United States Patent

Fletcher et al.

[15] **3,702,979**

[45] **Nov. 14, 1972**

[54] **ROTARY VANE ATTENUATOR WHEREIN ROTOR HAS ORTHOGONALLY DISPOSED RESISTIVE AND DIELECTRIC CARDS**

[72] Inventors: **James C. Fletcher,** Administrator of the National Aeronautics and Space Administration with respect to an invention of; **Charles T. Stelzried,** La Crescenta; **Tom Y. Otoshi,** La Canada; **David L. Nixon,** Arcadia, all of Calif.; **Robert W. Beatty,** Boulder, Colo.

[22] Filed: **Oct. 29, 1971**

[21] Appl. No.: **193,947**

[52] **U.S. Cl.** .....**333/81 B,** 333/98 R

[51] **Int. Cl.** **H01p 1/22**

[58] **Field of Search** .....333/81 B, 98 M

[56] **References Cited**

UNITED STATES PATENTS

2,542,185	2/1951	Fox	333/81 B
2,603,710	7/1952	Bowen	333/81 B

Primary Examiner—Paul L. Gensler
Attorney—Monte F. Mott et al.

[57] **ABSTRACT**

A rotary vane attenuator is described, comprising two stators and an intermediary rotor, each with a resistive card. The rotor, in addition to the resistive card, includes an orthogonally disposed card of dielectric material which has no resistive film thereon.

4 Claims, 3 Drawing Figures

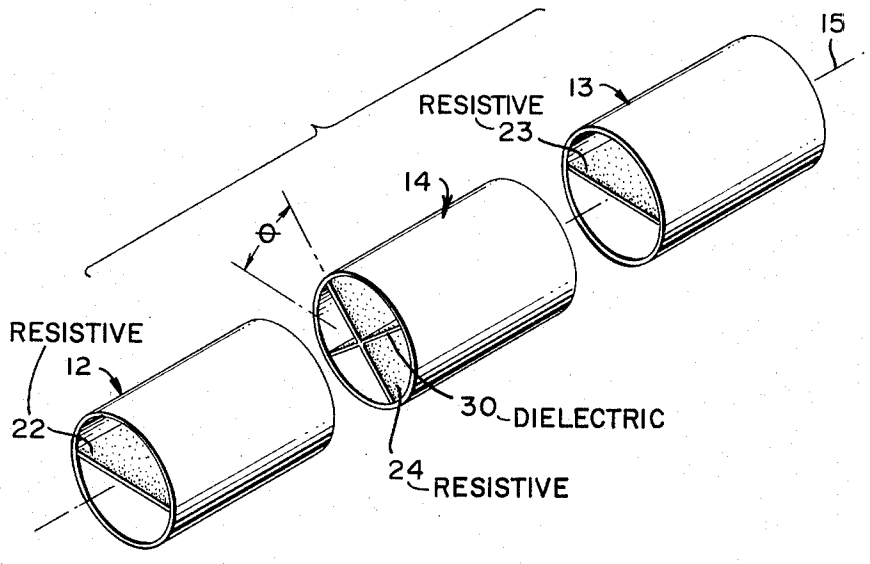


FIG. 1

PRIOR ART

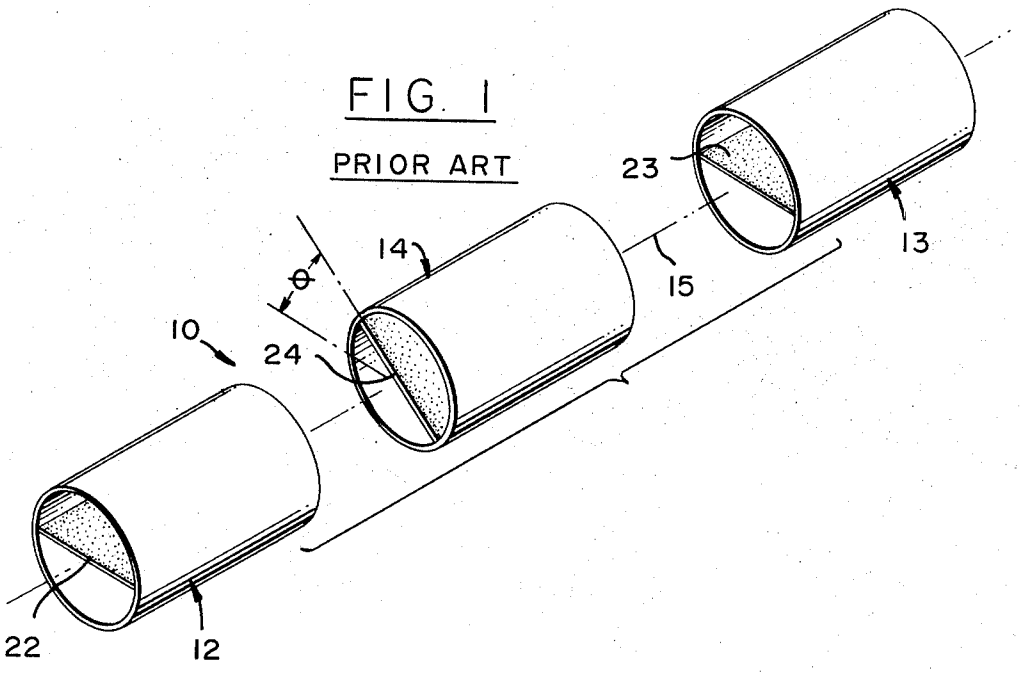


FIG. 2

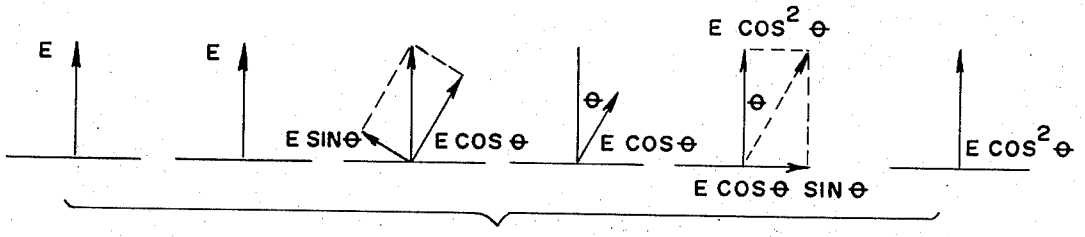
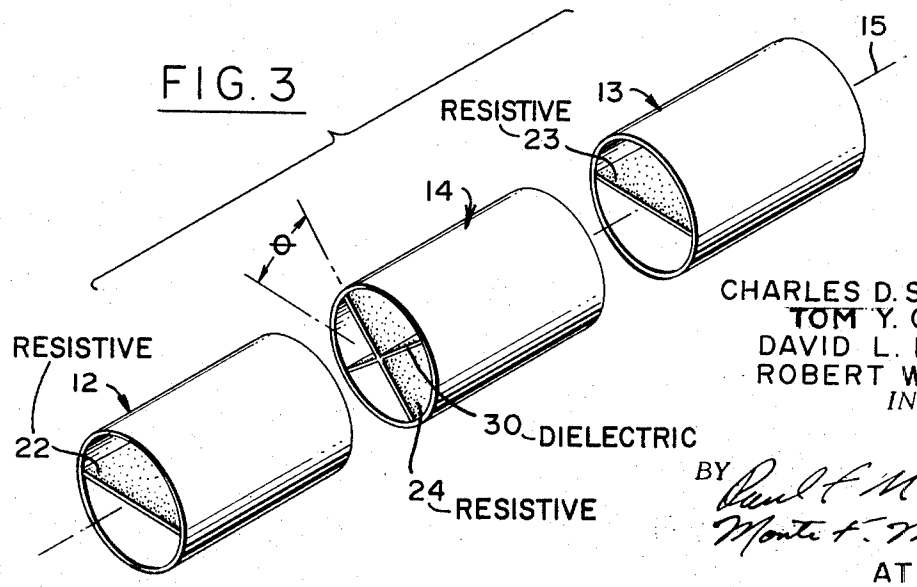


FIG. 3



CHARLES D. STELZRIED
TOM Y. OTOSHI
DAVID L. NIXON
ROBERT W. BEATTY
INVENTORS

BY Paul F. McCord
Monte F. Mott
ATTORNEYS

ROTARY VANE ATTENUATOR WHEREIN ROTOR HAS ORTHOGONALLY DISPOSED RESISTIVE AND DIELECTRIC CARDS

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to attenuators and, more particularly, to a rotary vane attenuator of reduced size and weight and which exhibits small phase shift over the attenuator's dynamic range.

2. Description of the Prior Art

At present various attenuators for energy in the microwave range are well known. These include the rotary vane (RV) attenuator. Basically such an attenuator consists of three sections of a waveguide arranged in tandem. The two outer sections are fixed and are known as stators and the middle section, which is free to rotate axially with respect to the stators, is known as the rotor. The latter is generally a round or cylindrical guide of short length, while each of the stators is generally a rectangular-to-round waveguide. In each section a resistive film card is placed across the guide. In the stators the resistive film cards are normal to the field of the applied wave. The construction is symmetrical and the device is bidirectional.

Two of the basic disadvantages of such an attenuator is its significant length and the phase shift which varies as a function of signal frequency. These two disadvantages greatly complicate attenuation calibration which is very undesirable whenever precise attenuation, as a function of rotor rotation angle, is required.

OBJECTS AND SUMMARY OF THE INVENTION

It is a primary object of the present invention to provide a new improved rotary vane attenuator.

Another object is to provide a compact precision rotary vane attenuator.

A further object of the present invention is to provide a new rotary vane attenuator in which phase shift is substantially independent of signal frequency.

These and other objects of the invention are achieved by providing a rotor in which, in addition to the resistive card, a dielectric card is placed orthogonally with respect to the resistive film card. It should be stressed that the dielectric card does not have any resistive film, deposited thereon. It has been discovered that the addition of the dielectric card enables the reduction of the attenuator length, and the phase shift is substantially independent of frequency. That is, any phase shift which is experienced is substantially constant over a significant portion of the attenuator's dynamic range.

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view of a prior art rotary vane attenuator;

FIG. 2 is a diagram of E field vectors; and

FIG. 3 is an isometric view of the attenuator of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is an isometric view of one type of a conventional rotary vane attenuator **10**, shown comprising stators **12** and **13** between which a rotor **14** is positioned. The three sections are aligned along an axial axis **15**. Positioned in each section is a resistive film card. The three cards in sections **12–14** are designated by numerals **22, 23** and **24**, respectively.

The operating principle of this type attenuator may be described in conjunction with FIG. 2 wherein the E field vectors at the input and output of each section are shown. When all resistive film cards are aligned, the E field of the applied wave is normal to the card. Thus no current flows in the resistive film and no attenuation occurs. If however, the rotor **14** is rotated so that card **24** forms an angle θ with cards **22** and **23**, the E field can be considered as split between two components; E $\sin\theta$ in the plane of card **24** and E $\cos\theta$ at a right angle thereto. The E $\sin\theta$ component is absorbed in card **24** while the E $\cos\theta$ component passes unattenuated to stator **13**. When it encounters card **23**, the E $\cos\theta$ component is split into two components; E $\cos\theta \sin\theta$ in the plane of card **23** and E $\cos^2\theta$ perpendicular thereto. Thus the E $\cos\theta \sin\theta$ component is absorbed by the resistive film on card **23** and the E $\cos^2\theta$ emerges from stator **13** at the same orientation as the original wave which entered stator **12**. Thus ideally attenuation is proportional only to angle θ at which the center card **24** (or rotor **14**) is rotated about axis **15** with respect to stators **12** and **13**. However, in practice it has been discovered that attenuation is frequency dependent due to the phase shift which is a function of frequency.

Phase shift and finite attenuation in the rotor vane can be measured and accounted by the expression

$$A=\frac{1}{\cos^4\theta+\frac{2\cos\phi}{\sqrt{L}}\sin^2\theta\cos^2\theta+\frac{1}{L}\sin^4\theta} \qquad (1)$$

wherein A = attenuation factor

L = power ratio between the normal and tangential components at the rotor output

ϕ = electrical phase shift difference between the normal and tangential components in the rotor in degrees.

In practice ϕ is frequency dependent. Generally L is made as large as possible so that equation (1) approaches

$$A=1/\cos^4\theta$$

In situations where this is not possible, for example, in a precision rotary vane attenuator, where the highest accuracy is required or reduced weight and/or size is important, equation (1) is especially valuable. However, since ϕ is frequency dependent, calibration of the rotary vane attenuator is very difficult.

It has been discovered that significant improvement in the attenuation **10** is achieved by inserting an additional card in the rotor **14** which is orthogonally positioned with respect to the resistive film card **24**. The added orthogonally positioned card however does not support a resistive film, as does card **24**. Rather, the added card is of dielectric material without any conductive film thereon. Such an arrangement is shown in FIG. **3** in which the added card without a resistive film, is designated by numeral **30**.

The incorporation of the dielectric card in the rotor has resulted in substantially constant phase shift with frequency, particularly with X-band attenuators. It has been discovered that with the knowledge of phase shift Φ and L in equation (1), the length of the attenuator need not be made great as is the case in the prior art. Thus, the overall size of the attenuator can be greatly reduced without sacrificing precision in attenuation. Also once the phase shift is known, the attenuator can be easily calibrated for the entire dynamic range.

Although a particular embodiment of the invention has been described and illustrated herein, it is recognized that modification and variations may readily occur to those skilled in the art and consequently it is intended that the claims be interpreted to cover such modifications and equivalents.

What is claimed is:

1. In a rotary vane attenuator of the type including first, second and third waveguide sections aligned along a selected axis, with said first and third sections being stationary and said second center section being rotatable about said axis, with said first and third sections supporting electrically conductive means in a common plane extending through said axis and said second section supporting electrically conductive means in a plane extending through said axis, the improvement comprising:

dielectric means in said second section extending orthogonally to the electrically conductive means which is supported in said second section, in a plane which passes through said selected axis.

2. The arrangement as recited in claim **1** wherein the electrically conductive means in each of said sections is a flat card with a resistive film thereon, and said dielectric means in said second section is a card of dielectric material which is not coated by a resistive film.

3. The arrangement as recited in claim **2** wherein each of the cards extends the length of the section in which it is supported, and at least the second section is cylindrical with its longitudinal axis coinciding with said selected axis.

4. A rotary vane attenuator comprising:

a first waveguide section having a longitudinal axis extending along and coinciding with a preselected axis;

a first card with resistive film thereon, supported in said first waveguide section in a first plane which extends through said preselected axis, said first waveguide section being fixedly positioned about said preselected axis;

a second waveguide section, spaced from said first section, and having a longitudinal axis extending along and coinciding with said preselected axis;

a second card with a resistive film thereon, supported in said second section in said first plane which extends through said preselected axis;

a third waveguide section between said first and second sections and having a longitudinal axis which extends along and coincides with said preselected axis, said third section being rotatable about said preselected axis;

a third card with a resistive film thereon, supported in said third section in a plane which extends through said preselected axis; and

a fourth card of dielectric material, which does not include a resistive film thereon, supported in said third section in a plane perpendicular to the plane in which the third card is supported, and which extends through said preselected axis.

* * * * *