United States Patent [19]

Hiramatsu

[11] **3,860,891**

[45] **Jan. 14, 1975**

[54] **MICROWAVE WAVEGUIDE WINDOW HAVING THE SAME CUTOFF FREQUENCY AS ADJOINING WAVEGUIDE SECTION FOR AN INCREASED BANDWIDTH**

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[73] Assignee: **Varian Associates,** Palo Alto, Calif.

[22] Filed: **June 11, 1973**

[21] Appl. No.: **368,806**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 102,590, Dec. 30, 1970, abandoned.

[52] **U.S. Cl.** ..... **333/21 R,** 333/33, 333/34, 333/98 P

[51] **Int. Cl.** **H01p 1/08,** H01p 5/08

[58] **Field of Search** ..... 333/98 P, 21 R, 33, 34

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Primary Examiner—Michael J. Lynch
Assistant Examiner—William W. Punter
Attorney, Agent, or Firm—Stanley Z. Cole; Robert K. Stoddard; Harry E. Aine

[57] **ABSTRACT**

A microwave waveguide window is disclosed wherein a dielectric filled window section of waveguide is sealed across a waveguide. The window filled section of waveguide in one embodiment is dimensioned to have approximately the same low frequency cutoff wavelength as that of the adjoining sections of guide, such that the window and that of the adjoining sections of the waveguide support approximately the same waveguide transmission modes. In certain windows of the present invention, a quarter wave matching transformer portion of the dielectric window extends from the window into the adjacent waveguide sections. In other windows of the present invention, one or both adjoining sections of waveguide have a substantially lower height, such as ridged waveguide, than the dielectric filled window section and a short section of transition waveguide is interposed between the window and the adjoining lower height waveguide with the dielectric window member projecting into the transition section of waveguide.

15 Claims, 28 Drawing Figures

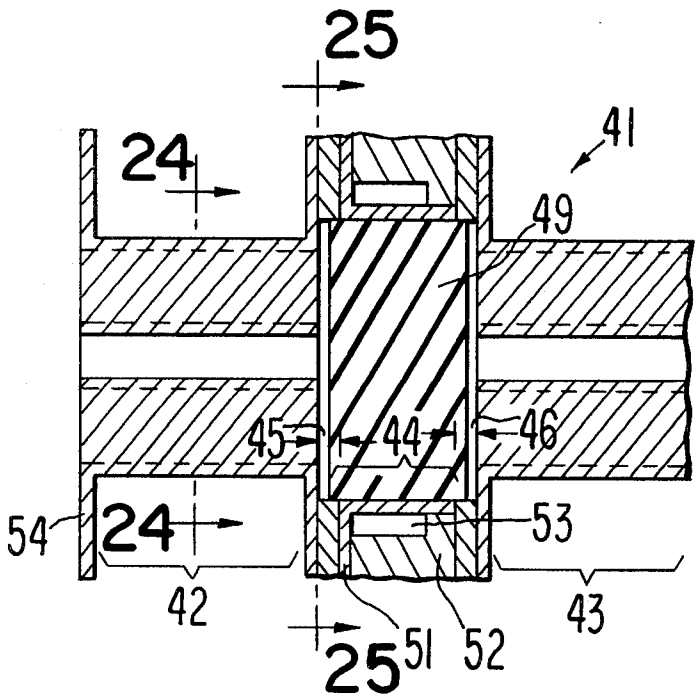


FIG. 1

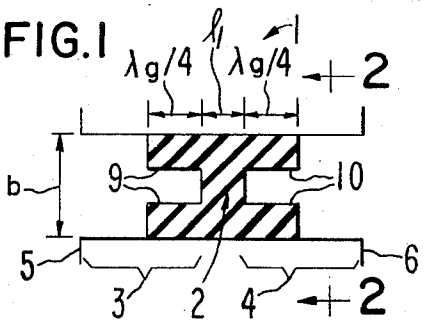


FIG. 2

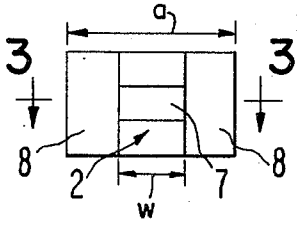


FIG. 3

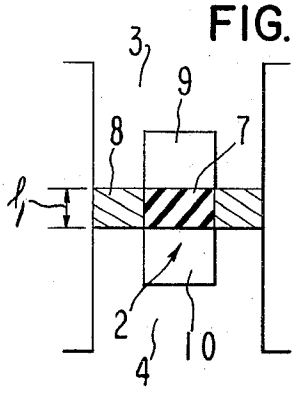


FIG. 4

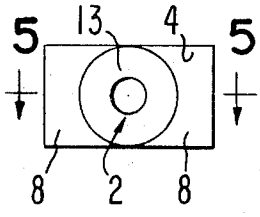


FIG. 4A

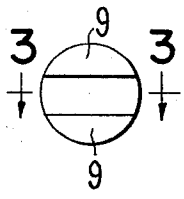


FIG. 5

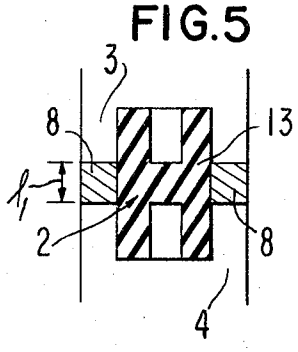


FIG. 7

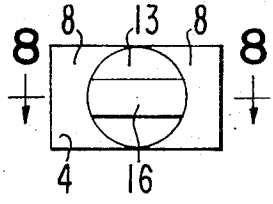


FIG. 6

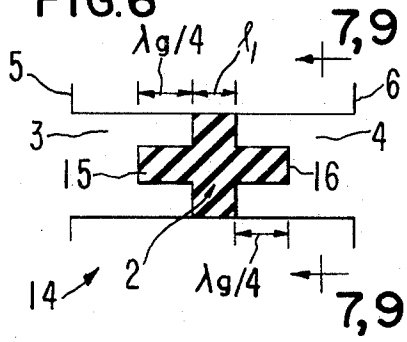


FIG. 9

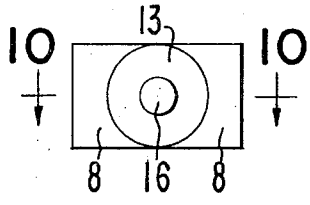
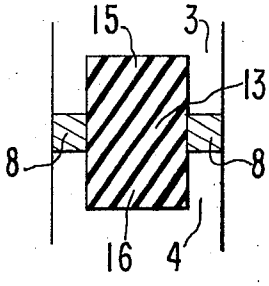


FIG. 8



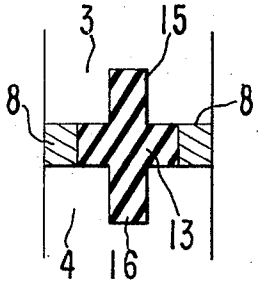


FIG. 11

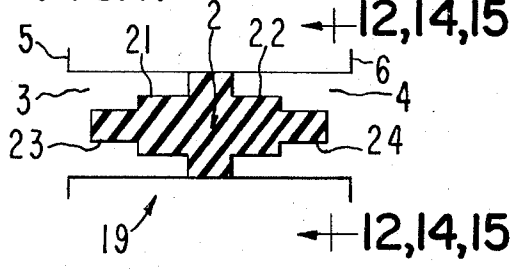


FIG. 10

FIG. 14

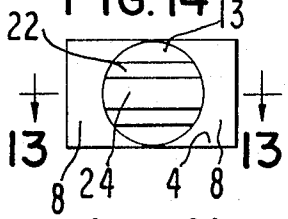


FIG. 12

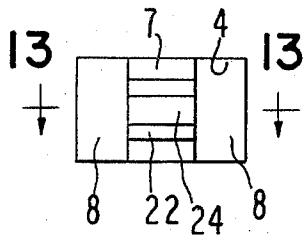


FIG. 13

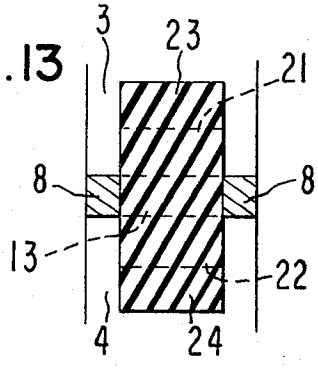
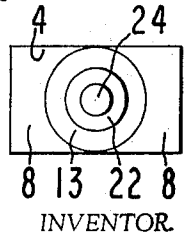


FIG. 15



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FIG.16

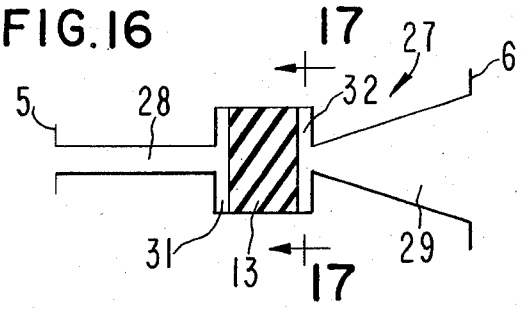


FIG.17

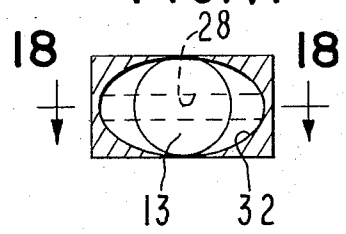
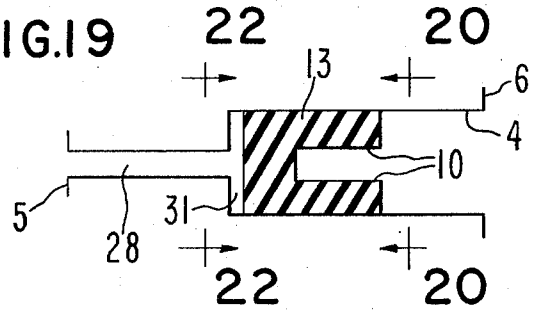


FIG.19



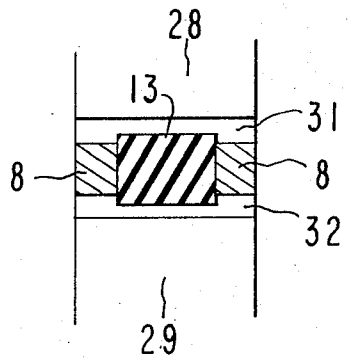
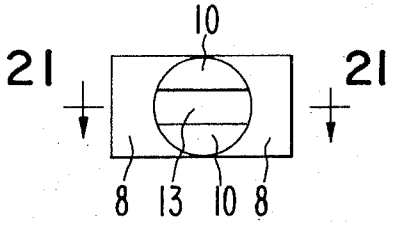


FIG.18

FIG.20



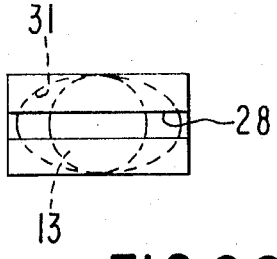


FIG.22

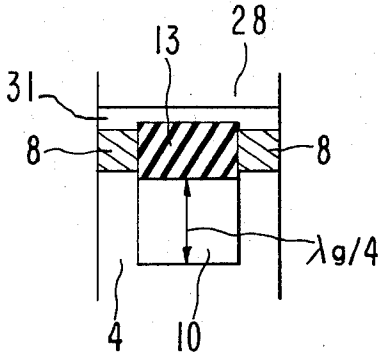


FIG.21

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FIG. 23

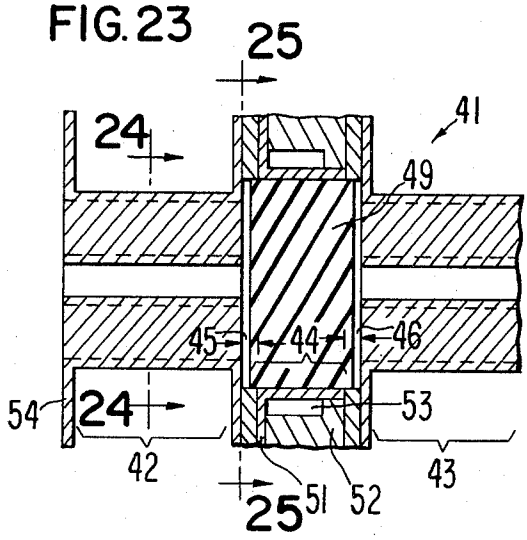


FIG. 24

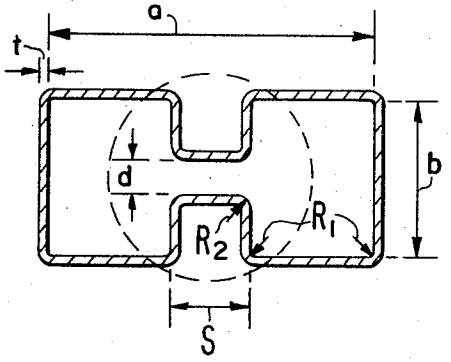


FIG. 25

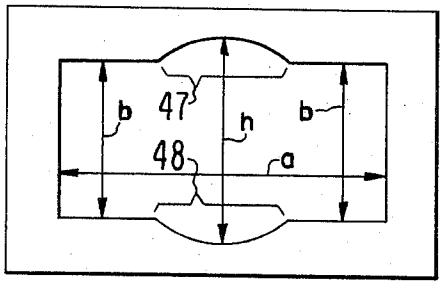


FIG. 26

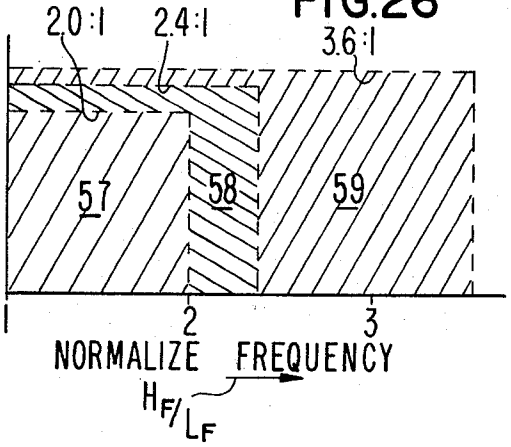
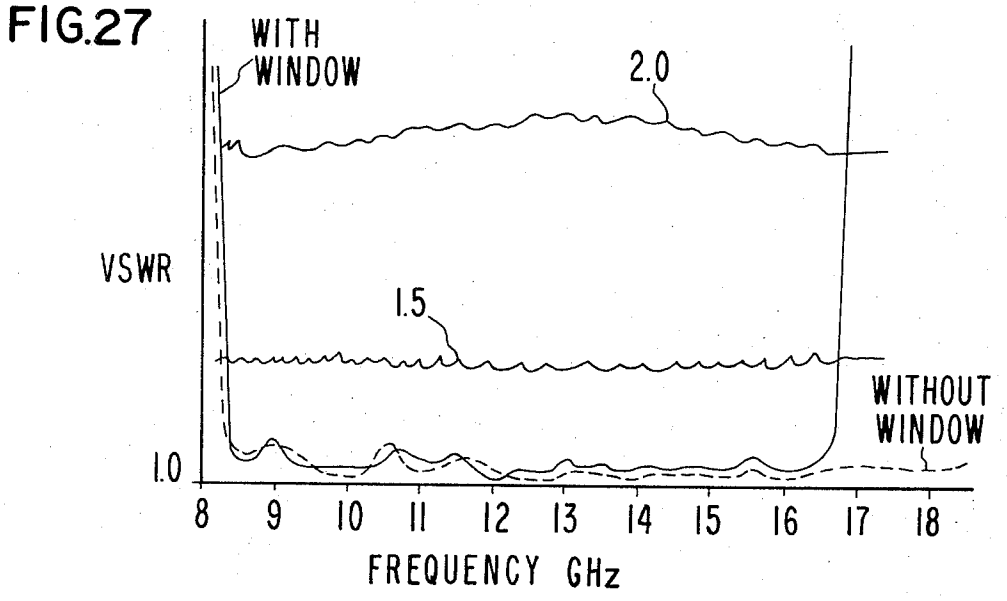


FIG. 27



MICROWAVE WAVEGUIDE WINDOW HAVING THE SAME CUTOFF FREQUENCY AS ADJOINING WAVEGUIDE SECTION FOR AN INCREASED BANDWIDTH

RELATED CASES

The present application is a continuation-in-part application of copending parent application Ser. No. 102,590 filed Dec. 30, 1970 now abandoned.

DESCRIPTION OF THE PRIOR ART

Heretofore, microwave waveguide window structures have been constructed which included a dielectric window section of guide interposed between adjoining sections of waveguide. In such microwave windows, the windows were not dimensioned to have essentially the same low frequency cutoff as the adjoining waveguide sections. In most instances, the dielectric filled window section of guide had a width which was approximately equal to the width of the adjoining waveguide sections, such that the low frequency cutoff in the window section of guide was substantially lower than the low frequency cutoff of the adjoining waveguide sections. Thus, the window was capable of supporting many transmission modes which could not be supported in the adjoining waveguide sections. These additional modes, which may be supported within the window section can be excited by wave energy within the bandpass of the waveguide and tended to reduce the useful bandwidth of the window structure.

In one type of prior art window, the window substantially filled the entire cross section of the waveguide including the adjoining waveguide sections and the dielectric window section was made an integral number of half wavelengths long so that the resultant characteristic impedance mismatch produced by the window was compensated over a narrow range of frequencies for which the wave reflections from one face of the window was cancelled by the wave reflection from the opposite face of the window.

In another prior art type of window, the axial length of the window section was made an integral number of odd quarter wavelengths, preferably one-quarter wavelength long, with the height of the window being selected such that it had an impedance equal to the square root of the product of the impedances of the adjoining waveguides on opposite sides of the window, such that the window formed a quarter wave impedance matching transformer. Such a window is disclosed and claimed in U.S. Pat. No. 2,576,186 issued Nov. 27, 1951. Both of these prior art types of windows were relatively narrow band having a useful bandwidth which was less than a half of the bandwidth of the waveguide. Therefore, it is desirable to obtain a microwave window having a bandwidth comparable to the bandwidth of the waveguides which adjoin the window.

SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of an improved microwave waveguide window.

One feature of the present invention is the provision of a microwave waveguide window having a dielectric window filled section of waveguide interposed between adjoining waveguide sections with the window section of waveguide dimensioned to have approximately the same cutoff wavelength as the adjoining waveguide sections, whereby the window section will support approximatly the same number of waveguide transmission modes for increasing the bandwidth of the window.

In another feature of the present invention, the window section of waveguide is dimensioned to have approximately the same characteristic impedance as the adjoining waveguide sections for impedance matching the window.

In another feature of the present invention, the window section of waveguide includes a portion of the dielectric window member extending from the window into at least one of the adjacent waveguide sections for cancelling wave reflections from the transition between the adjoining waveguide section of the window section.

In another feature of the present invention, at least one of the sections of waveguide adjoining the window section has at least a portion with a height substantially less than that of the window section and wherein a transition section of waveguide is interposed between the window section and the low height waveguide section, such transition section being dimensioned to have a length substantially shorter than a quarter wavelength.

In another feature of the present invention, the adjoining waveguide sections are of rectangular waveguide and the window section is of circular waveguide.

In another feature of the present invention, a dielectric filled section of non-ridged waveguide is interposed between sections of ridged waveguide, whereby a broadband high-power waveguide window assembly is obtained.

In another feature of the present invention, the dielectric filled section of non-ridged waveguide has a length equal to one-half of an electrical wavelength at a frequency within the passband of the window assembly, whereby wave reflections from opposite sides of the window cancel over a wide range of frequencies.

Other features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal section view, partly in schematic line diagram form, depicting a microwave waveguide window incorporating features of the present invention,

FIG. 2 is a sectional view of the structure of FIG. 1 taken along line 2—2 in the direction of the arrows,

FIG. 3 is a sectional view of the structure of FIGS. 2 and 4A taken along lines 3—3 in the direction of the arrows,

FIGS. 4 and 4A are sectional views similar to that of FIG. 2 depicting alternative embodiments of the present invention,

FIG. 5 is a sectional view of the structure of FIG. 4 taken along line 5—5 in the direction of the arrows,

FIG. 6 is a longitudinal sectional view partly in schematic line diagram form of alternative embodiments of the invention,

FIG. 7 is a sectional view of the structure of FIG. 6 taken along line 7—7 in the direction of the arrows,

FIG. 8 is a sectional view of the structure of FIG. 7 taken along line 8—8 in the direction of the arrows,

FIG. 9 is a view of the structure of FIG. 6 taken along line 9—9 in the direction of the arrows and depicting an alternative embodiment of the present invention,

FIG. 10 is a sectional view of the structure of FIG. 9 taken along line 10—10 in the direction of the arrows,

FIG. 11 is a longitudinal sectional view, partly in schematic line diagram form, of a microwave window incorporating alternative features of the present invention,

FIG. 12 is a view of the structure of FIG. 11 taken along line 12—12 in the direction of the arrows,

FIG. 13 is a sectional view of the structure of FIG. 12 taken along line 13—13 in the direction of the arrows,

FIG. 14 is a view of the structure of FIG. 11 taken along line 14—14 in the direction of the arrows depicting an alternative embodiment of the present invention,

FIG. 15 is a view of the structure of FIG. 11 taken along line 15—15 in the direction of the arrows depicting an alternative embodiment of the present invention,

FIG. 16 is a schematic longitudinal sectional view of a microwave window incorporating alternative features of the present invention,

FIG. 17 is a sectional view of the structure of FIG. 16 taken along line 17—17 in the direction of the arrows,

FIG. 18 is a sectional view of the structure of FIG. 17 taken along line 18—18 in the direction of the arrows,

FIG. 19 is a longitudinal schematic sectional view of a microwave window incorporating alternative features of the present invention,

FIG. 20 is a sectional view of FIG. 19 taken along line 20—20 in the direction of the arrows,

FIG. 21 is a sectional view of the structure of FIG. 20 taken along line 21—21 in the direction of the arrows,

FIG. 22 is a sectional view of the structure of FIG. 19 taken along line 22—22 in the direction of the arrows,

FIG. 23 is a longitudinal sectional view of a microwave window assembly incorporating features of the present invention,

FIG. 24 is a transverse sectional view of the structure of FIG. 23 taken along line 24—24 in the direction of the arrows,

FIG. 25 is a transverse sectional view of the structure of FIG. 1 taken along line 25—25 in the direction of the arrows and depicting the transition section of waveguide,

FIG. 26 is a plot of the normalized bandwidth of two types of ridged waveguide and for the microwave window assembly of FIG. 23, and

FIG. 27 is a plot of voltage standing wave ratio (VSWR) vs. frequency showing the passband characteristics for a window of the present invention and for ridged waveguide without the provision of the window.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1, 2 and 3, there is shown a microwave waveguide window 1 incorporating features of the present invention. The microwave waveguide window 1 includes a dielectric filled section of waveguide 2 of relatively short length l_1 adjoining second and third sections of the waveguide 3 and 4 which may be of any length. The ends of such waveguide sections 3 and 4 include flange assemblies 5 and 6 for mating to adjacent waveguide sections, not shown. The dielectric filled section of waveguide 2 forms part of a dielectric window member 7, as of beryllia or alumina ceramic, hermetically sealed in a gas tight manner, as by brazing, to a widow frame member 8, as of copper.

The width w of the window-filled section of waveguide 2 is dimensioned to have a cutoff wavelength substantially the same as, i.e., within 5 percent of, the cutoff wavelength of the adjoining rectangular waveguide sections 3 and 4. The cutoff wavelength λ_c is equal to $2a\sqrt{\epsilon}$ where a is the width of the rectangular waveguide and ϵ is the dielectric constant of the window material. In the case where the window material has a dielectric constant of 9 the width w of the window section 2 is one-third the width a of the waveguides 3 and 4. In addition, the window section of waveguide 2 is dimensioned to have the same characteristic impedance Z_c as the adjoining waveguide sections 3 and 4. The characteristic impedance Z_c is proportional to $377 \times b/a\sqrt{\epsilon}$ assuming that the dielectric filled section and the waveguide sections have the same cutoff wavelength. Thus, it is seen that the height of the dielectric filled window section b must be increased proportionately to the square root of ϵ to maintain the same characteristic impedance for the dielectric filled window section of waveguide 2. This means that the window section 2 has substantially the same height as the adjoining waveguide sections 3 and 4 on opposite sides of the window section 2.

In addition, portions of the dielectric window member are provided to project from the window member 2 into the adjoining waveguide sections 3 and 4 via approximately an integral number of odd quarter wavelengths and preferably only one-fourth wavelength to provide quarter wavelength transformer sections 9 and 10 for producing a wave reflection from the outer most faces thereof to cancel the wave reflections produced at the abrupt discontinuity produced by the conductive frame member 8. Moreover, in a preferred embodiment, the length l_1, of the window filled section of waveguide 2 is preferably made approximately one-half a guide wavelength long such that wave reflections produced by one face of the window are cancelled by wave reflections produced at the opposite face.

It is found that the window of FIGS. 1–3 provides an extremely wide bandwidth covering substantially the entire waveguide bandwidth. In a typical G- band (3.85 – 7.0 GHz) microwave waveguide window 1 of the configuration as shown in FIGS. 1–3, the waveguide sections 3 and 4 had a width a of 1.872 inches and a height of 0.872 inch. The window member 7 had a width w of 0.764 inch and a height of 0.870 inch. The window was made out of a material having a dielectric constant of 6, such as beryllium oxide or stycast plastic. The window portions 9 and 10 which projected into the adjoining waveguide sections had lengths of 0.450 inch, respectively. The thickness l_1, of the window member 7 was 0.105 inch and the height of each of the window projection portions 9 and 10 was 0.280 inch, respectively.

Referring now to FIGS. 1, 4 and 5, there is shown an alternative embodiment of the present invention. In this embodiment, the dielectric-window-filled section of guide is a circular section of dielectric-filled waveguide as opposed to a rectangular section of waveguide. The circular window 7 is brazed into a circular bore in the window frame 8. The circular section of waveguide is dimensioned to have a cutoff frequency substantially equal to, i.e., within 5 percent of, the cutoff frequency of the adjoining waveguide section 3 and 4. The window includes quarter wave sections projecting into the adjoining waveguide sections to cancel reflections from the window. The outwardly projecting portion of the window member 7 may be a hollow cylindrical portion

or two sections of a cylinder, as shown by FIGS. 4–5 and 3–4A respectively. The cylindrical section of dielectric filled waveguide has the advantage of ease of construction as compared to the rectangular window of FIGS. 1–3.

Referring now to FIG. 6, there is shown an alternative microwave window 14 incorporating features of the present invention. The window 14 is substantially the same as that of FIG. 1 with the exception that the quarter wave transformer window sections 9 and 10 have been replaced by center sections 15 and 16 projecting into the adjoining waveguide sections 3 and 4. As in the embodiment of FIG. 1, the window 14 may be of rectangular configuration, as shown in FIG. 2, or of circular configuration, as shown in FIG. 7 or FIG. 9. Likewise, the quarter wave projecting sections 15 and 16 may be of generally rectangular shape, as shown in FIG. 7, or of circular shape as shown in FIG. 9.

Referring now to FIGS. 11–15 there is shown a microwave window 19 incorporating alternative features of the present invention. Window 19 is substantially the same as previously described with regard to FIGS. 1–10 with the exception that the quarter wave transformer section protruding from the window member 7 into the adjacent waveguide sections 3 and 4 has two quarter wave sections for providing a smoother transition, and therefore, a lesser amount of wave reflection, to the waveguide sections 3 and 4 from the dielectric filled window section of guide 2. As in the previous embodiments, the window section 2 may be of rectangular configuration as shown in FIG. 12 with the quarter wave matching transformer section comprising the first quarter wave sections 21 and 22 projecting from opposite sides of the window member into the adjacent sections and an outer quarter wavelength matching section 23 and 24, respectively, of a lesser cross section. The rectangular configuration is shown in FIGS. 12 and 13. The circular window configurations 13 are shown in FIGS. 14 and 15.

Referring now to FIGS. 16–18, there is shown a microwave window structure 27 incorporating alternative features of the present invention. Microwave window 27 of FIG. 16 is particularly useful as the output window of a microwave traveling wave tube wherein the waveguide section 28 attached to the tube is constructed to be very thin in the direction of the beam to accommodate the beam focusing structure surrounding the tube. In a typical example, waveguide 28, which connects the window to the tube, will have a height *b* only approximately one-seventh the normal height of standard waveguide for the frequency band of interest. The problem that this introduces is the reduced height waveguide has a characteristic impedance which is one-seventh the characteristic impedance of the normal height guide.

Thus, the window 27 of FIG. 16 includes a window section of circular guide 13 interposed between the reduced height section of rectangular guide 28 and a tapered section of rectangular waveguide 29, tapering from the reduced height of waveguide 28 to the normal height of rectangular guide at output flange 6. Waveguide sections 28 and 29 and window waveguide section 13 are all dimensioned to have substantially the same cutoff wavelength, i.e., within 5 percent. A pair of short transition waveguide sections 31 and 32 of substantially oval cross section, respectively, are provided between the window section 13 and the waveguide sections 28 and 29. The oval transition waveguide sections 31 and 32 are dimensioned to have a cutoff wavelength substantially the same as the other waveguide sections 28, 29 and 13 and to have a height substantially equal to the height of the circular waveguide section 13. The oval sections 31 and 32 serve to guide the waves into the circular window section 13. In addition the dielectric window material projects slightly from the frame member 8 into the adjacent oval waveguide transition sections 31 and 32, respectively.

For example, in a typical window 27, the window material projects over the frame 8 into the adjacent sections 31 and 32 by approximately one-third the axial length of the transition sections 31 and 32, respectively, and by an amount less than one quarter of a guide wavelength. In addition, the window section 13 is made approximately half a guide wavelength long at the center frequency of the window. In a typical K_u band window designed for operation in K_u band (12.4 to 18 GHz), the waveguide 28 has a height of 0.086 inch and a normal width of 0.662 inch. The transition sections 31 and 32 have lengths of 0.013 inch, respectively, and the window member 13 projected into the adjacent oval transition is 31 and 32 by 0.005 inch. The waveguide window 13 is of circular waveguide having the normal waveguide diameter of 0.311 inch. The output waveguide 29 had a reduced height adjacent the window of 0.086 inch and a normal height at the output flange 6 of 0.311 inch. The resultant microwave window 27 has 80 percent bandwidth, whereas the standard waveguide has only 50 percent bandwidth.

Referring now to FIGS. 19–22 there is shown an alternative microwave window structure 13 incorporating features of the present invention. The window structure 13 is particularly suitable as the output or input window for a traveling wave tube because the reduced height guide 28 may be connected to the tube via input flange 5 and output flange 6 may be connected to the standard height waveguide. The structure of FIG. 19 is substantially the same as that of FIG. 16 with the exception that the reduced height input end of the output guide section 29 of the structure of FIG. 16 has been replaced by a normal height rectangular waveguide 4 of the type shown in FIGS. 1–10. In addition, while oval waveguide transition section 31 of FIGS. 16–18 has been retained, the second oval section of transition waveguide 32 has been eliminated. Also, quarter wave window projection portions 10, similar to those of FIGS. 3 and 4A have been incorporated.

Referring now to FIG. 23, there is shown a microwave window assembly 41 incorporating features of the present invention. The window assembly 41 includes first and second lengths of double ridged waveguide 42 and 43 having a cross-section as shown in FIG. 24. A dielectric filled section of waveguide 44 may be rectangular, oval or circular cross section, thee latter being the preferred embodiment due to its ease of fabrication.

A pair of short transition sections of waveguide 45 and 46 are provided at opposite faces of the window section 44 for transitioning the main mode of electromagnetic wave energy from the ridged waveguide into the dielectric filled section of waveguide 44 and thence from the dielectric filled section back into the ridged waveguide. The transition sections of waveguide 45 and 46 have inside cross-sectional dimensions as shown in FIG. 25 and each includes a central region of in-

creased height h, which is equal to the maximum height of the dielectric filled waveguide section **44** and outer regions of height b with an overall total width, a, each of the latter two dimensions a and b being preferably equal to the corresponding dimensions of the ridged waveguide sections **42** and **43.**

In addition, the central region of increased height h preferably has a contour matching the contour of the dielectric filled section. Thus, in the case where the dielectric filled section **44** is of circular cross-section, the central region of the transition section of waveguide has concave top and bottom wall portions **47** and **48** with a radius of curvature equal to the radius of curvature of the dielectric filled section **44.**

The dielectric fill **49,** as of alumina or beryllia ceramic, projects axially into each of the transition sections of waveguide **45** and **46** by an amount which is determined empirically to yield the least amount of wave reflection. In a typical example, it is found that the dielectric fill material **49** should project for an axial length approximately equal to half the axial length of the waveguide transition sections **45** and **46,** respectively. Also the transition sections **45** and **46** are dimensioned in length empirically to have the shortest length commensurate with the least amount of wave reflection from the transition sections **45** and **46.**

The dielectric filled section of waveguide **44** is formed by brazing a metallized dielectric fill member **49** to a cup-shaped frame **51.** An annular metallic member **52** is brazed to the cup-shaped frame **51** to define an annular coolant passage **53** between the frame **51** and the ring **56.** A pair of radial bores, not shown, communicate with the annular coolant passage **53** for conducting a flow of coolant therethrough for removing heat from the window in use.

The ridged waveguide sections **42** and **43** are brazed to the transition sections **45** and **46,** which in turn are brazed to the dielectric filled waveguide section including the cup frame **51** and the annular ring **52** to form a hermetically sealed microwave window assembly **44.** One of the ridged waveguide sections **42** is typically provided with a flange **54** for coupling to a utilization device or another section of waveguide, and the other section of ridged waveguide **43** may be provided with a flange or can be brazed directly or formed as a portion of a microwave tube or other source of microwave energy. In the case where the window assembly **44** is utilized as a portion of a microwave tube, that portion of the microwave window assembly **44** which faces the tube is typically evacuated in use.

In a typical example of a ridged waveguide microwave window assembly **44** of the present invention designed for passband operation between 8 and 16 GHz, the ridged waveguide and window elements have the following dimensions: Referring to the letter designations in FIG. **24,** the dimensions in inches are as follows: $a = 0.691$ inch; $b = 0.321$ inch; $d = 0.136$ inch; $s = 0.173$ inch; $t = 0.050$ inch; $R_1 = 0.020$ inch; $R_2 = 0.027$ inch and the waveguide provides 0.064 db attenuation per foot. The dielectric fill material is beryllia ceramic having a metallized O.D. of 0.419 inch and a metallized length of 0.145 inch with 0.020 nonmetallized projections extending axially into each of the transition sections **45** and **46.** The dielectric fill has a diameter of 0.416 inch and an axial length of 0.185 inch. The diameter h (See FIG. **25**) of the transition section is 0.417 inch and the dimensions a and b of the transition sections **45** and **46** are identical to the corresponding dimensions a and b of the ridged waveguide sections **42** and **43.** Each of the transition sections of waveguide has an axial length of 0.030 inch which is shorter than a quarter guide wavelength at the center frequency of the passband of the window.

The aforedescribed window assembly **44** provides a normalized passband, i.e., the ratio of highest useufl frequency to the lowest useful frequency of approximately 2.0:1, as shown by the cross-hatched region **57** of FIG. **26.** The ridged waveguide with the aforecited dimensions provides a normalized passband of approximately 2.4:1, as shown by the cross-hatched region **58** of FIG. **26.** Other double ridged waveguide can provide a bandwidth of 3.6:1 as shown by cross-hatched region **59** of FIG. **26.** The useful passband width of the ridged waveguide microwave window assembly **44** is primarily determined by the bandwidth of the dielectric filled section **44,** as the ridged waveguide sections are capable of propagating wave energy within the first transmission passband having substantially wider bandwidths as shown in FIG. **26.** Accordingly, the dielectric filled section **44** and the adjoining matching sections **45** and **46** are dimensioned to control the passband of the dielectric filled section **44.** Thus, these dimensions of **44, 45** and **46** can be chosen to place the passband of the window anywhere within the passband of the ridged waveguide.

In the case where the dielectric filled section of waveguide **44** is circular, the low frequency cutoff for that section is not independently controllable relative to the impedance of the section. Thus, the low frequency cutoff for the circular dielectric filled section **44** is determined by the impedance requirements to obtain a broad band match to the ridged waveguide. However, in the case of a rectangular dielectric filled section **44,** the low frequency cutoff and impedance are separately controllable. In such a case the height of the dielectric filled section **44** is chosen to match the characteristic impedance of the ridged waveguide sections and the width of the rectangular dielectric filled section **44** is dimensioned to make its low frequency cutoff preferably equal to, i.e., within 5 percent of, the low frequency cutoff of the ridged waveguide sections.

The ridged waveguide window assembly **44,** with the aforecited dimensions, provides extremely wideband, high power operation as shown by the passband characteristic of FIG. **27.** More particularly, the window provides a passband width of approximately 8.2 GHz to 16.5 GHz with a voltage standing wave ratio less than 1.3. The window assembly can be scaled in dimensions with frequency to provide wide passband operation over the entire microwave frequency range. In addition to its wide passband characteristics, the ridged waveguide window assembly **44** is relatively easy to fabricate. The critical dimensions, as far as bandwidth is concerned, are the axial lengths of the transition sections **45** and **46,** and the extent to which the dielectric fill **49** protrudes into each of these adjacent matching sections.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a microwave waveguide window for propagation of microwave frequencies within a selected bandwidth, hollow waveguide means, microwave dielectric window means hermetically sealed across said waveguide to define a first dielectric window-filled waveguide section interposed between second and third waveguide sections, said first, second and third waveguide sections are dimensioned to have approximately the same cutoff wavelength, whereby each of said first, second and third waveguide sections will support approximately the same number of waveguide transmission modes, said first waveguide section having a dielectric-filled length l_1 which is less than one wavelength long at the center frequency of said selected bandwidth, said second section of waveguide having substantially less characteristic impedance than said first section of waveguide, and including a transition section of waveguide interposed between said first and second sections of waveguide, said transition section of waveguide dimensioned to have approximately the same cutoff wavelength as said first and second waveguide sections and being substantially shorter than said first section of waveguide, and wherein said dielectric window material protrudes from said first section of waveguide into said transition section of waveguide by an amount substantially less than the length of said transition section of waveguide, whereby wave reflections from the waveguide transition from said second to said first waveguides are effectively cancelled.

2. The apparatus of claim 1 wherein said first and third sections of waveguide are dimensioned to have approximately the same characteristic impedance.

3. The apparatus of claim 2 wherein said second and third sections of waveguide are rectangular waveguides and said first section of waveguide is a section of circular waveguide.

4. The apparatus of claim 3 wherein said transition section of waveguide is of oval cross section.

5. In a microwave window assembly:

ridged waveguide means for transmission therethrough of microwave energy within a predetermined passband of frequencies;

a length of dielectric-filled non-ridged waveguide means transversely interposed in said ridged waveguide means to form a microwave window for hermetically sealing axially spaced first and second portions of said ridged waveguide means from each other; and

waveguide transition means disposed on opposite sides of said dielectric-filled waveguide means for transitioning the ridged waveguide transmission mode of wave energy into and out of said dielectric-filled section of non-ridged waveguide, wherein said dielectric-filled section of waveguide includes a dielectric fill structure which projects axially for a distance less than $\lambda/4$ into each of said transition sections of waveguide.

6. The apparatus of claim 5 wherein said dielectric filled waveguide section has a length corresponding to one-half a wavelength at a frequency within said predetermined passband of frequencies.

7. The apparatus of claim 5 wherein each of said transition means has a length shorter than one-quarter of a wavelength at the center frequency of said predetermined passband of frequencies.

8. The apparatus of claim 5 wherein said dielectric filled section of waveguide is generally of circular cross-section.

9. The apparatus of claim 5 wherein said dielectric filled section of waveguide is of circular transverse section.

10. The apparatus of claim 5 wherein said dielectric filled section of waveguide is of generally rectangular transverse section.

11. The apparatus of claim 5 wherein said dielectric filled section of waveguide is of rectangular transverse section.

12. The apparatus of claim 5 wherein said dielectric filled section of waveguide is dimensioned to have a characteristic impedance within 5 percent of the characteristic impedance of said ridged waveguide means at the center frequency of the 1.5 VSWR passband of said composite microwave window assembly.

13. The apparatus of claim 5 wherein each of said transition sections of waveguide includes a central region of a height approximately equal to the height of said dielectric filled waveguide.

14. The apparatus of claim 13 wherein each of said transition sections of waveguide includes outer lateral regions on opposite sides of said central region of lesser height than that of said central region.

15. The apparatus of claim 13 wherein said central region is defined between mutually opposed concave top and bottom waveguide wall portions.

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