United States Patent

[11] **3,634,783**

[72] Inventor **John P. Rooney**
Palo Alto, Calif.

[21] Appl. No. **27,584**
[22] Filed **Apr. 13, 1970**
[45] Patented **Jan. 11, 1972**

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

[54] **WAVEGUIDE LOAD**
11 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** ..... **333/22 R,** 333/31 A, 333/34, 333/81 B, 333/98 R
[51] **Int. Cl.** **H01p 1/26,** H03h 7/38, H03h 7/30
[50] **Field of Search** ..... 333/22, 22 F, 81 B, 81, 34, 98, 31

[56] **References Cited**

UNITED STATES PATENTS

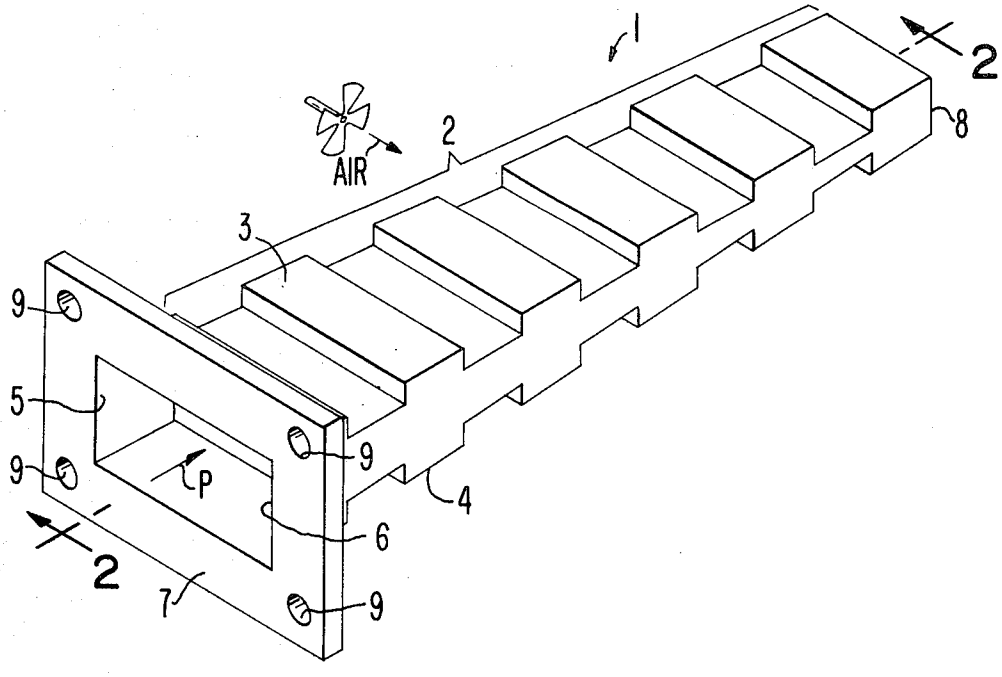
2,567,748	9/1951	White	333/34 X
2,587,055	2/1952	Marshall	333/22 X
2,599,944	6/1952	Salisbury	333/22 X
2,659,817	11/1953	Cutler	333/34
2,676,307	4/1954	Anderson	333/22
2,844,791	7/1958	Jacques	333/22 X
2,853,687	9/1958	Weber	333/81
2,875,418	2/1959	Rolfs	333/81
3,001,152	9/1961	Winkler	333/22
3,309,626	3/1967	Higgins	333/81 X
3,353,123	11/1967	Met	333/81 X

OTHER REFERENCES

" Microwave Engineering," Harvey; Academic Press, New York and London, 1963; QC 670 H38; pgs. 1003- 10,007.

Primary Examiner—Herman Karl Saalbach
Assistant Examiner—Marvin Nussbaum
Attorney—Stanley Z. Cole

ABSTRACT: A rectangular waveguide load is disclosed. The broad walls of a rectangular waveguide are periodically loaded by means of corrugations to define a slow wave structure. The walls of the waveguide are made of a material having a loss tangent which is no less than the loss tangent of stainless steel for decreasing the physical length of the load. The height and width of the waveguide may be tapered as well as the depth of the corrugations for increasing the attenuation per unit length.

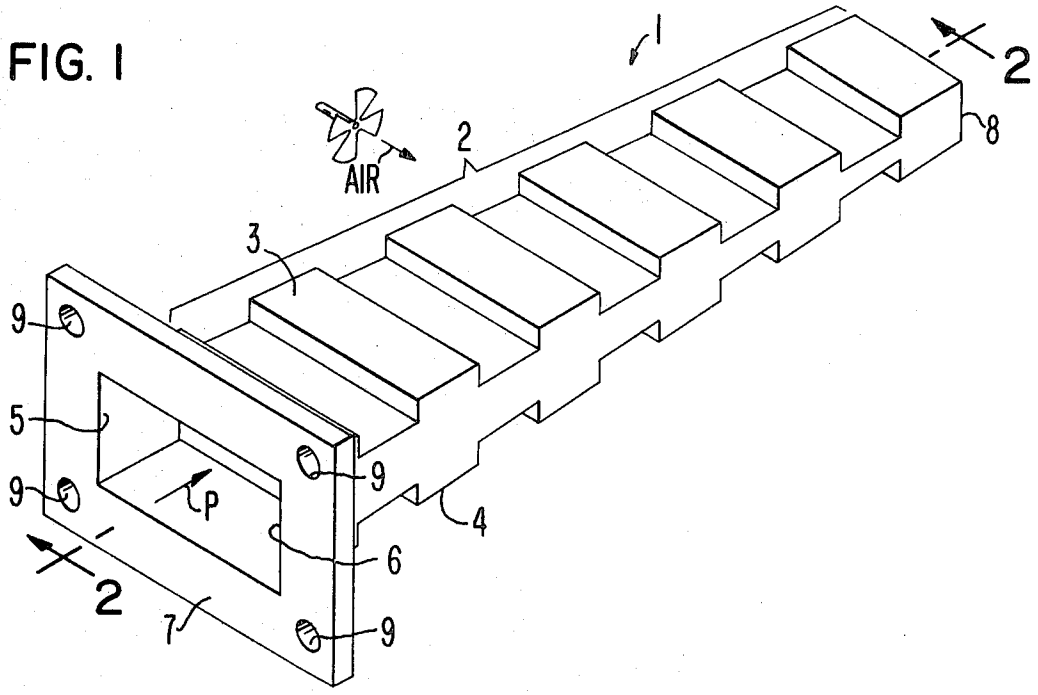


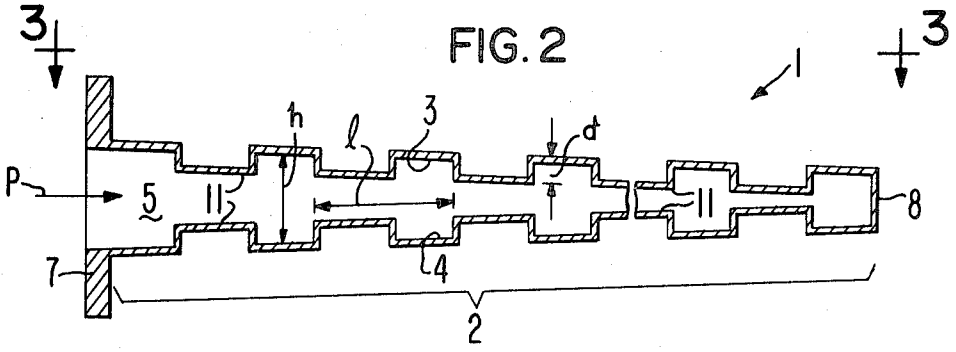
PATENTED JAN 11 1972

3,634,783

SHEET 1 OF 2

FIG. 1





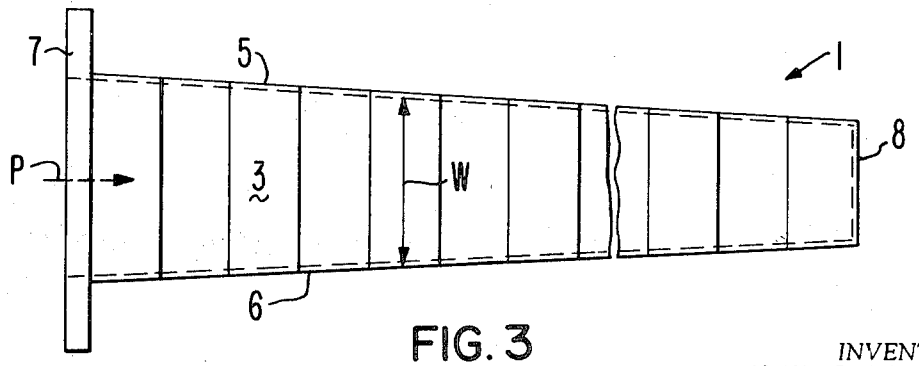


FIG. 3

INVENTOR.
JOHN P. ROONEY
BY Stanley Z. Cole
ATTORNEY

FIG. 4

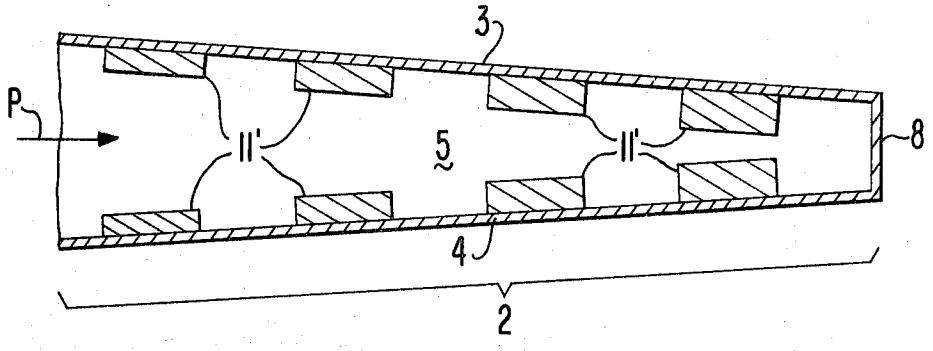
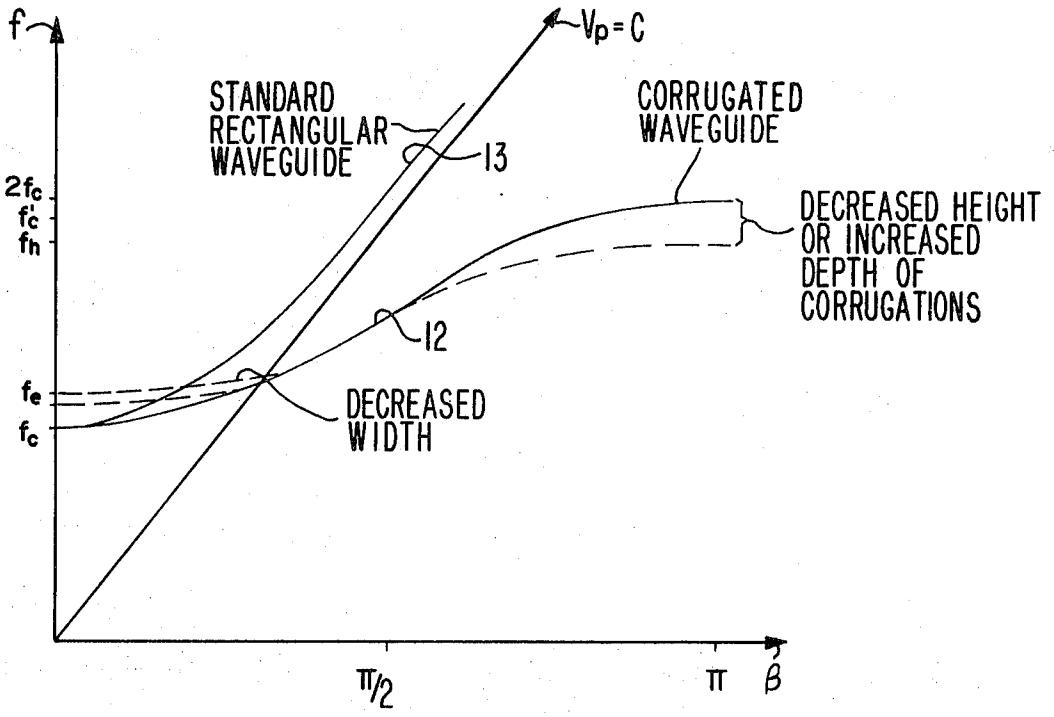


FIG. 5



INVENTOR.
JOHN P. ROONEY

BY

ATTORNEY

WAVEGUIDE LOAD

DESCRIPTION OF THE PRIOR ART

Heretofore, rectangular waveguide loads have been constructed which were tapered in both height and width and which had the internal walls thereof constructed of a material having a loss tangent which was no less than the loss tangent of stainless steel for increasing the attenuation of the load. Waveguide loads of this type are disclosed in U.S. Pat. Nos. 3,133,227 issued May 12, 1964 and 2,913,619 issued Nov. 17, 1959. The problem with this prior art loads is that for relatively high-power operation the loads have an excessive length such as 15 wavelengths at S-band.

It is also known from the prior art that a corrugated rectangular waveguide having an attenuative card mounted therein is useful as an extremely low power load. The corrugated wall provides iterative quarter-wave inductive loading to compensate for the capacitance of the resistive card and for positioning the electric field of the quarter-wave loading elements in the resistive card. Such loads are disclosed in Japanese Journal of the Institute of Electrical Communication Engineers, Vol. 37 and Vol. 38, pgs. 550–555 and pgs. 798–804 (1954 and 1955), respectively. The problem with this type of load is that poor heat transfer is provided from the resistive card to the walls of the waveguide, thereby restricting its usefulness to very low power application.

SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of an improved rectangular waveguide load.

One feature of the present invention is the provision, in a rectangular waveguide load, of periodic loading means for loading at least one of the resistive broad walls of the waveguide for introducing an upper cutoff frequency and for lowering the group velocity within the operating band of the load, whereby the physical length of the load is decreased for a given amount of attenuation within the operating band.

Another feature of the present invention is the same as the preceding feature wherein the periodic loading means comprises a corrugation of the broad wall of the waveguide.

Another feature of the present invention is the same as any one or more of the preceding features wherein the height and/or the width of the waveguide are tapered with decreasing dimensions taken in a direction of power flow within the waveguide, whereby the attenuation per given length of the load is increased.

Another feature of the present invention is the same as any one or more of the preceding features wherein the dimensions of the periodic loading elements are increased taken in a direction of power flow within the load for lowering the upper cutoff frequency and thereby increasing the attenuation per unit length of the load.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a rectangular waveguide load incorporating features of the present invention,

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

FIG. 3 is a view of the structure of FIG. 2 taken along line 3—3 in the direction of the arrows,

FIG. 4 is a view similar to that of FIG. 2 depicting an alternative embodiment of the present invention, and

FIG. 5 is a frequency versus β diagram depicting the dispersion and band-pass characteristics for a waveguide and for a corrugated waveguide load.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1—3, there is shown the waveguide load 1, of the present invention. The waveguide 1 includes a length of rectangular waveguide 2 having a pair of broad top and bottom walls 3 and 4, respectively, interconnected by a pair of narrow sidewalls 5 and 6, respectively. A waveguide flange 7 is affixed to one end of the rectangular waveguide 2 and the other end of the waveguide 2 is closed by means of an end closing wall 8 which forms reflective termination at that end of the waveguide load 1.

The waveguide 2 is preferably formed in a gastight manner and sealed to flange 7 in a gastight manner, as by welding. The flange 7 may include deformable gasket means in its face, not shown, for sealing flange 7, in a gastight manner, to a mating flange, not shown, on a device to be loaded, not shown. In this manner, waveguide load 1 may be pressurized or evacuated, as desired. The flange 7 includes a plurality of mounting holes 9 for bolting flange 7 to a mating flange on the device to be loaded.

Two or more of the walls of the waveguide 2, and preferably the top and bottom walls 3 and 4, respectively, are provided with periodic loading elements, such as inwardly projecting corrugations 11, whereby the waveguide is transformed into a slow wave structure having a dispersion characteristic as shown by solid lines 12 of FIG. 5. The periodic loading elements 11 introduce a high-frequency cutoff f'_c which is at a frequency slightly below $2f_c$ where f_c is the low-frequency cutoff for a standard rectangular waveguide of comparable dimensions which has not been provided with the periodic load elements 11 and having a dispersive characteristic as shown by curve 13. The periodic loading elements 11 serve to decrease the group velocity for wave energy within the periodically loaded waveguide 2 such that a waveguide of a given length will accommodate more electrical wavelengths at a given frequency, thereby serving to physically shorten the length of the waveguide load 1 for a given attenuation.

In addition, at least the interior surfaces of the walls of the waveguide 2 are either made of a material or coated with a material having a relatively high loss tangent such that the average loss tangent, as integrated over the entire surface of the waveguide 2, is no less than the loss tangent 18–8 stainless steel. In this manner, substantial attenuation of the wave energy is obtained due to the RF loss in the interior surface of the waveguide 2. In one embodiment of the present invention, the walls 3, 4, 5, and 6 are made of 18–8 stainless steel or iron. In an alternative embodiment, the interior walls of the waveguide 2 are coated with a lossy metallic material such as a lossy powder metal material marketed under the trademark Kanthal. Another possible lossy material for coating the inside walls of the waveguide is Nichrome.

The corrugated waveguide 2 of FIGS. 1–3 has a band-pass characteristic in the band of frequencies from f_l to f_h where f_l is typically $1.25f_c$ and f_h is typically $1.75f_c$. The dimensions of the corrugated waveguide 2 and the input end, are dimensioned to provide a match in the operating band from f_l to f_h, to the rectangular waveguide in which the load 1 is to be connected.

The attenuation per unit length of the corrugated waveguide 2 can further be increased by decreasing the height h of the waveguide 2 taken in the direction of power flow in the waveguide load 1. The direction of power flow is indicated by the arrow designated with P. Decreasing the height h of the corrugated waveguide 2 tends to lower the upper cutoff frequency f_c and when the height is decreased below the high-frequency band edge f_h, at the input end of the corrugated waveguide 2, a substantial increase in the attenuation per unit length for the section of decreased height will be obtained because the attenuation per unit length is markedly increased at the upper cutoff frequency f'_c of the corrugated waveguide 2. The upper band cutoff frequency f'_c can also be lowered by increasing the depth d of the corrugations taken in the direction of power flow in the corrugated waveguide 2.

In addition, the attenuation per unit length can be further increased by reducing the width w of the corrugated waveguide 2 taken in a direction of power flow within the corrugated waveguide 2. This decrease in the width w tends to

raise the low-frequency cutoff f_c for the waveguide, thus increasing the attenuation near the lower band edge frequency which has now been moved more toward the center of the passband of the corrugated waveguide structure **2**. The various tapered dimensions such as height, depth of the corrugations, and width of the waveguide **2** should be changed gradually along the waveguide **2** such as not to produce hot spots in the walls of the waveguide load **1**.

The reflective termination **8** serves to reflect power reaching wall **8** back toward the input end of the waveguide load **1** so as to be further attenuated in its passage back toward the input end. This allows the waveguide load **1** to be physically shorter for a given attenuation than if the reflective wall **8** were absent.

Referring now to FIG. **4**, there is shown an alternative embodiment of the present invention. This embodiment is essentially the same as that of FIGS. **1–3** with the exception that the periodic loading elements **11** are formed by an array of metallic members which are preferably made of any one or more of the aforementioned lossy materials and which are affixed, as by brazing, to the inside surfaces of the top and bottom walls **3** and **4** of the waveguide **2** to form a periodically loaded corrugated waveguide structure **2**. In a preferred embodiment, the loading members **11** are bars which extend transversely of the waveguide **2** from one narrow wall **5** to the opposed narrow wall **6**.

In a typical example at X-band the waveguide load **1** is capable of absorbing 10–20 kw. average power when the load is immersed in a water coolant jacket and 1 to 2 kw. average power when cooling air is directed against the outside walls of the load **1**.

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 waveguide load having a certain operating band of frequencies, a hollow rectangular waveguide means having a pair of broad top and bottom walls interconnected by a pair of narrow sidewalls, said walls of said waveguide means having a loss tangent for wave energy at the center frequency operating band of frequencies as averaged over its interior surfaces which is no less than the loss tangent of 18–8 stainless steel, and reactive loading means periodically loading at least one of said walls of said waveguide means for introducing an upper cutoff frequency and lowering the group velocity of wave energy within the operating band of the load, whereby the physical length of the load is decreased for a given amount of attenuation of wave energy within the operating band.

2. The apparatus of claim **1** including means at one end of said rectangular waveguide means for coupling said rectangular waveguide means to a waveguide to be loaded.

3. The apparatus of claim **2** including waveguide reflective means at a second end of said rectangular waveguide means for providing a wave reflective termination for said waveguide means.

4. The apparatus of claim **2** wherein said loading means comprises a corrugation of at least one of said broad walls of said waveguide means.

5. The apparatus of claim **1** wherein at least one of said broad walls of said waveguide means is made of a material having a loss tangent which is no less than the loss tangent of 18–8 stainless steel.

6. The apparatus of claim **1** wherein said loading means comprises a transverse corrugation of both said top and bottom broad walls of said waveguide means.

7. The apparatus of claim **2** wherein the height of said waveguide means between said top and bottom broad walls is tapered with decreasing height taken in a direction along said waveguide means away from said coupling means.

8. The apparatus of claim **2** wherein the width of said waveguide means between said pair of narrow sidewalls is tapered with decreasing width taken in a direction along said waveguide means away from said coupling means.

9. The apparatus of claim **2** wherein said periodic loading means has tapered dimensions such as to provide larger periodic loading to said waveguide means taken in the direction along said waveguide means away from said coupling means.

10. The apparatus of claim **4** wherein the depth of successive ones of said corrugations in said broad wall increases taken in a direction away from said coupling means and along said waveguide means.

11. The apparatus of claim **3** wherein said wave reflective means comprises a conductive wall closing off the second end of said rectangular waveguide means.

* * * * *