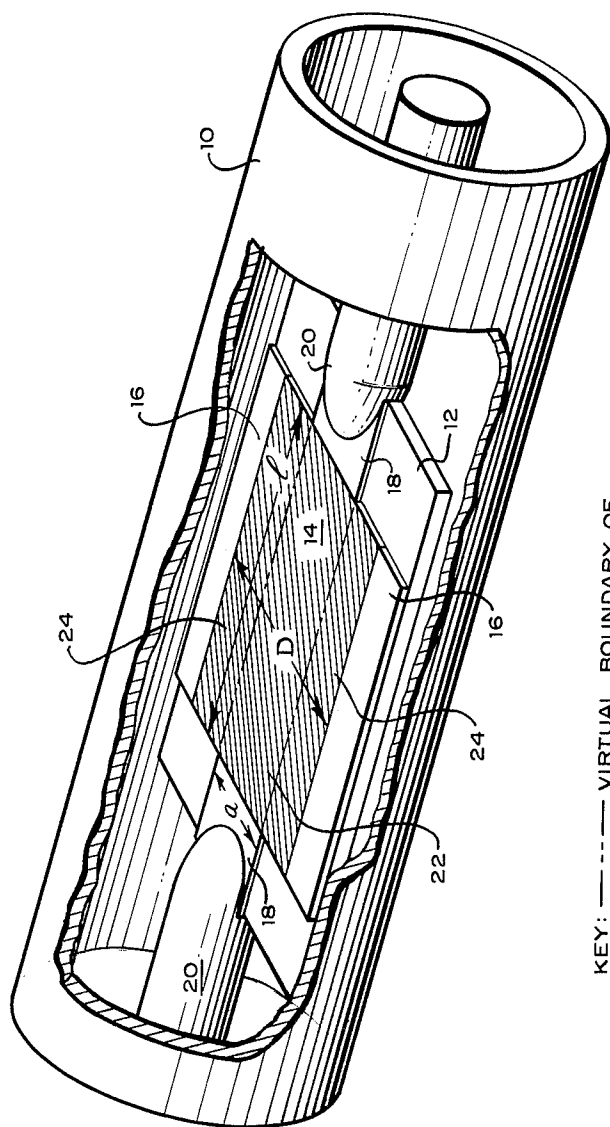


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FIXED COAXIAL LINE ATTENUATOR WITH DIELECTRIC-MOUNTED
RESISTIVE FILM
Filed Aug. 31, 1964

3,227,975



KEY: ——— VIRTUAL BOUNDARY OF
RESISTIVE REGIONS

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3,227,975

FIXED COAXIAL LINE ATTENUATOR WITH DIELECTRIC-MOUNTED RESISTIVE FILM

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3 Claims. (Cl. 333-81)

This invention relates to fixed attenuators and particularly to a distributed network resistive film attenuator.

It is an object of this invention to provide an improved resistive film attenuator having both distributed shunt and distributed series elements.

Another object of this invention is to provide a wide band attenuator having a substantially flat frequency response over a wide range of frequencies, for example, from D.C. to twelve and four tenths kilomegacycles per second (D.C.—12.4 Gc.).

In accordance with the illustrated embodiment of this invention there is provided a fixed coaxial attenuator comprising a dielectric plate supported within a cylindrical outer conductor between sections of a coaxial inner conductor. A rectangular sheet of resistive material having a predetermined width and a predetermined length is positioned on the dielectric plate between first and second pairs of electrodes so disposed that a common axis of each pair normally bisects a common axis of the other pair. The first pair of electrodes provides electrical contacts between the outer conductor and the lengthwise sides of the rectangular sheet along the full length thereof. The second pair of electrodes provides electrical contacts between the sections of the coaxial inner conductor and a central portion of the lateral sides of the rectangular sheet, which central portion bears a fixed relation to the predetermined width of the rectangular sheet.

Other and incidental objects of this invention will be apparent from a reading of this specification and an inspection of the accompanying drawing which shows a cutaway view of a coaxial attenuator according to this invention.

Referring to the drawing, there is shown a fixed coaxial attenuator including a cylindrical outer conductor 10 and a dielectric plate 12 supported therein. Dielectric plate 12 is made sufficiently wide so that the lengthwise edges thereof are contiguous with substantially diametrically opposed portions of outer conductor 10. Dielectric plate 12 may be formed from a thin sheet of aluminum oxide. A distributed element attenuation network including a rectangular resistive film 14 contiguously interposed between two pairs of highly conductive electrodes 16 and 18 is deposited on the surface of dielectric plate 12. Rectangular resistive film 14 may be formed by depositing a thin layer of Nichrome on the surface of dielectric plate 12. This layer is only a few angstroms in thickness, but is shown greatly exaggerated in the drawing for clarity of detail. A protective coating of silicon oxide is deposited over the resistive film 14 to protect it from humidity and other environmental effects. The electrodes 16 are disposed between the outer conductor 10 and the lengthwise edges of rectangular resistive film 14 along the full length thereof to provide a good electrical signal connection between the lengthwise edges of rectangular resistive film 14 and outer conductor 10. The electrodes 18 are disposed between the sections of coaxial inner conductor 20 and a predetermined central portion, a , of the lateral edges of rectangular resistive film 14 to provide a good electrical signal connection between this central portion and the sections of the coaxial inner conductor 20. The electrodes 16 and 18 may be formed by depositing a thin layer of silver on the dielectric plate 12.

Approximate relationships which may be used to design

an attenuator providing selected values of characteristic impedance, Z_0 , in ohms, and attenuation, α , in nepers per unit length, according to this invention are now developed. The following basic equations for the characteristic impedance and attenuation of a non-reactive lossy line are derived from transmission line theory:

$$(1) \quad Z_0 = \sqrt{R/G}$$

$$(2) \quad \alpha = \sqrt{RG}$$

where R is the series resistance per unit length and G is the shunt conductance per unit length. Referring to the drawing, the rectangular resistive film 14 is divided lengthwise into three separate resistive regions for purposes of analysis. A series resistance region 22 having a resistivity of τ_1 ohms per square and width of dimension a is interposed between two shunt resistance regions 24, each having a resistivity of τ_2 ohms per square and width of dimension $(D-a)/2$. The series resistance R in ohms per unit length is therefore given by:

$$(3) \quad R = \tau_1/a$$

and the shunt conductance G in ohms per unit length by:

$$(4) \quad G = 4/(D-a)\tau_2$$

Substitution of Equations 3 and 4 into Equations 1 and 2 gives:

$$(5) \quad Z_0 = \sqrt{\tau_1\tau_2(D-a)/4a}$$

$$(6) \quad \alpha = \sqrt{4\tau_1/a\tau_2(D-a)}$$

For the special case $\tau_1 = \tau_2 = \tau$ Equations 5 and 6 simplify to the following:

$$(7) \quad Z_0 = \tau/2\sqrt{(D-a)/a}$$

$$(8) \quad \alpha = 2\sqrt{1/(D-a)/a}$$

Thus, the attenuation, α in nepers per meter, is independent of resistivity and may be selected by using a rectangular resistive film 14 having an appropriate width of dimension D in combination with electrodes 18 having an appropriate width of dimension a . Different values of attenuation, A in nepers, may then be selected by altering the length, l , of rectangular resistive film 14. The attenuation, A , in nepers is readily converted to attenuation, A , in decibels by use of the relationship, one neper equals 8.686 decibels.

The characteristic impedance Z_0 may be selected by using a rectangular resistive film 14 having the appropriate resistivity τ in ohms per square. Because the resistivity τ of rectangular resistive film 14 varies with the thickness thereof, the resistivity may be selected by controlling the thickness of the material deposited.

More exact relationships for the characteristic impedance Z_0 and attenuation α in terms of the dimensions D and a and film resistivity τ may be developed through the successive use of conformal transformations and the use of the ordinary network parameters Z_{oc} and Z_{sc} , the open circuit and short circuit impedances respectively of the attenuation network.

A fixed attenuator may be built in accordance with this invention which has a substantially flat frequency response for frequencies ranging from D.C. to at least 12.4 Gc. and which is capable of handling up to eight watts of power.

We claim:

1. In an electromagnetic wave energy transmission path including outer and inner conductors, a dielectric member supported within said outer conductor, a flat region of resistive material supported on said dielectric member, a first pair of electrodes spaced a first predetermined distance apart on said dielectric member connecting said outer conductor and two opposite boundaries of said

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flat resistive region along the full length thereof, and a second pair of electrodes spaced a second predetermined distance apart on said dielectric member connecting said inner conductor and two remaining boundaries of said flat resistive region along a central portion thereof, the width of said central portion bearing a fixed relation to said first predetermined distance.

2. In an electromagnetic wave energy transmission path including outer and inner conductors, a dielectric member supported within said outer conductor, a rectangular region of resistive material supported on said dielectric member, a first pair of electrodes spaced a first predetermined distance apart on said dielectric member connecting said outer conductor and two opposite boundaries of said rectangular resistive region along the full length thereof, and a second pair of electrodes spaced a

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second predetermined distance apart on said dielectric member connecting said inner conductor and the two remaining boundaries of said rectangular resistive region along a central portion thereof, the width of said central portion bearing a fixed relation to said first predetermined distance.

3. In an electromagnetic wave energy transmission path including outer and inner conductors, the apparatus as claimed in claim 2 wherein the edges of said second electrodes which face each other are straight lines.

No references cited.

HERMAN KARL SAALBACH, *Primary Examiner*.

15 R. F. HUNT, *Assistant Examiner*.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,227,975

January 4, 1966

William R. Hewlett et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 34, equation (7) should appear as shown below instead of as in the patent:

$$Z_0 = \tau/2 \sqrt{(D-a)/a}$$

Signed and sealed this 18th day of October 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents