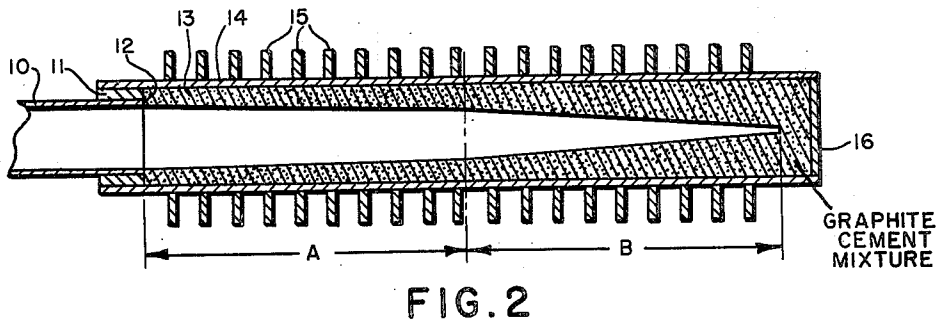
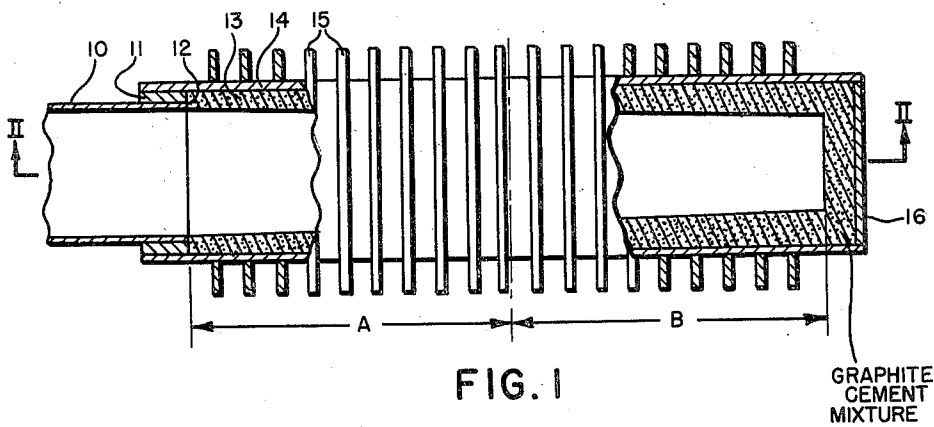


Aug. 27, 1957

R. M. FANO
WAVE GUIDE TERMINATION
Filed Feb. 8, 1946

2,804,598



INVENTOR.
ROBERTO M. FANO

BY

Max Hays

ATTORNEY

1

2,804,598

WAVE GUIDE TERMINATION

Roberto M. Fano, Boston, Mass., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Application February 8, 1946, Serial No. 646,446

7 Claims. (Cl. 333—22)

This invention relates to a wave guide termination, and more particularly to a matched impedance wave guide termination capable of dissipating a large amount of power.

One conventional type of high power termination employs a tapered insert of an absorbing, or lossy, material so positioned in the wave guide as to absorb the power propagated through the wave guide. Such terminations are subject to power breakdown at relatively low peak powers because of the increased potential gradient produced by the insertion of the material into the wave guide. Also, because of the mechanical configuration of such designs, the generated heat is conducted away from the lossy material by only the walls of the wave guide supporting the insert.

Another conventional type of high power attenuator comprises a lossy section of wave guide having walls composed of a high resistivity material, such as powdered iron particles mixed in a resinous binder and compressed to form a homogeneous mass. The relative power dissipation per unit length of such a section is non-uniform, leading to excessive heating of a portion of the section while the remainder remains relatively cool. Moreover, unless the dimensions of such a wave guide are properly proportioned in relation to the operating frequency, a substantial amount of reflection of energy may take place.

It is a general object of this invention to provide an improved matched impedance wave guide termination.

It is another object of this invention to provide a matched impedance wave guide termination capable of dissipating a large amount of power.

It is a further object of this invention to provide a matched impedance wave guide termination in which the heat dissipation is substantially uniform throughout its length.

These and other objects will be more apparent upon consideration of the following description together with the accompanying drawings, in which:

Fig. 1 is a cut-away view partly in section of an embodiment of this invention; and

Fig. 2 is a sectional view alone line II—II of Fig. 1.

Referring to the drawings, a conventional wave guide transmission line 10 having a rectangular cross section is terminated in a tapered wave guide 13 having walls of a lossy material, such as a homogeneous mass of graphite and cement. The inside dimensions of lossy wave guide 13 are equal, at the junction 12 with wave guide 10, to the inside dimensions of the conventional wave guide 10, to which the source of electromagnetic energy is connected. The contacting end surfaces of both the lossy and conventional wave guides must be smooth and in intimate contact at junction 12 between the two sections of wave guide if power breakdown is to be prevented.

The tapered section of lossy wave guide 13 is supported mechanically within a thermally conductive envelope 14 having preferably a rectangular cross-section and having one end closed by a conductive end plate 16. Envelope 14 is fastened to a thermally conductive block 11, which

2

in turn is removably fastened to wave guide 10. A plurality of radiating fins 15 of thermally conductive material are fastened to the outside of envelope 14 to dissipate the heat absorbed by the lossy wave guide 13. The heat dissipation characteristics can be improved further by darkening all exposed surfaces.

The impedance of the lossy wave guide 13 is matched so that a negligible amount of energy is reflected back into wave guide 10 if the dimensions of the lossy wave guide 13 at any point satisfy the equation,

$$2b/a = (\lambda_c^2/\lambda^2) - 1$$

where b is the narrow dimension of wave guide 13, a is the wide dimension of wave guide 13, λ is the free space wave length of the incident electromagnetic energy, and λ_c is the cutoff wave length of wave guide 13.

The surface density of power dissipation over all of the four walls of wave guide 13 is equal when $\lambda_c/\lambda = \sqrt{2}$. Under these conditions, the proper ratio of b/a is $1/2$, which is very convenient practically.

It can be seen that both the narrow and wide dimensions of the lossy wave guide 13 thus can be tapered simultaneously to provide a termination producing substantially no reflection of energy. The rate and shape of the tapers can be so designed that the rate of power dissipation per unit length is uniform.

Section A of the drawings shows a section of lossy wave guide 13 designed to conform with the above described equations. If it is desired to conserve space, a tapered section A several wave lengths long can be terminated as shown by a second section B, in which the narrow dimension is tapered more rapidly than in section A. The wide dimension must not be reduced below the minimum value which will support propagation of the incident electromagnetic energy. Since a large amount of the incident power will be absorbed and dissipated by section A, the small amount of power reflected by section B, the dimensions of which do not conform to the above equations, will be negligible and will be further absorbed by section A before reaching wave guide 10.

It is possible to produce a wave guide termination as described which will absorb substantially as much power as wave guide 10 is capable of transmitting without breakdown. The impedance characteristics can be made to produce a standing wave ratio of less than 1.03 over a frequency band as wide as 40 percent of the mean frequency.

Since certain changes may be made in the above described article and different embodiments of the 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, and therefore, that the invention is to be limited only by the prior art and the spirit of the appended claims.

What is claimed is:

1. A high power matched impedance wave guide termination comprising, a wave guide section having a closed end, said wave guide having a rectangular internal cross section and having tapered walls composed of a lossy material, the dimensions of said cross section satisfying at all longitudinal points the relation $2b/a = (\lambda_c^2/\lambda^2) - 1$, where b is the narrow dimension of said cross section, a is the wide dimension of said cross section, λ_c is the cutoff wave length of said wave guide, and λ is the free space wave length of the electromagnetic energy within said wave guide, whereby substantially all of the electromagnetic energy incident upon said termination is absorbed.

2. A high power, matched impedance wave guide termination attachable to a first wave guide of conductive material having a rectangular cross section, said termination comprising, a second wave guide section having

3

tapered walls of a homogeneous mass of graphite and cement, a thermally conductive envelope surrounding said second wave guide section and attachable to said first wave guide, and a plurality of thermally conductive heat radiating fins disposed about the outer surface of said envelope, said second wave guide section having internal dimensions coincident with said first wave guide at the junction between said first and second wave guides, said internal dimensions of said second wave guide section being reduced gradually for several wave lengths from said junction along the longitudinal axis of said second wave guide section, said dimensions substantially satisfying at all points along said axis the relation

$$2b/a = (\lambda_c^2/\lambda^2) - 1$$

where b is the narrow dimension of the cross section of said second wave guide section, a is the wide dimension of said cross section, λ_c is the cutoff wave length of said second wave guide, and λ is the free space wave length of the electromagnetic energy within said wave guides, said narrow dimension being reduced more rapidly for several wave length thereafter to produce a closed end, whereby substantially all electromagnetic energy introduced into said first wave guide is absorbed by said termination.

3. A load for a length of rectangular wave guide comprising, a lossy wave guide section of rectangular cross section closed at one end, said lossy wave guide being matched in impedance to said length of wave guide and having uniformly tapered walls increasing in thickness toward said closed end, the cross-sectional dimensions of said wave guide section being maintained at a ratio of two-to-one along said taper.

4. A matched termination for a rectangular wave guide

4

comprising a lossy rectangular wave guide section composed of material of high resistivity, said lossy wave guide being closed at one end and having internal dimensions at the open end thereof equalling the internal dimensions of the wave guide to which it is joined, the walls of said lossy wave guide section increasing in thickness between said open and said closed end in a symmetrical taper.

5. Apparatus as in claim 4, wherein the cross sectional dimensions of the interior of said lossy wave guide section are maintained at a ratio of two-to-one along said taper.

6. Apparatus as in claim 4, wherein the broad dimensions of the interior of said lossy wave guide section are maintained at twice the narrow dimensions of the interior of said lossy wave guide section throughout the length of said taper.

7. Apparatus as in claim 4, including a thermally conductive envelope for said lossy wave guide section to remove heat therefrom.

References Cited in the file of this patent

UNITED STATES PATENTS

686,246	Bachmann et al.	Nov. 12, 1901
1,525,183	H'Doubler	Feb. 3, 1925
2,197,123	King	Apr. 16, 1940
2,207,845	Wolff	July 16, 1940
2,409,599	Tiley	Oct. 15, 1946
2,472,201	Eyges	June 7, 1947
2,423,526	Sontheimer et al.	July 8, 1947
2,427,098	Keizer	Sept. 9, 1947
2,438,915	Hansen	Apr. 6, 1948
2,461,005	Southworth	Feb. 8, 1949
2,464,277	Webber	Mar. 15, 1949