United States Patent

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[72] Inventors Robert E. Eggers
San Jose;
Karl J. Heintz, Palo Alto, both of, Calif.
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[73] Assignee Teledyne, Inc.
Los Angeles, Calif.

[54] **MICROWAVE TUBE TRANSFORMER-WINDOW ASSEMBLY HAVING A WINDOW THICKNESS EQUIVALENT TO ONE-QUARTER WAVELENGTH AND METALLIC STEP MEMBERS TO TRANSFORM IMPEDANCE**
6 Claims, 8 Drawing Figs.

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[51] **Int. Cl.** H01p 1/08, H01p 5/08, H03m 13/00
[50] **Field of Search** 333/98 P, 98, 35; 315/5

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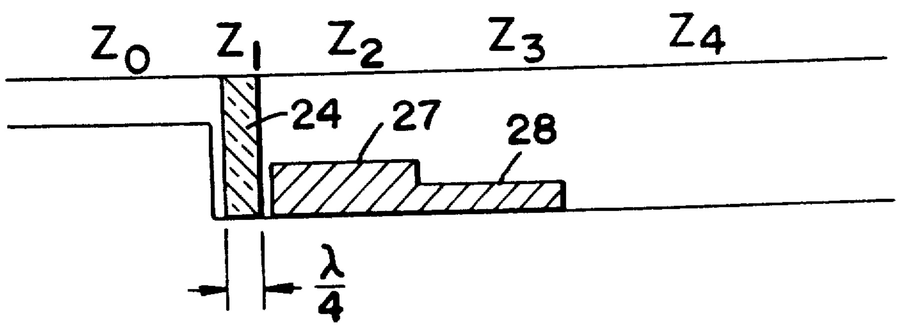
Primary Examiner—Herman Karl Saalbach
Assistant Examiner—Wm. H. Punter
Attorney—Limbach, Limbach & Sutton

ABSTRACT: A microwave tube transformer-window is described utilizing a waveguide step transformer with a solid block window one-quarter wavelength long and producing the same impedance as the replaced step.



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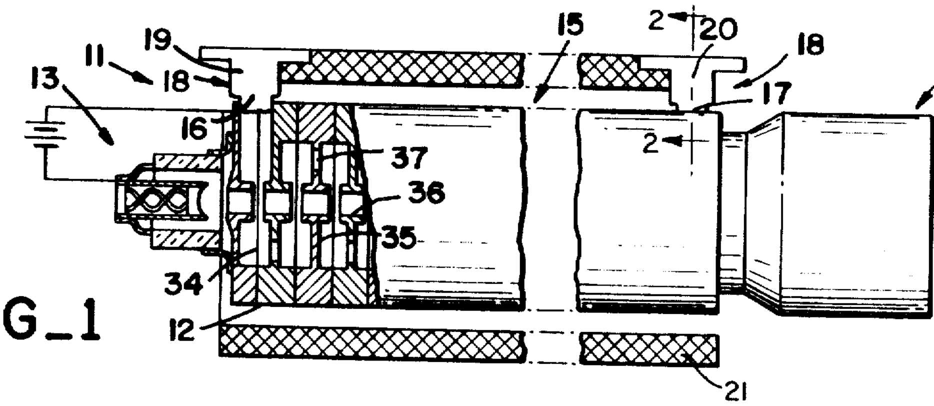

FIG_1

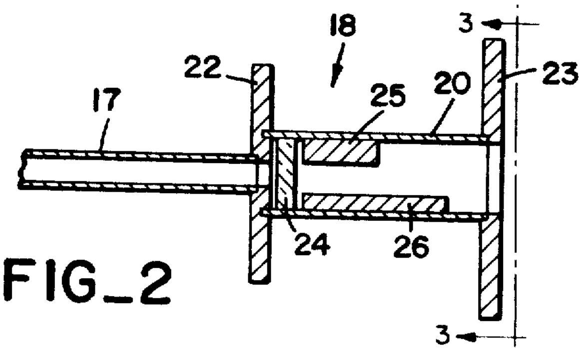

FIG_2

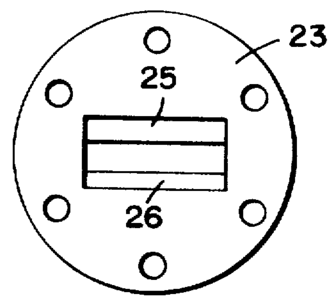

FIG_3

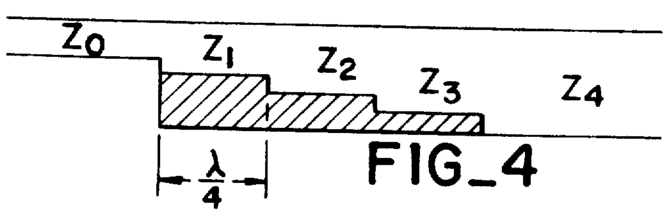

FIG_4

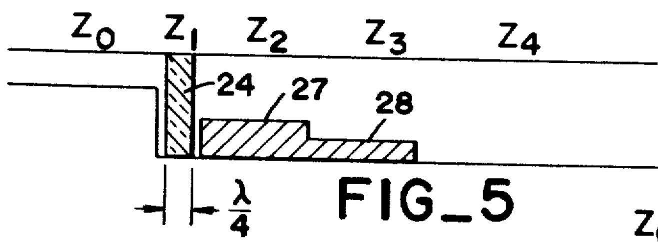

FIG_5

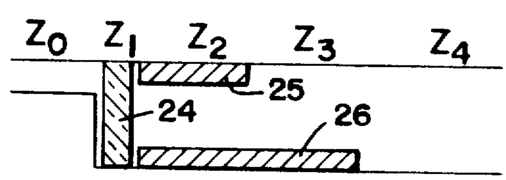

FIG_6

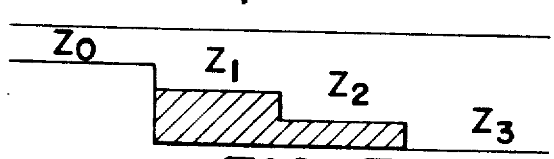

FIG_7

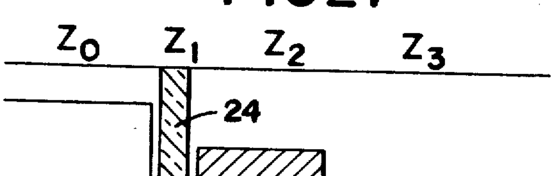

FIG_8

INVENTORS
ROBERT E. EGGERS
BY KARL J. HEINTZ

ATTORNEYS

MICROWAVE TUBE TRANSFORMER-WINDOW ASSEMBLY HAVING A WINDOW THICKNESS EQUIVALENT TO ONE-QUARTER WAVELENGTH AND METALLIC STEP MEMBERS TO TRANSFORM IMPEDANCE

The present invention relates in general to a microwave waveguide sealing and transformation assembly and more particularly to a microwave tube transformer-window.

In microwave devices such as traveling-wave tubes, klystrons, magnetrons and the like, step transformations are provided between the characteristic impedance of the wave propagating structure within the tube and an external waveguide, and a microwave-permeable window is provided in a waveguiding structure to form a vacuum seal for maintaining reduced pressure within the tube. One type of window and waveguide structures presently employed is a thin disc or circular poker chip window, larger in diameter than the largest dimension of the waveguide and less than one-quarter guide wavelength provided along the guide to serve as a vacuum seal but without performing an impedance transformation. This type window is fragile due to its large diameter and small thickness. Also, due to the large window diameter, spurious modes exist in this window assembly. Alternatively, a window one-half wavelength in thickness and matching the waveguide in its other dimensions, is utilized as a vacuum seal but again without performing an impedance transformation. This half wavelength window is very narrow band due to its large thickness. A step window having two or more one-quarter wavelength steps has been utilized to serve as both a seal and transformer. This step window has many spurious modes due to the various transverse wavelengths in its several steps, and the steps make the window susceptible to damage.

Broadly stated, the present invention is directed to a microwave waveguide seal and transformation assembly wherein a window, one-quarter wavelength in thickness, is located in an external wave portion which has a cross section and impedance larger than a contiguous internal waveguide portion adjacent the window. The window has an impedance between that of the internal and that of the external waveguides, and at least one metallic step member is provided in the external waveguide exteriorly of the window and providing an impedance between that of the window and that of the external waveguide. The step member is dimensioned to provide an impedance over a length equivalent to a quarter of the guide wavelength, and preferably, the successive impedances existing between the interior and exterior waveguides differ by substantially equal amounts.

A window transformer assembly in accordance with the present invention provides a vacuum seal and transformation in a short distance and a window assembly with almost the same bandwidth and voltage standing wave ratio as the equivalent step waveguide transformer.

Other objects and advantages of this invention will become apparent when reading the following description and referring to the accompanying drawing in which similar characters of reference represent corresponding parts in each of the several views.

In the drawings:

FIG. 1 is an elevational view of a traveling-wave tube embodying the present invention.

FIG. 2 is an enlarged sectional view of a portion of the structure shown in FIG. 1 delineated by line 2–2.

FIG. 3 is a view of a portion of the structure shown in FIG. 2 taken along line 3–3 in the direction of the arrows.

FIG. 4 is a schematic view illustrating the impedance longitudinally of the waveguide.

FIG. 5 is a side elevational view schematically illustrating the waveguide in accordance with one embodiment of the present invention.

FIG. 6 is a view according to FIG. 5 illustrating another embodiment of the present invention.

FIGS. 7 and 8 are views similar to FIGS. 4 and 5 of still another embodiment of the present invention.

While the invention, in accordance with the present invention, is directed broadly to a microwave tube transformer-window it is ideally suited for use with an electron discharge device where it is necessary to maintain within a vacuum envelope the wave-beam interaction structure which has a characteristic impedance much lower than that of the external waveguide. Therefore, for purposes of illustration the present invention will be described as applied to the input and output waveguides of a traveling-wave tube wherein a microwave-permeable window is used in an impedance matching transformer to provide a series of incremental impedance changes from the low impedance of the wave-beam interaction structure to the high impedance of that external waveguide.

Referring now to the drawing with particular reference to FIG. 1, there is shown a traveling-wave tube 11 utilizing the present invention. The tube 11 includes an elongate vacuum envelope 12 provided at one end with a beam generating assembly 13 for projecting a beam of electrons longitudinally of the tube 11 to a collector assembly 14. A beam-wave interaction structure 15 such as a folded waveguide circuit or coupled cavity circuit 15 is located between the beam-generating assembly 13 and the collector assembly 14 for providing wave-beam interaction between the electron beam and a microwave signal directed to the circuit 15 from an input waveguide 16 and directed from the circuit via an output waveguide 17.

The interaction structure 15 which can be any slow or fast wave structure is shown for illustrative purposes as a coupled cavity structure made up of cavity resonators 34 formed by partially hollowed out discs 35 located within the envelope and centrally apertured at 36 for passage of the beam axially of the tube. The discs 35 are provided with coupling irises 37 for coupling electromagnetic wave energy between cavity resonators 34.

The waveguides 16 and 17 are each provided with a transformer-window assembly 18 for connection to external waveguides 19 and 20, respectively. A solenoid 21 is provided longitudinally around the tube 11 for confining the beam of electrons traveling from the beam generating assembly 13 to the collector assembly 14. As is well known, in the traveling-wave tube art a microwave signal directed to the traveling-wave tube 11 from the input waveguide 16 is amplified in the interaction with the electron beam and is directed via output waveguide 17 to a load.

Referring now to FIG. 2, there is shown a transformer-window assembly constructed in accordance with the present invention. As illustrated, the output waveguide 17 which is internal of the vacuum envelope of the tube 11, is provided with a connection flange 22 for connection to the output external waveguide 20 which is in turn provided with a waveguide flange 23 for connection to other standard microwave components. In the embodiment illustrated, waveguides 17 and 20 are rectangular waveguides, and waveguide 17 has a cross section and an impedance smaller than the respective cross section and impedance of waveguide 20. In the transformer-window assembly in accordance with the present invention for providing a vacuum seal and matching the impedance between the two waveguides 17 and 20, a microwave-permeable window 24 such as of beryllia ceramic is located within and sealed within the larger exterior waveguide 20 adjacent connection to the smaller interior waveguide 17 but slightly spaced from the flange 22 to decrease the discontinuity susceptance caused by changes in waveguide dimensions between interior waveguide 17 and exterior waveguide 20. The window 24 has a thickness equivalent to one-quarter of the guide wavelength.

Located within exterior waveguide 20 exteriorly of the window 24 are a pair of elongate metal step members 25 and 26 such as of Kovar secured to opposite walls of waveguide 20. Step member 26 is longer than step member 25 so that the two members provide two steps of a step transformation that will be described in greater detail below.

The transformer-window assembly in accordance with the present invention is based upon the standard quarter wavelength step impedance transformer as schematically illustrated in FIG. 4 wherein a plurality of quarter wavelength steps in the impedance are provided to form a transition from one impedance Z_o to another impedance Z_n, n being the number of steps and the embodiment illustrated in FIG. 4 including four steps.

In the transformer-window construction in accordance with the present invention as schematically illustrated in FIG. 5, a ceramic block window one-quarter wavelength long producing the same impedance as the first step replaces the first, lowest impedance step of the transformer in the exterior waveguide. The remaining two steps 27 and 28 provide impedances Z_2 and Z_3. As shown in FIG. 6, steps 27 and 28 can be formed by two metal step members 25 and 26 positioned on opposite walls of the waveguide 20 instead of a single stepped metal member.

For a window assembly in a microwave tube as described above, Z_o and Z_n ($Z_n=Z_4$ for the embodiments shown in FIGS. 1—6) are fixed due to design requirements other than that of the window itself. Also Z_1 is fixed by the choice of ceramic material for the window and Z_1 is approximately equal to $Z_n/\sqrt{\epsilon_1}$, where ϵ_1 is the relative dielectric constant of the ceramic. The remaining number of steps are then chosen to give a balanced transformer with proper Z_2, Z_3, etc. with substantially equal differences in impedance between successive steps. Each step has a length substantially equivalent to one-quarter of the guide wavelength for the dielectric medium existing in that step, ϵ_o existing for air or vacuum and ϵ_1 for ceramic.

FIGS. 7 and 8 are similar to FIGS. 4 and 5, respectively, and illustrate a three-step transformer-window assembly in accordance with the present invention, and wherein only a single block metal member is required in the exterior waveguide.

Although the foregoing invention has been described in some detail by way of illustration and example for purposes of clarity of understanding, it is understood that certain changes and modifications may be practiced within the spirit of the invention as limited only by the scope of the appended claims.

What we claim is:

1. A microwave waveguide seal and transformation assembly comprising a first waveguide portion of first cross section and first impedance, a second waveguide portion of second cross section and second impedance larger than said first cross section and impedance, and connected to said first waveguide portion, a dielectric member located and sealed within said second waveguide portion adjacent the connection with said first waveguide portion, said dielectric member having a thickness equivalent to a quarter of the guide wavelength and a third impedance between said first and said second impedances, at least one metallic member positioned in said second waveguide portion on the side of said dielectric member opposite said first waveguide portion, said metallic member dimensioned to provide within said second waveguide a fourth impedance between said third and said second impedances.

2. The microwave waveguide assembly of claim 1 with substantially equal differences between successive impedances between said first and second impedances.

3. The microwave waveguide assembly of claim 2, wherein said metallic member is dimensioned to provide said fourth impedance over a length equivalent to a quarter of the guide wavelength.

4. In a microwave tube having an interior waveguiding portion of a first cross section and maintained at a predetermined pressure less than atmospheric pressure to provide a first impedance, and a contiguous exterior waveguiding portion of a second cross section larger than said first cross section and maintained at a pressure greater than that of said interior waveguiding portion to provide a second impedance greater than said first impedance; a microwave-permeable window positioned and sealed within said exterior waveguide portion adjacent said interior waveguiding portion, said window having a thickness equivalent to a quarter of the guide wavelength and a third impedance between said first and second impedances, and at least a pair of metallic step members in said exterior waveguide portion exteriorly of said window and dimensioned to provide a pair of impedance regions between said window and said exterior waveguiding portion with substantially equal impedance steps between said third and second impedances.

5. In a microwave tube of claim 4, said window and step member dimensioned to provide substantially equal differences between successive impedances between first and second impedances.

6. In a microwave tube of claim 5, said step members dimensioned to provide said respective impedances over lengths equivalent to quarter wavelengths of the guide.