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CONTIGUOUS SLOTTED AND UNSLOTTED WAVEGUIDE PORTIONS HAVING SUBSTANTIALLY THE SAME CHARACTERISTIC IMPEDANCE

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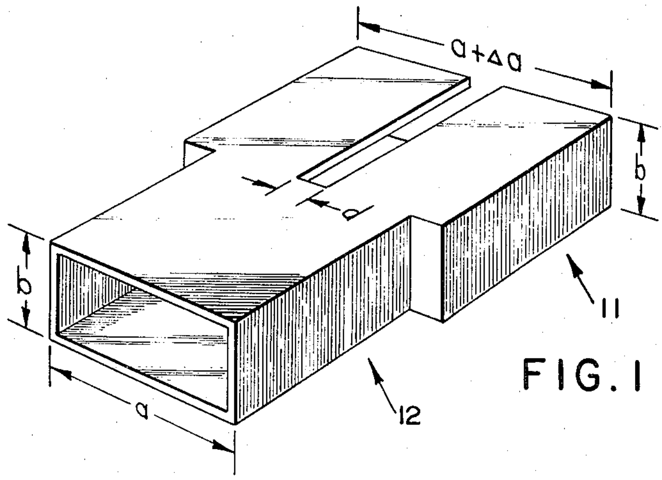

FIG. 1

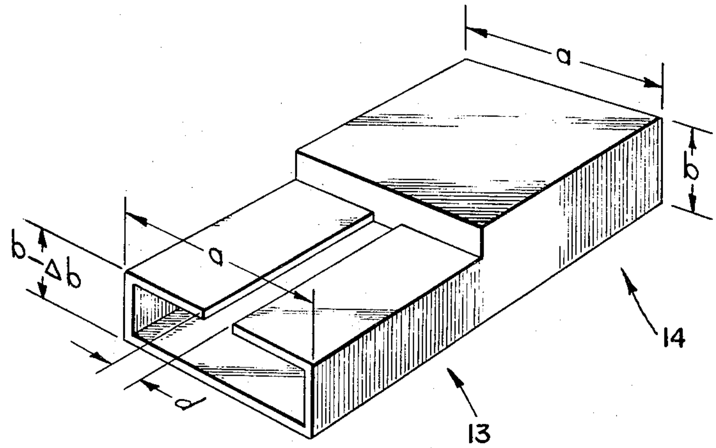

FIG. 2

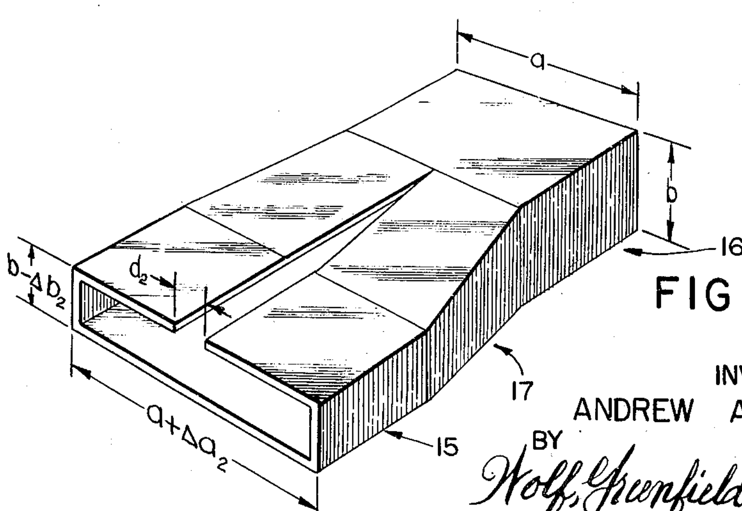

FIG. 3

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U.S. Cl. 333—33 7 Claims

ABSTRACT OF THE DISCLOSURE

A slotted waveguide portion contiguous with an unslotted waveguide portion are arranged so that both have substantially the same characteristic wave impedance and propagation characteristics by making the slotted portion a little bit wider and/or a little bit shorter than the unslotted portion.

BACKGROUND OF THE INVENTION

The present invention relates in general to contiguous slotted and unslotted portions having substantially the same characteristic impedance and wave propagation characteristics especially useful for making slotted waveguide measurements.

Slotted waveguides are widely used for making measurements at microwave and higher frequencies. A probe penetrating through the slot normally senses an indication of the electric field strength at points along the length of the slotted waveguide to provide indications of the VSWR in the slotted waveguide as a result of devices connected to the ends of the slotted waveguide. Although such slotted waveguides are useful for many applications, prior art devices themselves introduce enough of a mismatch to seriously limit the accuracy of the measurements being made. These problems are especially serious at the extremely short wavelengths when the width of the slot becomes comparable to a dimension of the waveguide.

It is an important object of this invention to provide methods and means for enhancing the accuracy of slotted waveguide measurements.

It is a further object of the invention to achieve the preceding object with a slotted waveguide having a slotted portion that has its wave impedance and propagation characteristics matched to that of the unslotted portion.

It is still a further object of the invention to achieve the preceding objects over a relatively wide frequency range for the TE_{01} mode in rectangular waveguide.

It is still another object of the invention to achieve the preceding objects with relatively little additional physical apparatus capable of being reproducible when making slotted waveguides in production quantity.

It is still a further object of the invention to achieve the preceding objects with fixed structure that does not require adjustment from slotted waveguide to slotted waveguide.

SUMMARY OF THE INVENTION

According to the invention, there is a waveguide having a slotted portion with a longitudinal slot formed in the waveguide wall intercoupled with an unslotted portion with the cross sectional area of the slotted portion slightly changed from that of the unslotted portion so that the impedance and propagation characteristics of both the slotted and unslotted portions are substantially the same.

Numerous other features, objects and advantages of the invention will become apparent from the following specification when read in connection with the accompanying drawing in which:

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view of one embodiment of the invention in which a slotted portion of the waveguide is formed with its width slightly greater than that of the unslotted portion to effect the desired wide band impedance and propagation characteristics match;

FIG. 2 is a perspective view of another embodiment of the invention in which the slotted portion of the waveguide is slightly shorter than the unslotted portion to effect the desired wideband impedance and propagation characteristics match; and

FIG. 3 is a perspective view of still another embodiment of the invention embodying a stepped transition portion to effect the desired wide band impedance and propagation characteristics match.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference now to the drawing and more particularly FIG. 1 thereof, there is shown a perspective view of an embodiment of the invention in which the slotted portion of the waveguide **11** is slightly greater than the unslotted portion **12**. The width of the unslotted portion is a and that of the slotted portion a plus Δa while the height of both waveguides is b. The slot width is d. The increase in width Δa is selected to be just enough so that the impedance and propagation characteristics in both slotted portion **11** and unslotted portion **12** are substantially the same. The manner of selecting this difference will now be described.

A waveguide slotted line, if made of the same size as the unslotted waveguide in which measurements are to be made, has a higher characteristic impedance than that of the unslotted waveguide. Let the unslotted waveguide impedance be Z_0 and let the waveguide impedance of the slotted waveguide section (provided with a longitudinal central slot through one of the wider walls) be $Z_0+\Delta Z_0$.

In general, the characteristic impedance of a waveguide is given by Equation 1.

$$Z_0=Kb/[1-(f_0/f)^2]^{1/2} \qquad (1)$$

where:

a=the internal width of the waveguide,
b=the internal height of the waveguide,
K=a constant,
f_0=the cutoff frequency of the TE_{10} mode, and
f=operating frequency.

Let it be assumed that the addition of the slot increases the characteristic impedance by ΔZ_0 and increases the cutoff frequency f_0 by Δf_0.

In a waveguide without a slot

$$f_0/f=\lambda/2a \qquad (2)$$

Since

$$\lambda f=c \qquad (3)$$

where:

c=the velocity of light.

We may substitute the value of λ in terms of f into Equation 2 and thus obtain the relationship between f_0 and a in which

$$f_0=c/2a \qquad (4)$$

or

$$a=c/2f_0 \qquad (4a)$$

From the above it follows that we can make up for the increase in f_0 by Δf_0 by increasing dimension a by Δa as given by Equation 5

$$\Delta a/a=|-c\Delta f_0/2f_0^2| \qquad (5)$$

Dividing Equation 5 by Equation 4a we obtain

$$\Delta a/a=\Delta f_0/f_0 \qquad (5a)$$

When we wish to decrease Z_0 by ΔZ_0 we may do this by decreasing the waveguide height b. The relationship between ΔZ_0 and Δb can be obtained from Equation 1 as

$$\Delta Z_0/Z_0 = -\Delta b/b \qquad (6)$$

Referring to FIG. 2, there is shown an alternate embodiment of the invention in which the height of the slotted portion is reduced by Δb as explained above to establish the characteristic impedance and propagation characteristics of the slotted portion **13** and unslotted portion **14** substantially the same.

The dimensions Δa and Δb can be computed with the guidance of the equations set forth above and the dimensions trimmed experimentally to optimize the matching of impedance and propagation characteristics. Alternatively, there exists an essentially experimental way for determining the parameters Δa and Δb. First, measure the cutoff frequency and impedance in an unslotted waveguide. Then cut a slot in this waveguide of the desired width d and again measure the cutoff frequency and impedance. The first cutoff frequency and impedance measurements are the parameters f_o and Z_0, respectively, and the differences between each first measurement and the corresponding second measurement are Δf_o and ΔZ_0, respectively, Δa and Δb may then be determined from Equation 5*a* and Equation 6. It may be desirable to effect part of the compensation by changing the height and part of the compensation by changing the width. This would involve an alteration of the cross sectional area of the slotted portion with respect to the unslotted portion so that the impedance and propagaion characteristics of the two contiguous portions remain substantially the same.

Referring to FIG. 3 there is shown still another embodiment of the invention in which the slotted portion **15** is coupled to the unslotted portion **16** by means including a transition slotted portion **17**. The specific embodiment illustrated in FIG. 3 includes both height, width and slot width compensation. Thus, the heights of unslotted portion **16**, transition portion **17** and slotted portion **15** are respectively b, $b-\Delta b_1$ and $b-\Delta b_2$.

The width of unslotted portion **16**, transistion portion **17** and slotted portion **15** are respectively a, $a+\Delta a_1$ and $a+\Delta a_2$. The width of the slot in transition portion **17** is b_1 and that of slotted portion **15** is d_2, and d_2 being greater than d_1. Preferably, the electrical length of transition portion **17** is an odd multiple of quarter guide wavelengths at the center of the frequency at the desired operating band. The principles set forth above are applicable to choosing the different dimensions.

It is evident that those skilled in the art may now make numerous uses and modifications of and departures from the specific embodiments described herein without departing from the inventive concepts. Consequently, the invention is to be construed as embracing each and every novel feature and novel combination of features present in or possessed by the apparatus and techniques herein disclosed and limited solely by the spirit and scope of the appended claims.

What is claimed is:

1. High frequency apparatus comprising,

means defining a slotted waveguide portion formed with a slot of predetermined dimensions along the direction of energy propagation,

means defining an unslotted waveguide portion contiguous with said slotted waveguide portion,

said slotted and unslotted waveguide portions being characterized by finite cutoff frequencies and having different cross sectional areas with means for establishing the relationship between said different cross sectional areas so that the impedance characteristics and cutoff frequencies of said slotted and unslotted portions are substantially the same,

whereby said waveguide portions of different cross sectional areas coact with said slot of predetermined dimensions to form a waveguide having substantially the same impedance and finite cutoff frequency along its length.

2. High frequency apparatus in accordance with claim **1** wherein said slotted and unslotted waveguide portions are dimensioned to propagate the TE_{01} mode.

3. High frequency apparatus in accordance with claim **2** wherein said cross sectional areas are rectangular.

4. High frequency apparatus in accordance with claim **3** wherein the width of said slotted portion is slightly greater than that of said unslotted portion.

5. High frequency apparatus in accordance with claim **3** wherein the height of said slotted portion is slightly less than that of said unslotted portion.

6. High frequency apparatus in accordance with claim **4** wherein the height b of said slotted portion is slightly less than that of said unslotted portions by a difference Δb to establish substantially the same empedance Z_0 in said slotted and unslotted portions and the width a of said slotted portion is Δa greater than that of said unslotted portion to establish substantially the same cutoff frequency f_o in said slotted and unslotted portions.

7. High frequency apparatus in accordance with claim **1** wherein said slotted and unslotted waveguide portions have a common axis and said slot is along the length and generally parallel to said axis.

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