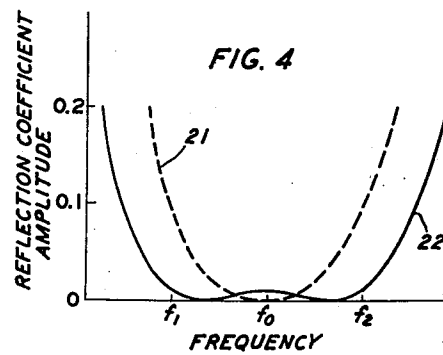
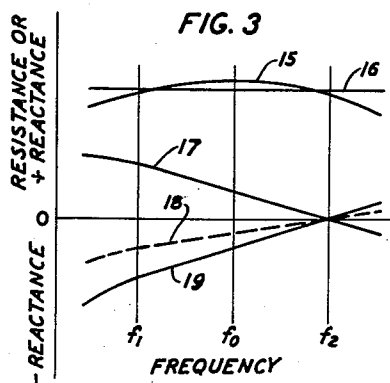
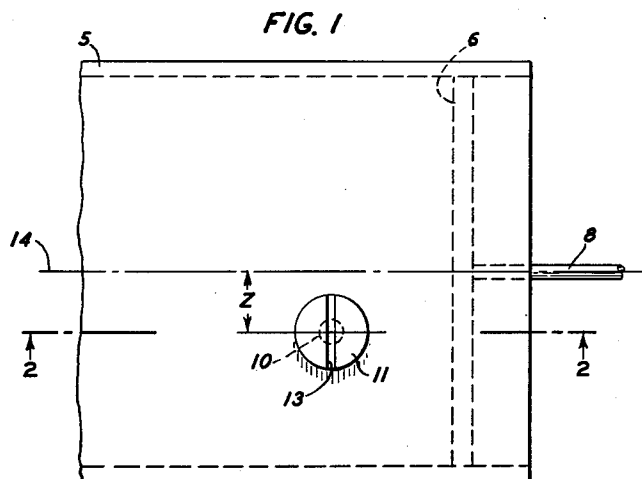
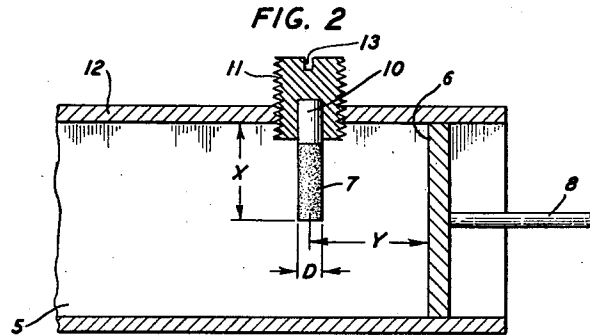


Aug. 25, 1959

E. W. HOUGHTON
WAVE-GUIDE TERMINATION

2,901,711

Filed Feb. 5, 1957



INVENTOR
E. W. HOUGHTON
BY

Ralph T. Holcomb
ATTORNEY

1

2,901,711

WAVE-GUIDE TERMINATION

Edward W. Houghton, Chatham, N.J., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Application February 5, 1957, Serial No. 638,412

4 Claims. (Cl. 333—22)

This invention relates to wave transmission lines and more particularly to a dissipating termination for a wave guide.

An object of the invention is to terminate a wave guide in an impedance which closely matches its characteristic impedance, in both resistance and reactance, over a wide band of frequencies. Other objects are to extend the frequency range over which the impedance match occurs, and to reduce the size and increase the reproducibility and stability of the device.

Wave guides used in microwave systems often require a dissipative termination which closely matches the impedance of the guide over a comparatively wide band of frequencies. Perhaps the most common termination comprises a tapered strip or block of dissipative material located at the end of the line. A structure of this type is undesirably long, and variation in the composition of the material makes it difficult to reproduce and unstable in operation. In general, terminations employing probes or transverse resistors provide an impedance match at only a single frequency.

The termination in accordance with the present invention is applicable to wave guides of the hollow-pipe type. The guide, which may be of rectangular or other suitable cross section, is closed at the end by a reflector. A probe having resistance associated therewith projects from a side of the guide, only part way across, in the direction of the electric field of the electromagnetic waves. The length and resistance of the probe, and its position with respect to the reflector and the center of the guide, are chosen to provide a terminating impedance the resistive component of which matches the resistive component of the wave-guide impedance over a selected band of frequencies. Furthermore, the transverse dimensions of the probe are so chosen that the reactance of the probe substantially cancels the reactance of the section of wave guide terminating in the reflector, as seen from the probe, over the same band. A reflection coefficient of one percent or less over a band of ten percent or more may be obtained.

The position of the reflector and the penetration of the probe within the guide may be made adjustable, if desired. Ordinarily, the probe is spaced approximately a quarter wavelength from the reflector, thus providing a very compact structure. A suitable resistive probe may comprise a ceramic core partly or entirely coated with carbon. One end of the probe may be plated with metal and inserted in a suitable metallic holder which fits into a hole in the side of the guide. As this type of resistor is quite stable, a termination using it is easy to reproduce and has electrical characteristics which are correspondingly stable with time and with changes in temperature and humidity.

The nature of the invention and its various objects, features, and advantages will appear more fully in the following detailed description of a typical embodiment illustrated in the accompanying drawing, of which

2

Fig. 1 is a top view of a dissipative wave-guide termination in accordance with the invention;

Fig. 2 is a sectional side view of the structure shown in Fig. 1, taken at the line 2—2 in the direction of the arrows;

Fig. 3 is a plot of impedance versus frequency characteristics used in explaining the invention; and

Fig. 4 is a plot showing a typical characteristic of the amplitude of the reflection coefficient versus frequency obtainable with the termination shown in Figs. 1 and 2 and, for comparison, a characteristic obtainable in a prior structure of comparable size.

The termination shown in Figs. 1 and 2 comprises a wave guide 5, a reflector 6 at the end thereof, and a resistive probe 7. The guide 5 is of the hollow-pipe type and is rectangular in cross section, with unequal transverse dimensions. Other suitable cross-sectional shapes may be used, if desired. The reflector 6 is in the form of a metallic piston which makes a good electrical contact with the walls of the guide 5. The piston 6 is movable along the guide and is provided with a push rod 8 to facilitate its adjustment.

The probe 7 comprises a cylindrical, ceramic core entirely or partly coated with a film of carbon, as indicated by the stippling, and plated at the end 10 with metal. The end 10 fits tightly into a circular hole in a metallic holder 11 which is threaded to engage a threaded hole in a wider side 12 of the guide 5. A slot 13 permits the holder 11 to be turned by a screw driver to adjust the distance X that the probe 7 extends into the guide 5.

In accordance with the invention, the termination is designed to match both the resistive and the reactive component of the impedance of the guide 5 over a comparatively wide band of frequencies. In Fig. 3, the curve 15 represents the resistive component of the characteristic impedance of the guide, as modified by the presence of the reflector 6, over a range of frequencies extending to either side of the selected mid-band frequency f_0 , near which the curve has its maximum value. The resistance of the probe 7 is substantially constant over this band, as shown by the curve 16. In order to provide the desired match between the guide 5 and the termination, the direct-current resistance R of the probe, the distance X, the distance Y from the reflector 6 to the center of the probe, and the distance Z from the center line 14 of the guide 5 to the center of the probe are chosen to make curve 16 match the curve 15 as closely as possible over the band of interest between the frequencies f_1 and f_2 . The optimum final adjustment of these parameters is probably best determined experimentally. As is seen, the curve 15 preferably crosses the curve 16 at two points in the band of interest.

The solid-line curve 17, having a substantially uniform negative slope between f_1 and f_2 and crossing the zero axis at f_2 , represents the reactance of the section of wave guide terminating in the reflector 6 as viewed from the base of the probe 7. In order for the termination to match the guide, this reactance must be annulled. In accordance with the invention, this is accomplished by properly choosing the diameter D, or other transverse dimension, of the probe 7. The broken-line curve 18, with positive slope and a value of zero at f_2 , shows the reactive component of the terminating impedance corresponding to a certain diameter D. As D is decreased, the slope increases but the frequency of zero reactance does not change. A proper choice of D gives the solid-line curve 19, which has a positive slope equal in magnitude to the negative slope of the curve 17. Under these circumstances, the reactance of the probe substantially cancels the reactance of the section of guide terminating in the reflector and a good impedance match

3

is provided for the guide 5 throughout the band of interest.

The broken-line curve 21 of Fig. 4 shows the type of reflection coefficient amplitude characteristic obtainable with terminations of comparable size heretofore used. The solid-line curve 22 shows the greatly improved characteristic obtainable with the termination disclosed herein. While the curve 21 touches the zero axis only once, the curve 22 touches twice. Over the frequency band from f_1 to f_2 , the curve 22 does not exceed 0.01 in magnitude. This is only about a tenth of the deviation of the curve 21 over this same band. In a typical case, the band between f_1 and f_2 may be ten percent or more of the mid-band frequency f_0 .

The curve 22 is a measured characteristic for a termination of the type shown in Figs. 1 and 2 designed for a rectangular wave guide 5 having inside dimensions of 0.795 by 1.590 inches. The probe 7 had a direct-current resistance R of 100 ohms and a diameter D of an eighth of an inch, extended into the guide for a distance X of 0.499 inch, and had a carbon deposit extending for a distance of 0.450 inch from the inner end. The center of the probe was spaced a distance Y of 0.554 inch from the reflector 6 and a distance Z of 0.623 inch from the center line 14. The mid-band frequency f_0 was 6175 megacycles, the wave-guide wavelength 2.391 inches, and the free-space wavelength 1.916 inches.

It is to be understood that the above-described arrangement is only illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention. For example, after the proper distance Y has been found, the movable piston 6 may be replaced by a fixed transverse partition or end plate. Also, in special cases, the probe 7 may be centered in the wall 12 of the guide, so that the distance Z is zero.

What is claimed is:

1. In combination, a wave guide, a reflector at one end thereof, and a probe having resistance associated therewith, the probe projecting from a side of the guide part way only thereacross in the direction of the electric field of the waves therein, the length and resistance of the probe and its position with respect to the reflector and the center of the guide being chosen to provide a terminating impedance the resistive component of which matches the resistive component of the characteristic impedance of the guide over a comparatively wide band

4

of frequencies and the transverse dimensions of the probe being so chosen that the reactance of the probe substantially cancels the reactance of the section of guide terminating in the reflector, as seen from the probe, over the same band.

2. The combination in accordance with claim 1 in which the probe comprises a ceramic core coated with a film of carbon.

3. In combination, a wave guide of rectangular cross section with unequal transverse dimensions, a reflector at one end thereof, and a resistor projecting part way across the guide from a wider side thereof, the resistor comprising a cylindrical core of insulating material coated with a thin layer of carbon, the length and resistance of the resistor and its location with respect to the reflector and the center of the guide being chosen to provide a terminating impedance the resistive component of which substantially matches the resistive component of the characteristic impedance of the guide over a comparatively wide band of frequencies and the diameter of the resistor being such that the reactance of the resistor is substantially equal in magnitude to the reactance of the section of guide terminating in the reflector, as viewed from the resistor, over the same band.

4. In combination, a wave guide of the hollow-pipe type and a wide-band termination therefor comprising a transverse reflector within the guide and a resistive probe projecting inwardly from a wall of the guide, the probe having a core of nonconducting material coated with a thin layer of carbon, the length and resistance of the probe and its position with respect to the reflector and the center of the guide being chosen to make the resistance of the probe match the resistive component of the characteristic impedance of the guide, as modified by the presence of the reflector, at two frequencies within and near the edges of the transmission band, and the transverse dimensions of the probe being so chosen that the reactance of the probe substantially cancels the reactance of the section of wave guide terminating in the reflector, as viewed from the base of the probe, over the same band.

References Cited in the file of this patent

UNITED STATES PATENTS

2,151,118	King et al.	Mar. 21, 1939
2,579,327	Lund	Dec. 18, 1951
2,588,103	Fox	Mar. 4, 1952