June 9, 1959 J. H. DRY, JR 2,890,369

ATTENUATOR

Filed Oct. 2, 1956

FIG_1

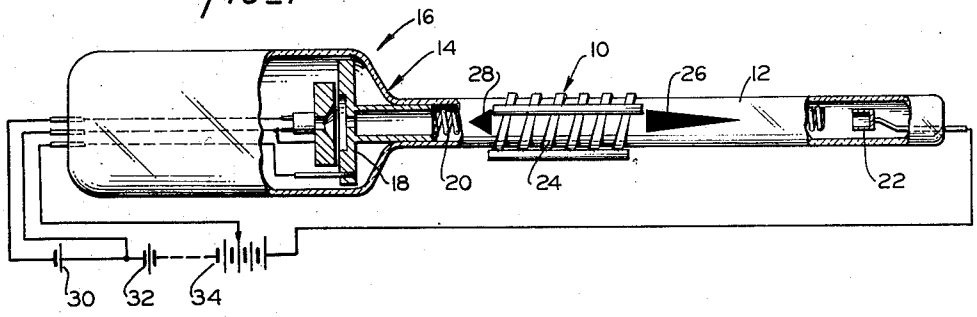


FIG_2

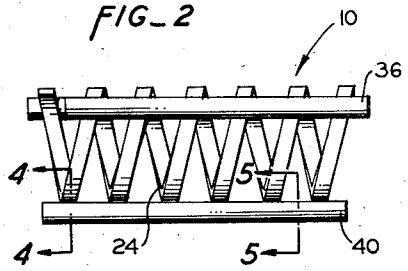


FIG_3

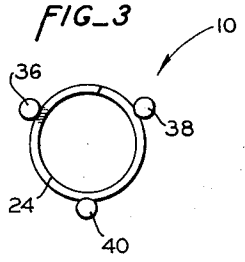


FIG_4

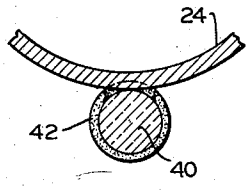
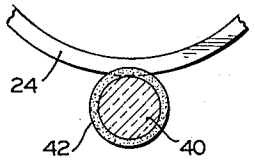


FIG_5



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ATTENUATOR

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1 Claim. (Cl. 315—3)

This invention relates generally to high frequency devices, and more particularly pertains to an improved attenuator for traveling wave tubes and a method for fabricating the same.

Inherent in the structure of traveling wave tubes of the helix type are a number of mismatches which cause the generation of reflected waves which interfere with the signal intended to be amplified by the tube. To minimize such interference, attenuators have been used to attenuate the undesirable reflected waves, and for optimum performance, it is desirable that the attenuators have predictable and constant performance characteristics. That is, when it is determined that a certain degree of attenuation is necessary, it is desirable that the design of the attenuator lend itself to the fabrication of a unit having such characteristics. Moreover, the attenuator should be adapted to absorb waves of both low and high power, and preferably should be movable relative to the helix of the traveling wave tube in order to optimize the efficiency and power output of the tube.

Heretofore, attenuators of this class consisted of a single or multifilar winding surrounded by and in contact with a lossy material, such as a film of colloidal graphite of a given resistivity, and normally took the form of a tungsten helix tightly enclosed in a glass tube having a coating of colloidal graphite painted on its inner surface.

The attenuation of a device of this type being a function of the resistivity of the coating of the graphite, critical control of the thickness of the coating was necessary, and the practice has been to coat a number of glass tubes and select those giving the most nearly correct attenuation characteristics. This process is obviously expensive, particularly since it involves the fabrication and ultimate discard of many tubes. Also, it has been observed that slight changes in the contact between the wire of the helix and the coating on the glass enclosure cause appreciable changes in the loss characteristics of the attenuator, and since light vibration or shock have a noticeable effect on the contact, the characteristics of the attenuator were erratic and unreliable.

With an appreciation of the problems associated with prior art attenuators, applicant has as a primary object of this invention to provide an improved attenuator for traveling wave tubes which overcome such shortcomings and disadvantages.

Another object of the invention is to improve the operation of traveling wave tubes.

A more specific object of the invention is to provide an attenuator which is easily and conveniently assembled with a traveling wave tube and which is adapted for adjustment relative to the helix of the traveling wave tube.

Another object of the invention is to provide an attenuator for the undesirable reflected waves in a traveling wave tube and having a construction such that its characteristics are not materially effected by vibration and shock.

In the attainment of the foregoing objects, the attenuator contemplated by the invention comprises a helix formed of conducting material, for example tungsten, having an optimum number of turns per inch for the traveling wave tube for which it is to be used, to which one or more insulating rods, formed of ceramic for example, coated with a lossy material, are secured. The helix is preferably formed of tungsten ribbon stock, tungsten being preferable because of its favorable high temperature characteristics, and the ribbon form being desirable since it affords flat surfaces to increase the area of mechanical contact between the rod, or rods, and the helix thereby to enhance the rigidity of the structure. While a single ceramic rod substantially coextensive with the helix may be used, it is preferable to use three or more rods arranged parallel to the axis of the helix and equally distributed about the circumference of the helix to increase the rigidity of the structure and to provide sufficient surface area to achieve the loss usually necessary. The ceramic rods are preferably glazed to each convolution of the helix at the point of intersection therewith to provide an open cage-like structure. The ceramic rods are then coated with a resistive material, such as a colloidal graphite suspension, the open structure permitting the spraying, instead of painting, of the colloidal suspension.

Greater control of the thickness and consistency of the lossy graphite coating may be achieved with spraying than was possible with the painting, or spraying, of the interior of the glass tube of prior art attenuators.

The loss path of the attenuator of the invention is from turn to turn of the conducting helix along the graphite coating on the ceramic rods, and consequently should any graphite suspension be coated on the tungsten stock during the spraying operation, it will not affect the characteristics of the attenuator. The glazed connection between the ceramic rods and the helix, at several points, each to the other, precludes relative movement of the helix and the lossy film on the rods, thereby eliminating undesirable changes in the loss characteristics of the attenuator with shock and vibration. The construction further permits a selection of an inside diameter for the helix such that it may be assembled over the glass enclosure for the helix of a traveling wave tube, the ceramic rods being secured to the outer diameter of the helix so as not to interfere with relative movement of the attenuator and the envelope of the tube.

Other objects, features and advantages of the invention, and a better understanding of its construction and operation will become apparent from the following description, taken in connection with the accompanying drawings, in which:

Fig. 1 is an elevation view, partially in section, of a typical traveling wave tube, having assembled therewith an attenuator constructed in accordance with the invention;

Fig. 2 is an elevation view of a preferred embodiment of the attenuator constructed in accordance with the invention;

Fig. 3 is an end view of Fig. 2;

Fig. 4 is a fragmentary sectional view taken along line 4—4 of Fig. 2; and

Fig. 5 is a fragmentary view taken along line 5—5 of Fig. 2.

Referring now to the drawing, and more particularly to Fig. 1, there is illustrated a typical traveling wave tube **16**, generally comprising an elongated glass envelope **12**, **14**, enclosing a source of electrons, such as electron gun **18**, at the right end of the tube arranged to direct a beam of electrons along the axis of a helix **20** for collection at the opposite end of the tube by collector **20**. As is well known, an electromagnet (not shown) customarily surrounds the tube in the vicinity of helix **20** to provide a longitudinal magnetic focusing field to confine the electron beam and enable it to pass completely through the helix **20**. Appropriate operating potentials are applied to the electrodes of traveling wave tube **16** by suitable voltage sources **30**, **32** and **34**.

Without here discussing in detail the operation of tube **16**, which is well known, suffice it to say that loss must be added in the vicinity of helix **20**, so that the backward loss of the tube (loss for a wave traveling from output to input) will be greater than the forward gain. In prior art tubes in which the helix was supported by a surrounding glass tube, loss was added by applying a colloidal graphite suspension, such as "Aquadag," on the inside or outside of the glass tube, which provided some control of distribution of loss with distance, but had the shortcomings described hereinabove. In accordance with the present invention, attenuator **10** is structurally independent from the helix **20** of the traveling wave tube, being assembled with the tube exteriorly of the envelope **12**, as shown. The inside diameter of helix **24** of the attenuator is selected to snugly, yet slidably, fit the outside diameter of envelope **12** in the region of helix **20**, whereby the position of the attenuator may be adjusted to couple helix **24** with helix **20** of the tube to obtain maximum attenuation of reflected waves. In general, it has been found that the optimum position of attenuator **10** is between one-third and one-half of the distance from electron gun **18** to collector **22**. The conducting helix **24** electrically couples radio frequency energy traveling along helix **20** in the direction from the collector **22** toward the gun **18**, this energy being absorbed in the lossy coating on the ceramic rods of the attenuator. To match the impedance of helix **24** to the traveling wave tube **16**, tapered impedance-matching patches **26** and **28**, which may be a colloidal graphite suspension, are painted on the outer surface of envelope **12** at the extremities of attenuator **10** when properly positioned. While only two of such patches are illustrated, a plurality of similar tapered patches, substantially uniformly circumferentially arranged about envelope **12** in the region of the attenuator, may be employed to advantage.

Having described the applicability and utility of the present attenuator to a traveling wave tube, reference is now made to Figs. 2 through 5 for a better understanding of its construction. The attenuator comprises a helix **24** formed of conducting material, preferably tungsten ribbon stock, wound into a helix having a spacing between turns suitable for the frequencies at which it is to be employed. Attached to helix **24**, preferably by glazing, are one, and preferably three or four, ceramic rods **36**, **38** and **40**, with the glazing applied at each intersection of a rod with a convolution of the helix. Each of rods **36**, **38** and **40** is substantially coextensive with helix **24** and are uniformly distributed about the circumference of the helix and parallel to the axis of the helix. Each of the rods is coated with a coating of lossy material **42**, preferably colloidal graphite of predetermined resistivity, clearly indicated in the enlarged illustration of Figs. 4 and 5.

In the fabrication of the attenuator, a tungsten wire, preferably of ribbon form, is wound on a cylindrical mandrel to form a helix, the helix thereafter being fired for approximately 15 minutes at a temperature of approximately 900° C. to stabilize its shape. Ceramic rods **36**, **38** and **40** are preferably fabricated with a longitudinal strip of glazing material on their surfaces, and are placed in a jig (not shown) with the glazing material directed radially inward so as to be adjacent the turns of the helix **24**. The jig is constructed properly to position the ceramic rods and to allow the helix to be inserted therebetween. With the helix and rods so held in position, the assembly is fired at the glazing temperature of the glazing material, which may be approximately 1250° C., to achieve a bond between the helix and the ceramic rods. The assembly is then removed from the furnace and after cooling at room temperature, is removed from the jig. Thereafter, the ceramic rods and the helix are sprayed with a substantially uniform coating of lossy material, such as colloidal graphite, to a thickness of a few microns, the coating thickness being selected to have optimum resistivity consistent with the tube type on which attenuator is to be used.

While the use of tungsten as the helix material is preferred because of its favorable high temperature characteristics, it will be understood that other suitable conducting material may be employed without departing from the invention. Also, while ribbon stock is preferred to afford a flat relatively large area of contact between the helix and the ceramic rods, it will be understood that the helix may also be formed of stock of circular or other cross-sectional shape, without altering the operation of the attenuator. It will also be understood that although the rods have been described as being formed of ceramic, primarily because of the ease of bonding them to tunsten wire and their stable temperature characteristics, other materials which do not expand or contract materially with changes in temperature, which will receive a coated lossy material, and which can be conveniently bonded to the helix, may be employed. Colloidal graphite is preferred as the lossy material, because of the ease of control of its thickness and resistivity, but it will be understood that other materials having suitable characteristics may be employed without departing from the spirit of the invention.

From the foregoing it is apparent that applicant has provided an attenuator of a construction which permits convenient control of its characteristics during the fabrication thereof and which ensures constancy of such characteristics with changes in temperature and under conditions of vibration and shock. The construction of the attenuator permits adjustment of its position relative to the helix of the traveling wave tube with which it is used to optimize its effectiveness, and hence the efficiency of the traveling wave tube. There has also been described a process for fabricating the attenuator, which method may be practiced without unusual skill on the part of the operator, and thus suitable for utilization of mass production techniques, yet yields consistently good results with relatively few rejected parts.

Although a preferred embodiment of the invention and a process for fabricating the same have been shown and described, it is recognized that many variations may be made without altering the operation or departing from the spirit of the invention. The foregoing description, therefore, is not to be construed as limiting the invention, but merely illustrative of one form the attenuator may take.

What is claimed is:

A traveling wave tube assembly which comprises: an elongated envelope containing first and second spaced apart electrodes; a first helical conductive member within said envelope and intermediate said electrodes; a second helical conductive member in contact with and slidable along the outside surface of said envelope within an area defined by said first member, said second member including a conducting helix and at least three supporting rods, formed of ceramic material, said rods being rigidly attached to each convolution of the helix and coated

with a lossy material conductively connected to said helix at each point of attachment to said rods; and, at least one tapered patch of lossy material on a surface of said envelope also within said defined area, said patch comprising an impedance matching coupling between said first and second helical members.

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