Sept. 23, 1958 H. E. WEBER 2,853,687

WAVEGUIDE ATTENUATORS

Filed Aug. 11, 1953

FIG. 1

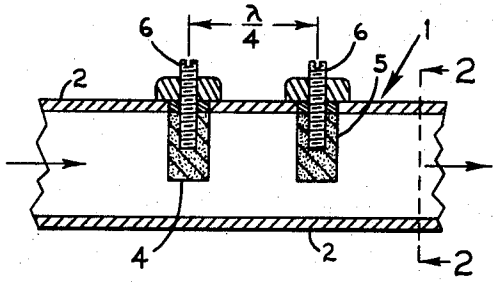



FIG. 2

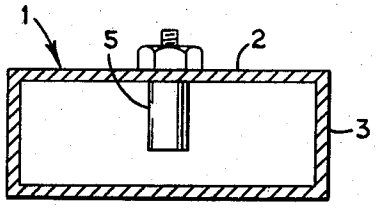



FIG. 3

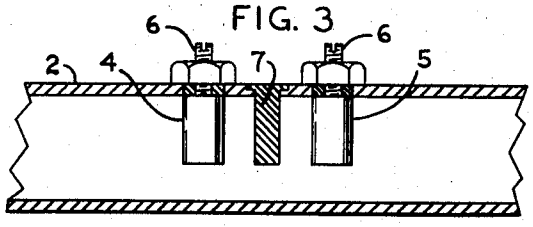



FIG. 4

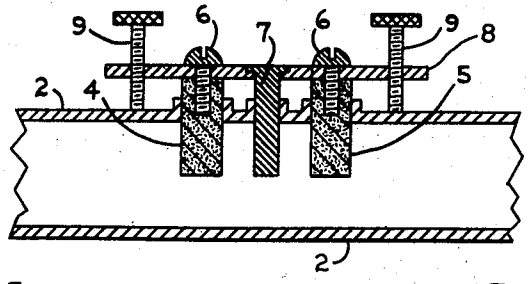



FIG. 5

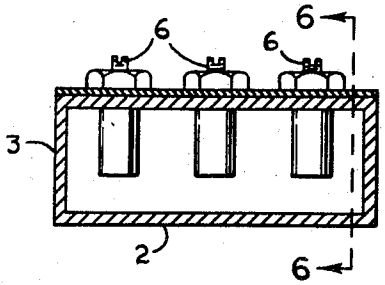
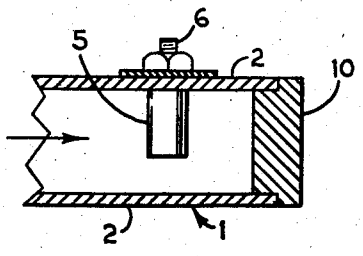



FIG. 6




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# WAVEGUIDE ATTENUATORS

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Application August 11, 1953, Serial No. 373,700

5 Claims. (Cl. 333—81)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

My invention relates to waveguides and is particularly directed to attenuators for changing the microwave power level in the waveguide while at the same time matching the impedance between the sections of the waveguide on either side of the attenuator.

The power level between two points in a length of waveguide may be reduced by absorbing some of the energy and dissipating it in a different form. That energy which is not passed on or absorbed and dissipated is inevitably reflected back toward the input end of the waveguide. The latter condition is not to be desired since it means essentially that there is an impedance mismatch between the two sections and standing waves result. It is well known in basic transmission circuit theory that maximum power transfer and high efficiency is possible only when the impedances of the generator end and the load end of the waveguide are matched to each other and are equal in magnitude.

In the past various methods have been used to attenuate microwave power in the 3 cm. region. Among these are so-called resistance cards comprising plates of glass or Bakelite coated with aquadag or colloidal suspensions of fine carbon powder. Unfortunately such attenuation cards in a waveguide are larger in size than is permissible by the structural parameters imposed on certain microwave equipment. In airborne equipment, for example, size and weight limitations prevent the use of conventional attenuators.

An object of my invention is an improved attenuator for microwave power in waveguide type transmission lines.

A more specific object of my invention is an attenuator for waveguides which will change the microwave power level in the waveguide while at the same time matching the impedance between the sections of the waveguide on either side of the attenuator.

A still more specific object of my invention is to provide an attenuator for waveguides which will sharply reduce power levels in the waveguide with a minimum voltage standing wave ratio.

Still another object of my invention is to provide an adjustable attenuation of power in a waveguide with corresponding adjustments of reactance at the site of the attenuator to match impedances of the sections on either side of the attenuator.

Still another object of my invention is to provide an attenuator for waveguides that are small in size and light in weight.

Other objects of my invention will appear in the following description of preferred embodiments of my invention. While my invention is defined with particularity in the appended claims, said preferred embodiments may be better understood by referring to the accompanying drawings in which:



Fig. 1 is a longitudinal sectional view of a waveguide and attenuator,

Fig. 2 is a lateral sectional view along line 2—2 of Fig. 1,

Figs. 3 and 4 are longitudinal sectional views of waveguides embodying attenuators of my invention,

Fig. 5 is a plan view of a waveguide termination embodying my novel attenuator, and

Fig. 6 is a sectional view taken on line 6—6 of Fig. 5.

The waveguide 1 contemplated in my invention is of the usual rectangular cross section, the width being approximately twice the depth of the waveguide. The side panels 2 and edge panels 3 are usually of drawn, integral construction and the materials of the waveguide walls may be of brass, copper, or other highly conductive metal. According to an important feature of my invention two cylinders, 4 and 5, each comprising powdered iron pressed and held in a coherent mass by an organic binder, are mounted in one of the wider walls of the waveguide and project inwardly toward the opposite wall. The powdered iron cylinders extend inwardly from the wide wall on a line parallel to, or coincident with, the center line of the waveguide. Conveniently, the powdered iron may be cast under pressure around the threads of a machine screw, such as 6, for attachment to its support. The cylinders are spaced along the center line a distance approximately equal to one or an odd number of quarter wavelengths of the operating frequency of the waveguide. It has been found that the amount of attenuation to an electromagnetic wave travelling in its dominant mode from, say, the left to the right hand end of the waveguide is attenuated approximately proportional to the depth of insertion of the powdered iron cylinders into the waveguide. It has been found, further, that the reflection toward the input end of the waveguide and the voltage standing wave ratio is comparatively low, particularly when compared with attenuators of the resistance card type. While the specific reason for the reduced standing wave ratio in my device is not known with certainty, it is believed that each powdered iron cylinder absorbs nearly one-half of the microwave power removed from the waveguide by the attenuator, that the absorbed power is dissipated by eddy current heat losses in the particles of iron, and that the reflections from the downstream cylinder effectively cancels or neutralizes reflections that may occur from the upstream cylinder. This appears to be true at least for small insertion depths.

Experimentation indicates that the attenuation for any particular insertion depth is a function of the diameter of the powdered iron cylinders. This fact yields the alternative of using cylinders of larger diameter rather than using greater insertion depth for greater attenuation. Stated differently, the attenuation is a function of diameter and of the insertion depth of the powdered iron cylinders, while the matching may be made dependent on other interrupting devices in the waveguide.

Such an interrupting device for matching the input impedance to output impedance comprises a tuning post 7 of solid metal such as copper mounted at or near the site of the attenuator. Conventently, the post may be mounted between the powdered iron cylinders and preferably midway between the cylinders. It has been found that the reactances of the post necessary to match the input and output impedances of the waveguide is determined by the depth of insertion of the post and that this depth is approximately the same as the depth of insertion of the cylinders. As the insertion of the cylinders increases the amount of attenuation increases and, as expected, the amount of mismatch of input to output impedances increases. By inserting the matching post at the same rate or to the same depth as the cylinders, the matching re-

actance automatically increases with the degree of mismatch of the input and output impedances.

According to my invention the cylinders and the post are made of about the same length and are attached to a common mounting plate 8 in a single unitary structure which if desired may be adjustably mounted on the wide wall of the waveguide. If the unit is adjusted inwardly or outwardly, as by screws 9, to change the attenuation, input and output impedances are correspondingly matched.

The following table demonstrates the relatively low voltage standing wave ratio, VSWR, which is indicative of small reflections, that may be measured in a waveguide with my novel powdered iron cylinders placed one quarter wavelength apart along the center line of the waveguide. The waveguide was approximately .9 inch wide and .4 inch deep in cross section and was operated at a frequency corresponding to a wavelength of 1.76 inches.

*Waveguide attenuator*

| Insertion inside of wave guide wall to end of culinders 4, 5 | VSWR | |
|---|---|---|
| | With matching post 7 | Without matching post 7 |
| .083 inch | 1.02 | 1.01 |
| .149 inch | 1.04 | 1.20 |
| .175 inch | 1.08 | 1.40 |
| .215 inch | 1.20 | 1.90 |

For insertion depths of the powdered iron cylinders of .175 inch, for example, which is nearly one-half the depth of the waveguide, the VSWR has increased to only 1.40. Even then, the ratio was reduced to a mere 1.08 by the addition of a solid brass post midway between the powdered iron cylinders. It is interesting to note the relatively low VSWR for all values of insertion depth of the attenuator without the post and the still lower values when the reactance of the post is added to match impedances.

My unitary attenuator in admirably adapted for terminating a rectangular waveguide. As shown in Figs. 5 and 6 three powdered iron cylinders are aligned parallel to the short circuiting plug 10 in the end of the waveguide. In this application of my invention, the center-to-center spacing of the powdered iron cylinders need not necessarily be limited to the quarter wave spacing referred to above. In a waveguide about .9 inch by .4 inch inside dimensions operating at 1.76 inches wavelength, this spacing was found to be .140 inch and the voltage standing wave ratio of the termination was as low as 1.08 at a power level of approximately 20 milliwats. The power handling capacity may be increased by increasing the diameter of the powdered iron cylinders and/or by increasing the insertion depth. Fine matching may be conveniently accomplished by telescoping the shorting plug toward or away from the line of cylinders.

The attenuator of my invention will sharply reduce power level in a waveguide while at the same time matching the impedance of the sections of the waveguide on either side of the attenuator.

My novel attenuator is adjustable and with the metal post, a compensating adjustment of reactance at the site of the attenuator is made for matching the impedances of the sections on either side of the attenuator. Further, my novel attenuator is small in size and light in weight and is adapted for small size waveguide structures of the type usually used in airborne equipment. Many modifications may be made in my novel attenuator without departing from the spirit of my invention. For example, the "cylinder" contemplated here need not necessarily be limited to circular configuration.

I claim:

1. A waveguide control device comprising: a metal walled waveguide; a pair of coherent cylinders of powdered iron particles extending into the waveguide from a wall thereof, said coherent powdered iron cylinders being spaced apart about one-quarter wavelength of the operating frequency of the waveguide; a metal cylinder extending into the waveguide from a wall thereof between said coherent powdered iron cylinders; and adjustable means supporting said cylinders in said waveguide to control the depth of penetration of the cylinders in the waveguide whereby microwave energy in the waveguide may be attenuated with the neutralization of reflected energy and a match of input and output impedances.

2. A waveguide control device as set forth in claim 1 wherein said adjustable means supporting said cylinders in the waveguide is operative to control the depth of penetration of said coherent cylinders and said metal cylinder in unison.

3. A waveguide control device as set forth in claim 1 wherein said adjustable means supporting said cylinders in the waveguide is operative to control the depth of penetration of said coherent powdered iron cylinders selectively.

4. A waveguide control device comprising: a metal walled waveguide; a pair of coherent powdered iron cylinders extending into the waveguide from a wall thereof, said coherent powdered iron cylinders being spaced apart about one-quarter wavelength of the operating frequency of the waveguide whereby microwave energy in the waveguide reflected from either coherent powdered iron cylinder tends to be neutralized by the other coherent powdered iron cylinder; a solid metal post extending into the waveguide from a wall thereof between said coherent powdered iron cylinders for matching the input and output impedances of the waveguide; means supporting said coherent powdered iron cylinders and said solid metal post in common; and means on said supporting means in operative association with the waveguide to control the depth of penetration of said cylinders and said post within the waveguide to adjustably control the attenuation, energy neutralization, and impedance match of microwave energy within the waveguide.

5. A waveguide control device as set forth in claim 4 wherein the axes of said pair of coherent powdered iron cylinders and the axis of symmetry of said solid metal post lie on a plane through the longitudinal center of the waveguide.

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