means for shielding against the escape of microwave energy through said access opening when said assembly is in a first position, a power supply for said microwave generator, a plurality of switch means for selectively de-energizing said microwave generator, one of said switch means responding to a predetermined clearance between said door closure means and said liner collar for de-energizing said generator to prevent leakage of microwave energy through said predetermined clearance and another of said plurality of said switch means being operated following a second predetermined clearance between said door closure means and said liner collar for de-energizing said microwave generator power supply irrespective of the operation of said one of said switch means, said door closure means including a viewing field for observing articles within said oven cavity, said viewing field being completely covered by a frangible optically transparent shield member, electrically conductive means on one face of said frangible shield member for blocking the escape of microwave energy through said frangible shield member, a first portion of said electrically conductive material being electrically insulated from the other portions of said electrically conductive material, said first portion of said electrically conductive material forming a part of said microwave generator power supply and being responsive to fragmentation of said frangible shield of a predetermined degree for opening said power supply to de-energize said microwave generator to thereby prevent the escape of microwave energy from the interior of said oven cavity.

12. In a microwave oven, the combination of, an inner liner forming an oven cavity, a microwave generator for directing a radio frequency mode interiorly of said oven cavity, said liner including a continuous collar for forming an access opening to said oven cavity, door closure means for shielding against the escape of microwave energy through said access opening when said assembly is in a first position, a power supply for said microwave generator, a plurality of switch means for selectively de-energizing said microwave generator, one of said switch means responding to a predetermined clearance between said door closure means and said liner collar for de-energizing said generator to prevent leakage of microwave energy through said predetermined clearance and another of said plurality of said switch means being operated following a second predetermined clearance between said door closure means and said liner collar for de-energizing said microwave generator power supply irrespective of the operation of said one of said switch means, said door closure means including a viewing field for observing articles within said oven cavity, said viewing field being completely covered by a frangible optically transparent shield member, electrically conductive means on one face of said frangible shield member for blocking the escape of microwave energy through said

frangible shield member, a first portion of said electrically conductive material being electrically insulated from the other portions of said electrically conductive material, said first portion of said electrically conductive material forming a part of said microwave generator power supply and being responsive to fragmentation of said frangible shield of a predetermined degree for opening said power supply to de-energize said microwave generator to thereby prevent the escape of microwave energy from the interior of said oven cavity, a pilot indicator of ionizable material located exteriorly of said shield member in said door closure assembly for detecting microwave energy that passes through fractures in said frangible shield member, said pilot indicator giving a visual warning indication upon detecting a predetermined level of microwave energy leakage.

13. In the combination of claim 12, means responsive

to energization of said pilot indicator for interrupting said microwave generator power circuit.

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15 RICHARD M. WOOD, *Primary Examiner*.

L. H. BENDER, *Assistant Examiner*.