

[54] WAVEGUIDE BANDSTOP FILTER

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[58] Field of Search..... 333/21 R, 21 A, 73 W, 76, 333/81 R, 81 B, 98 R, 98 M; 219/10.55

[56] References Cited

UNITED STATES PATENTS

2,553,649 5/1951 Garfitt..... 333/73 W X

3,593,155 7/1971 Lowe et al. 333/73 W X
3,758,737 9/1973 Ironfield 219/10.55

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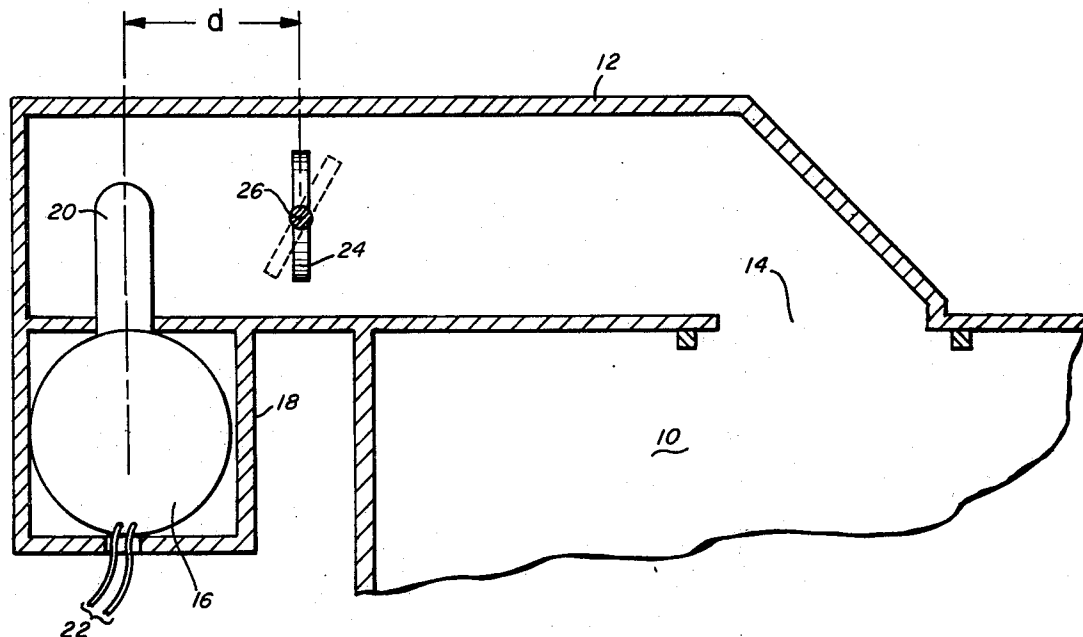
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[57]

ABSTRACT

The filter is in the form of a resonant ring disposed inside of the waveguide which feeds microwave energy to the cooking cavity of a microwave oven. The ring is preferably disposed adjacent the magnetron, can be either dielectrically or conductively supported, is rotatable for varying E vector coupling and is preferably for second harmonic suppression.

7 Claims, 6 Drawing Figures



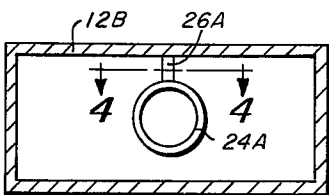
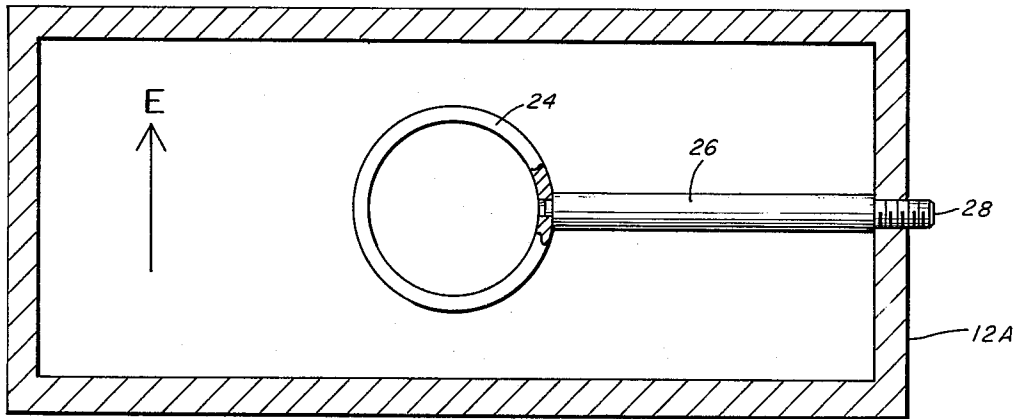
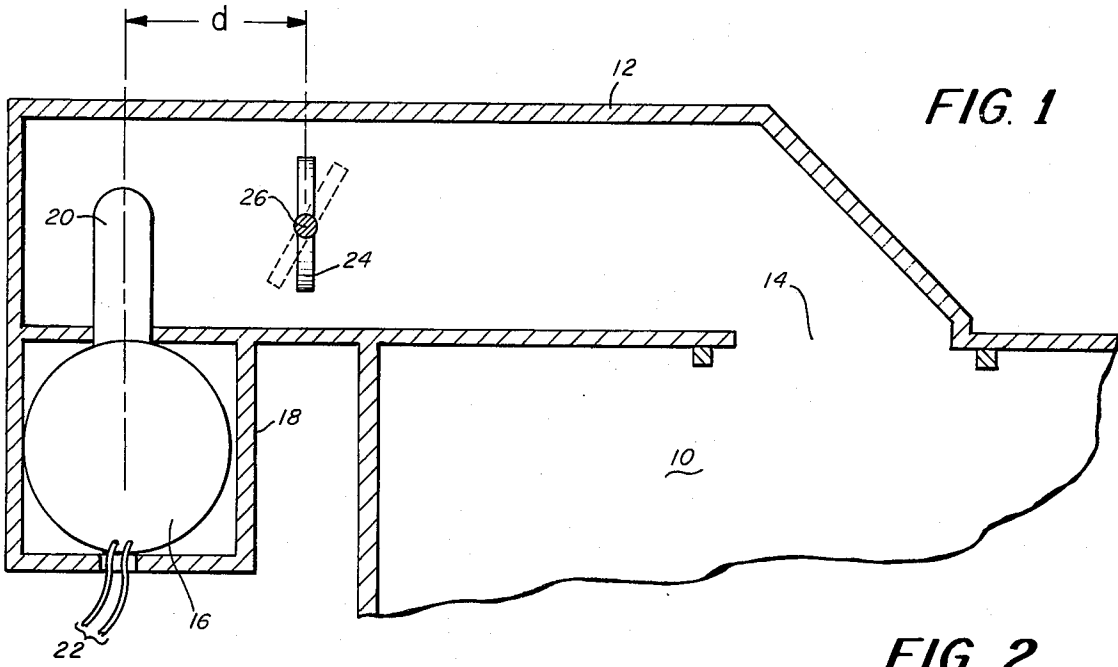


FIG. 3

FIG. 5A
MAGNETRON
OUTPUT

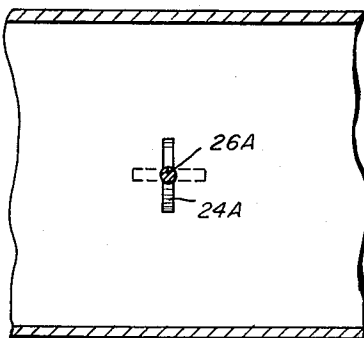
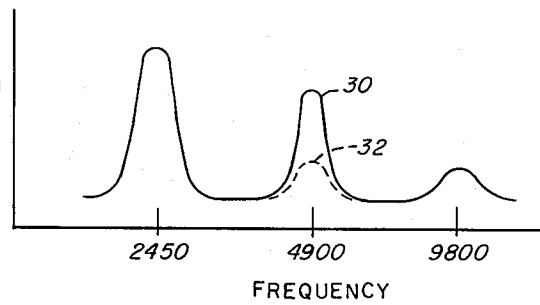
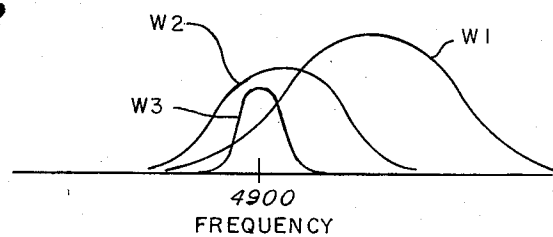


FIG. 4

FIG. 5B
MAGNETRON
OUTPUT



WAVEGUIDE BANDSTOP FILTER

BACKGROUND OF THE INVENTION

The present invention relates in general to a waveguide bandstop filter and is more particularly concerned with a resonant ring filter preferably for use in a waveguide coupling microwave energy to a microwave cooking cavity.

In the operation of microwave ovens it is sometimes found necessary to provide for suppression of one or more of the harmonics of the operating frequency. Most known waveguide bandstop filters are conventionally constructed by coupling from the waveguide to resonators outside the waveguide. These structures are generally complicated and do not couple well to all modes at harmonic frequencies. Waveguide low pass filters are known that are disposed in the waveguide but they are usually relatively complicated including cascaded high and low impedance sections of waveguide.

In accordance with this invention a simple filter structure is used that provides adequate filter rejection. Although resonant ring structures are known (see U.S. Pat. Nos. 3,593,155; 2,553,649; and 2,480,189) the structure of the present invention is considered an improved filter structure and one that is particularly adapted for use in waveguide associated with a microwave cooking cavity.

SUMMARY OF THE INVENTION

Although the filter of the present invention may be used in many different applications, it is preferably adapted for use in a microwave oven having an oven cooking cavity, a source of microwave energy at a predetermined operating frequency and a waveguide for coupling the energy from the source to the cavity. The filter structure of this invention is for suppressing at least one of the harmonics of the operating microwave frequency. The filter structure comprises a resonant ring and means for supporting the resonant ring within the waveguide adjacent the source of microwave energy and having at least a part of the ring extending in the direction of the E vector in the waveguide.

In accordance with a preferred embodiment of the present invention the resonant ring is supported by a conductive member from the narrow wall of the waveguide and the ring is disposed close to and at an empirically determined distance from the microwave energy source so as to provide optimum harmonic suppression.

DESCRIPTION OF THE DRAWINGS

A more comprehensive understanding of additional features and advantages of the present invention will be gained upon a reading of the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a cross-sectional view of a portion of a microwave oven and showing the filter structure of the present invention;

FIG. 2 is a partially cut-away cross-sectional view through the waveguide showing the filter structure in more detail;

FIG. 3 shows an alternate arrangement to that shown in FIG. 2;

FIG. 4 is a cross-sectional view taken along line 4—4 of FIG. 3; and

FIGS. 5A and 5B show graphs associated with the filter structure of this invention.

DETAILED DESCRIPTION

FIG 1 shows a portion of a microwave oven including walls defining an oven cavity 10, a waveguide 12 coupling by way of port 14 to the oven cavity 10 and a magnetron 16 which is contained within a housing 18 and includes a radiating end 20 extending into the waveguide 12. The magnetron 16 is shown schematically as having a pair of leads 22 connecting to a power source. The structure including the oven cavity, waveguide and magnetron may be of conventional design.

In accordance with the present invention there is provided the resonant ring 24 which is depicted in FIG. 2 as being of circular shape. However, this ring could also be of elliptical shape or even square or rectangular shape. In particularly for lower frequency suppressions it may be desirable to make the ring of elliptical or rectangular shape.

As most clearly depicted in FIG. 2 the ring 24 is connected by a metallic support 26 from the narrow wall 12A of the waveguide. The threaded end 28 of support 26 may protrude out from the outer surface of the waveguide so as to provide a means for providing limited rotational movement of the member 26 which in turn causes rotation of the ring 24 such as to the position shown in dotted in FIG. 1. The purpose of this rotation is discussed in more detail hereinafter.

In FIG 1 it is noted that the ring 24 is disposed a predetermined distance d from the center line of the magnetron 16. In accordance with this invention this distance is not arbitrarily selected. Once the particular magnetron has been selected the distance d is empirically determined by moving the ring 24 towards and away from the magnetron until the optimum position is obtained. In this connection note that in FIG. 5A there is shown the magnetron output with a spurious second harmonic signal about 4900 megahertz. By employing appropriate measuring apparatus it is possible to move the ring 24 so that the output peak 30 is reduced to the dotted peak 32 in the event that second harmonic suppression is desired. In this way, the proper phase relationship is established between the magnetron and the resonant ring filter. It is preferred that the distance d be as small as possible and yet provide this optimum phase relationship. The distance from the ring to the magnetron should be as close as possible so as to reduce the "long-line effect." If this phase relationship is not established by the proper placement of the ring 24 there will be an enhancement of the spurious harmonic signals.

In this way, the harmonic power from the magnetron is not only reduced at the other side of the rejection filter, but it is also reduced at any other exits from the magnetron such as where the leads 22 exit therefrom.

In accordance with another aspect of the present invention, it is noted that the ring 24 is supported by a conductive member 26 from the narrow wall of the waveguide. The prior are U.S. Pat. No. 3,593,155 teaches the use of dielectric supports for a ring as voltages are going to be applied thereto. The metal support 26 extends from the narrow wall because it is not desired to have any metal support with any appreciable component thereof extending in the direction of the E vector as depicted in FIG. 2. Any appreciable component of the member 26 in the direction of the E vector will couple energy and provide a discontinuity in the

waveguide. Accordingly, the ring is supported from the narrow wall of the waveguide.

Also, in accordance with this invention it is preferred that the embodiment of FIG. 2 be employed wherein the support member 26 is conductive and of substantially the same or larger diameter than the width of ring 24. In this way, the member 26 functions, in addition to a support, also as a heat sink for removing any heat generated in the ring to the larger waveguide heat sink. If the ring 24 has a dielectric support the electrical characteristics could be changed. For example, there could be a slight alteration of the center stopband frequency when the ring expands and there could be a decrease in the Q when the ring is hotter and thus the filter would not provide optimum rejection.

In accordance with another aspect of the present invention it is preferred that the ring 24 be rotational as depicted in the solid and dotted outline in FIG. 1. Regarding this feature, reference is also made to the graph of FIG. 5B. In the solid position shown in FIG. 1 a maximum portion of the ring 24 extends in the direction of the E vector and thus the coupling is at a maximum. In FIG. 5B waveform W1 depicts this condition wherein the stopband width is at a maximum. As the ring 24 is rotated to the dotted position shown in FIG. 1 the coupling becomes weaker and as shown by waveforms W2 and W3 the bandwidth and frequency successively decreases as the coupling weakens. It is preferable for some exact applications to rotate the ring 24 to a position wherein both conditions can be simultaneously achieved. The ring would in that case be rotated to a position wherein the bandwidth is suitably narrow and yet there is no appreciable frequency shift.

Regarding the dimensions of the ring itself, the ring is resonant when the inner circumference is approximately one wavelength long. As previously indicated, if the ring is inserted in a rectangular waveguide the resonant frequency is effected or shifts by rotation of the plane of the ring. The ring may also be used in multiples to achieve higher rejection than with the use of a single ring. However, for many applications the single ring structure is sufficient. In the application of the resonant ring of this invention to microwave ovens it was found that adequate second harmonic suppression was provided without significant effect on the fundamental power transmitted to the microwave oven cavity. Low power measurements of the ring yielded more than a 20db rejection at the ring resonant frequency for any plane of the ring when it was centrally located. The 10db rejection bandwidth was about 180 megahertz.

In one example the ring that was used had a 0.875 outer diameter; a 0.775 inner diameter; and was 0.1 inches thick; and it was also found with the use of the ring, the VSWR only changed from 1.8:1 to 2.2:1 by introduction of the ring.

FIGS. 3 and 4 show an alternate arrangement wherein there is shown a ring 24A supported by member 26A from a wide wall 12B of the waveguide. In this embodiment the support 26A is a dielectric support and thus need not extend from the narrow wall as in the embodiment shown in FIG. 2. In this embodiment the ring 24A can also be rotated as indicated in FIG. 4 and one of the advantages is that the rotation in this manner does not change the E coupling. Therefore, rotation can be accomplished so as to tune to the proper center rejection frequency.

Having described a limited number of embodiments of the present invention it should now be obvious to those skilled in the art that there are many other embodiments and modifications of those disclosed herein all of which are contemplated as following within the spirit and scope of the present invention. As previously mentioned, for example, the ring can be of many different configurations. Also, the support from the narrow wall can be provided from opposite narrow walls also to provide additional support and heat dissipation from the ring structure. Also, it is contemplated that the ring structure can be used in applications other than in association with a microwave oven.

What is claimed is:

1. For a microwave oven having means defining an oven cooking cavity, a source of microwave energy at a predetermined frequency and a waveguide for coupling the energy from the source to the cavity, a filter for suppressing a harmonic of the operating microwave frequency comprising a resonant ring and means for supporting the resonant ring within the waveguide and from a wall thereof adjacent the source of microwave energy and having at least a part of the ring extending in the direction of the E vector of the field in the waveguide, said source including a magnetron having a radiating end with said ring disposed an empirically predetermined distance from the radiating end so as to minimize the magnitude of the second harmonic generated by the magnetron.
2. The filter of claim 1 wherein said means for supporting includes a conductive member having means for permitting its support from a narrow wall of the waveguide.
3. The filter of claim 2 wherein said ring is circular and has an inner diameter on the order of one wavelength of the center rejection band frequency.
4. The filter of claim 3 wherein said conductive member has a cross-sectional area equal to or greater than the width of the ring so as to provide good heat transfer.
5. The filter of claim 2 wherein said ring is rotatable to vary E vector coupling.
6. The filter of claim 1 wherein said means for supporting includes a dielectric member supporting said ring from a wide wall of the waveguide.
7. In combination:
 - a plurality of walls defining an oven cooking cavity, a source of microwave energy for generating a signal having a principle operating frequency,
 - a rectangular waveguide having a pair of broad walls and a pair of narrow walls and for coupling the signal from the source to the cooking cavity,
 - a circular resonant ring filter structure for suppressing a harmonic of the operating microwave frequency,
 - and means for supporting the resonant ring within the waveguide adjacent the source of microwave energy and having at least a part of the ring extending in the direction of the E vector of the field in the waveguide,
 - said means for supporting the resonant ring including a conductive member having means for permitting its support from one of the narrow walls of the waveguide in a manner to allow limited rotation of the member which in turn rotates said ring to vary the suppression bandwidth without materially varying the center suppression frequency,

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said conductive member having a cross-sectional area equal to or greater than the width of the ring so as to provide good heat transfer between the ring and waveguide walls,

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and wherein said ring has an inner diameter on the order of one wavelength of the center rejection band frequency.

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