

Jan. 14, 1958

A. LAUER

2,820,171

TRAVELLING WAVE TUBE

Filed Feb. 8, 1954

2 Sheets-Sheet 1

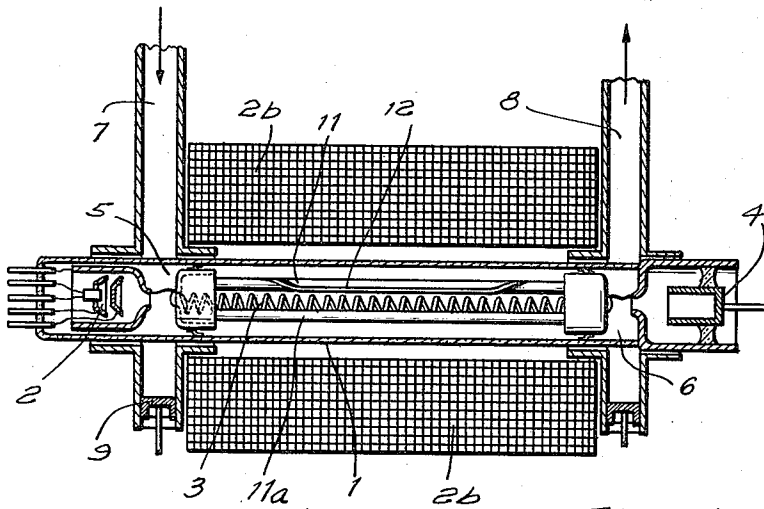


FIG. 1.

FIG. 4.

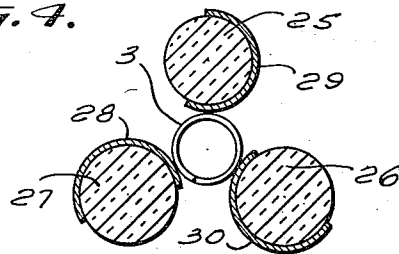
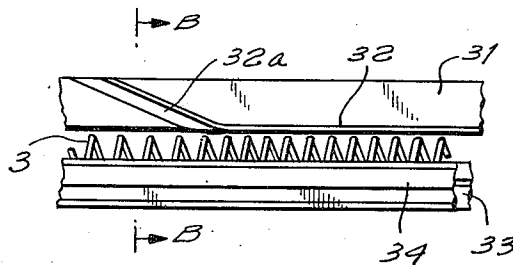


FIG. 5.

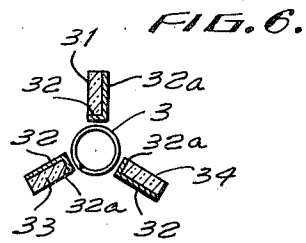


FIG. 6.

INVENTOR.

ANTON LAUER

BY

[Signature]

Jan. 14, 1958

A. LAUER
TRAVELLING WAVE TUBE

2,820,171

Filed Feb. 8, 1954

2 Sheets-Sheet 2

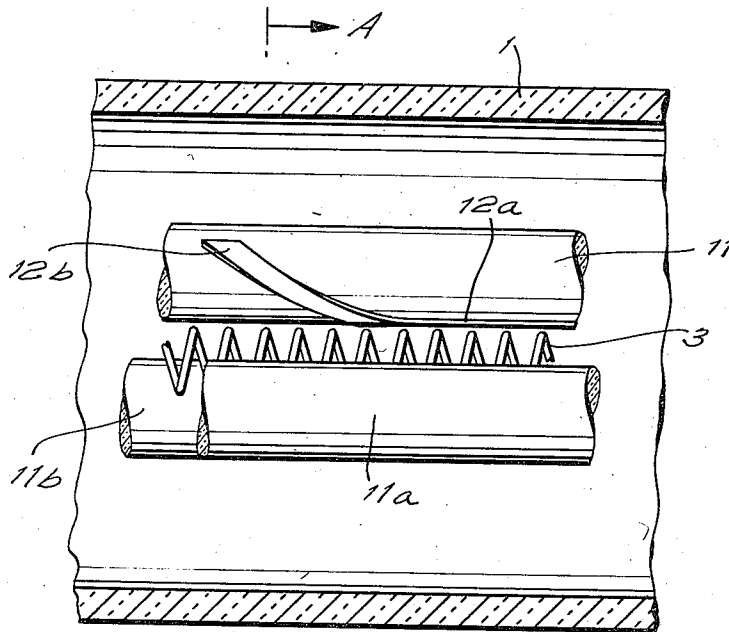


FIG. 2.

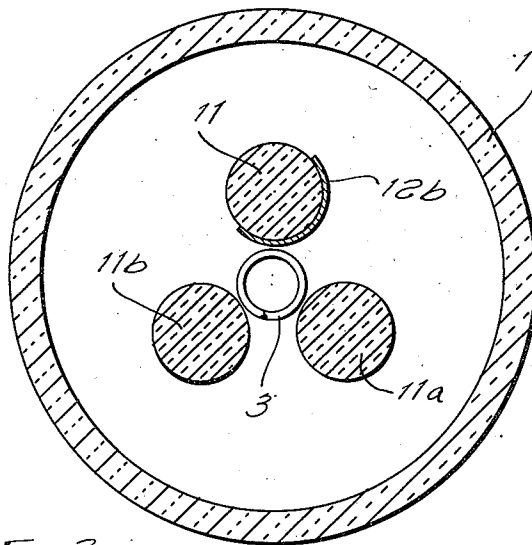


FIG. 3.

INVENTOR.
ANTON LAUER
BY
Michael J. [Signature]
att

1

2,820,171

TRAVELLING WAVE TUBE

Anton Lauer, Ulm, Germany, assignor to Telefunken Gesellschaft fuer drahtlose Telegraphie G. m. b. H., Hannover, Germany

Application February 8, 1954, Serial No. 408,965

Claims priority, application Germany February 7, 1953

16 Claims. (Cl. 315—3.5)

This invention relates to a device for attenuating microwave and particularly to an improved device for attenuating the feedback of energy from the output end to the input end of a travelling wave tube.

Traveling wave tubes are well known in the art and consequently only a brief explanation of the theory of operation of the tube will be given. The traveling wave tube consists of an evacuated closure containing an electron gun, a delay means to which is attached an input and output signal termination, and an electron collector. The input signal is applied at the electron gun end of the delay means. The delay means usually consists of a helix of wire and the wave travels along the helix at approximately the speed of light. Measured along the axis of the helix, however, the velocity of the wave will be considerably reduced. In traveling along the helix, the signal is, under proper conditions, amplified by interaction with the electron beam so that the power transferred to the output of the tube may be a hundred or more times greater than the introduced at the input.

In a traveling wave tube there is feedback from the output end thereof to the input end thereof as a result of the direct coupling between the output and input end and the high amplification of the tube and also because of mismatching of the load at the output of the tube. This feedback causes undesirable self-oscillation. A number of methods are known in the prior art for reducing these oscillations. For example, the helix of wire may be wound of a wire having considerable loss, or an attenuator may be inserted at some place along the helix. The attenuator may consist of a coating of graphite applied to a short section of one or more of the non-conducting rods in which the helix is supported. Another known method for attenuating the feedback of energy is to enclose the helix of wire in a tube of dielectric material and to coat the dielectric material with a layer of a lossy substance. In order to avoid unwanted reflections, the ends of the layer of lossy material are made of reduced thickness.

The above methods for reducing feedbacks are somewhat complicated and are expensive to construct. Furthermore, these known arrangements have not proved to be entirely satisfactory in practice.

It is an object of the present invention to provide a new type of attenuation device which is quite simple to construct and which operates in a very efficient manner.

In accordance with the invention, there is provided a travelling wave tube mainly consisting of an electron source emitting an electron beam and a collector of electrons spaced from the source in the path of the beam. A delay means such as a helix of wire is arranged with its input end in the region of the electron source and its output end in the region of the collector of electrons. The delay means extends along the path of the electron beam and is coupled at its input end to a signal source and at its output end to an output device. The tube is provided with a device for attenuating the feedback from the

2

output end thereof to the input end thereof which comprises at least one elongated member formed of a dielectric material and arranged outside of the delay means and extending parallel to the path of the electron beam, and a lossy substance secured to the elongated member and extending along at least a portion of the length thereof.

In a preferred embodiment of the invention, the feedback attenuation device comprises a plurality of cylindrical or rectangular elongated rods of dielectric material symmetrically arranged about the outside of the helix of wire and within the tube envelope. One or more of the dielectric members has a strip of lossy material secured to the outer surface thereof and in close proximity to the helix of wire near the center portion of the strip and extending away from the helix of wire at the end portions of the strip. In order to provide proper matching, it is preferable to have the end portion of the strip extend away from the close proximity to the helix of wire over a distance of several wave lengths.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a schematic diagram of a traveling wave tube according to the invention;

Fig. 2 is a plan view, somewhat enlarged, of the center portion of the tube illustrated in Fig. 1;

Fig. 3 is a cross-section along the line A—A of Fig. 2;

Fig. 4 is a cross sectional view of a second embodiment of the invention;

Fig. 5 is a plan view of a third embodiment of the invention; and

Fig. 6 is a cross-section along the line B—B of Fig. 5.

Referring now to Fig. 1, there is shown a traveling wave tube comprising a glass envelope 1 within which is located an electron gun 2 for forming an electron beam. The delay means of the tube is a helix of wire 3 extending from its input end which is arranged in the vicinity of the electron gun to its output end which is arranged in the vicinity of the collector of electrons 4. The helix of wire is mounted between supports 5, 6. The beam is properly focussed by means of a focussing coil 2b which is concentric with the tube. Energy is supplied to the tube through an input wave guide 7 and extracted from the tube by means of an output wave guide 8. The input and output wave guides are tuned by means of plungers 9 and 10 respectively.

In accordance with the invention the traveling wave tube is provided with three cylindrical dielectric members 11, 11a and 11b (11b cannot be seen in Fig. 1) symmetrically arranged with respect to the helix of wire.* In order to attenuate the feedback of energy from the output to the input end of the traveling wave tube, at least one of the members 11 is provided with a strip of lossy material 12 such as graphite, carbon, or any other substance well known in the art for attenuating high frequency energy, secured to the outer surface of the member.

Figures 2 and 3 illustrate in somewhat more detail the center portion of the traveling wave tube. As can be seen from Fig. 2, the three dielectric rods 11, 11a and 11b are symmetrically disposed about the helix of wire 3. In a preferred embodiment of the invention the center portion 12a of the strip of lossy material 12 is positioned in

* The dielectric members are also arranged in such a manner along the helix, that their influence on the wave velocity is the same or nearly the same over the whole length of the helix.

3

the direct proximity of the helix of wire 3 and the end portion 12b of strip 12 extends along a helical line away from the helix of wire 3. The dielectric members are all of the same uniform cross-section. The strip of lossy material is of the same thickness throughout its entire extent.

The greatest degree of attenuation occurs at the center portion of the strip of dielectric material. This is because the electromagnetic field generated by the helix of wire rapidly falls off in the radial direction away from the wire. The center portion of the strip which is in close proximity to the wire lies in a very strong electromagnetic field and the end portion of the strip lies, for practical purposes, outside of the electromagnetic field. The very gradual increase in the spacing between the strip and the coil results in a very fine matching arrangement. With such an arrangement, it is no longer necessary as in the previously described arrangement, to decrease the thickness of the strip of lossy material toward the end portion of the strip and this is a great advantage for it is technically quite difficult to obtain a gradual reduction in the thickness of a strip of lossy material.

The dielectric members may be made of a material such as ceramic. In a preferred embodiment, dielectric members are chosen which have a dielectric constant equal to or greater than six. In such case, the dielectric member is made to have diameter somewhat greater than that of the helix. In such a case the wave velocity along the axis of the helix is nearly independent of the frequency over a large frequency range. Then the D. C.-voltage of the helix is nearly constant for all frequencies in this band. This is caused by the drop of the external field, which changes with frequency in such a manner, that it drops quicker with higher frequencies.

Dielectric members of the size to eliminate the dispersion of the helix are also very useful in obtaining a good taper at the ends of the attenuating strip by turning away these ends from the helix surface. In such a case the diameters of the dielectric members are so great, that an attenuating strip which is arranged at one of these is with the ends nearly completely removed out of the field.

With the arrangement described in Figs. 1 to 3, it has been found possible to obtain practically a constant attenuation of the feedback energy over a broad band of frequencies.

Fig. 4 shows a cross-section of a second embodiment of the invention. Here, the helix 3 is surrounded by three cylindrical dielectric members 25, 26 and 27 as in the previous embodiment, however, instead of a single strip of attenuating material on one of the members there are provided strips 28, 29 and 30 respectively secured to the three rods. With this embodiment, it is possible to obtain an even greater attenuation of the feedback energy than with the previously described embodiment.

Figs. 5 and 6 show a third embodiment of the invention consisting of rectangular shaped dielectric rods rather than cylindrical rods. There are three rods 32, 33, 34 symmetrically disposed about the helix 3 and each of the rods has secured to the outer surface thereof a strip 32 of lossy material. As in the previous described embodiments the center portion of strip 32 lies directly adjacent the helix so that the center portion plays the major part in attenuating the electromagnetic wave and the end portions 32a of the strips 32 extend along a curved line out of the very strong electromagnetic field. Although Figs. 5 and 6 illustrate each dielectric member provided with a strip of lossy material, it is to be understood that the invention is also operative with only one of the dielectric members provided with a strip of lossy material.

In all of the previously described embodiments of the invention, three dielectric members are shown symmetrically disposed about the coil. It is to be understood, however, that the invention is not limited to three members or to one, two or three strips of dielectric material.

It will be understood that each of the elements de-

4

scribed above, or two or more together, may also find a useful application in other types of traveling wave tubes differing from the types described above.

While the invention has been illustrated and described as embodied in a traveling wave tube having a helix of wire which forms the delay means thereof, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A traveling wave transmitting structure comprising in combination one helical conductor; a plurality of elongated members formed of dielectric material symmetrically arranged with respect to said helical conductor and extending in the direction of said helical conductor; and a strip of lossy substance secured to the surface of at least one of said members and extending along the greater portion of the length thereof, said lossy substance being of constant cross-section over its entire length and being located in close proximity to said helical conductor near the center portion of said strip and extending away from said helical conductor and out of the strong electromagnetic field of said helical conductor at the end portions thereof.

2. A traveling wave transmitting structure comprising in combination one helical conductor, a plurality of elongated, solid cylindrically shaped members formed of dielectric material and symmetrically arranged outside of said helical conductor and extending in the direction of said helical conductor and a plurality of strips of a lossy substance, each of said strips being of constant cross-section over its entire length and being secured to the surface of one of said members and extending along the greater portion of the length thereof, said strips being located in close proximity to said helical conductor near the center portion of said strips and extending away from said helical conductor at the end portions of said strips.

3. A traveling wave transmitting structure comprising in combination one helical conductor, a plurality of elongated, cylindrically shaped, solid members which are formed of dielectric material and symmetrically arranged outside of said helical conductor and extending in the direction of said helical conductor, said members having a diameter slightly greater than that of said helical conductor and a dielectric constant of at least six and a plurality of strips of a lossy substance, each of said strips being of constant cross-section over its entire length and being secured to the surface of one of said members and extending along the greater portion of the length thereof, said strips being located in close proximity to said helical conductor near the center portion of said strips and extending away from said helical conductor at the end portions of said strips.

4. A traveling wave transmitting structure comprising in combination one helical conductor, at least one elongated member of dielectric material arranged outside of the helical conductor and extending in the direction of said helical conductor, and a lossy substance in the form of a strip of constant cross-section over its entire length and being secured to said member extending along at least a portion of the length of the helical conductor and extending away from said helical conductor for a distance equal to at least several wave lengths at the frequency of the electromagnetic wave excited in said helical conductor

and out of the strong electromagnetic field of said helical conductor at least at one end portion of said strip.

5. A traveling wave transmitting structure comprising in combination one helical conductor, a plurality of elongated, solid members formed of dielectric material and symmetrically arranged outside of said helical conductor and extending in the direction of said helical conductor said members having a diameter slightly greater than that of said helical conductor and a dielectric constant of at least six and lossy substance secured to at least one of said members in the form of a strip having a constant cross-section over its entire length and extending along at least a portion of the length of said member and extending away from said helical conductor for a distance equal to at least several wave lengths at the frequency of an electromagnetic wave excited in said helical conductor and out of the strong electromagnetic field of said helical conductor at least at one end portion of said strip.

6. In a traveling wave tube comprising an electron source emitting an electron beam along a predetermined path, a collector of electrons arranged spaced from said electron source in the path of said electron beam, a delay means having an input end arranged in the region of said electron source and an output end arranged in the region of said collector of electrons, said delay means extending along said predetermined path of said electron beam, input means coupled to said input end of said delay means for exciting an electromagnetic wave therein, and output means coupled to said output end of said delay means for collecting the energy amplified by said electron beam, a device for attenuating the feedback from said output end to said input end comprising, in combination, a plurality of elongated members formed of dielectric material symmetrically arranged within said tube and outside of said delay means and extending in the direction of said electron path; and a strip of a lossy substance having a constant cross-section over its entire length and being secured to the surface of at least one of said members and extending along the greater portion of the length thereof, said lossy substance being located in close proximity to said delay means near the center portion of said strip and extending away from said delay means and out of the strong electromagnetic field of said delay means at the end portions thereof.

7. In a traveling wave tube having a helix of wire therein extending from the signal input end of said tube to the signal output end thereof for producing a relatively slow electromagnetic wave as measured along the axis of said delay means, a device for attenuating the feedback from said signal output end to said signal input end comprising, in combination, a plurality of elongated, solid, cylindrically shaped members formed of dielectric material and symmetrically arranged outside of said helix of wire and within said tube and extending in the direction of said helix of wire; and a plurality of strips of a lossy substance, each of said strips of lossy substance being of a uniform cross-section over its entire length and being secured to the surface of one of said members and extending along the greater portion of the length thereof, said strips being located in close proximity to said helix of wire near the center portion of said strips and extending away from said helix of wire at the end portions of said strips.

8. In a traveling wave tube having a helix of wire therein extending from the signal input end of said tube to the signal output end thereof for producing a relatively slow electromagnetic wave as measured along the axis of said delay means, a device for attenuating the feedback from said signal output end to said signal input end comprising, in combination, a plurality of elongated, solid, cylindrically shaped members formed of dielectric material and symmetrically arranged outside of said helix of wire and within said tube and extending in the direction of said helix of wire, said members having a diameter slightly greater than that of said helix of wire and

a dielectric constant of at least six; and a plurality of strips of a lossy substance, each of said strips being of a uniform cross-section over its entire length and being secured to the surface of one of said members and extending along the greater portion of the length thereof, said strips being located in close proximity to said helix of wire near the center portion of said strips and extending away from said helix of wire at the end portions of said strips.

9. A traveling wave tube comprising in combination, an electron source emitting an electron beam along a predetermined path; a collector of electrons arranged spaced from said electron source in the path of said electron beam; a delay means having an input end arranged in the region of said electron source and an output end arranged in the region of said collector of electrons, said delay means extending along said predetermined path of said electron beam; input means coupled to said input end of said delay means for exciting an electromagnetic wave therein; output means coupled with the output end of said delay means for collecting the energy amplified by said electron beam; and a device for attenuating the feedback from said output end to said input end comprising a plurality of elongated members of rectangular cross section formed of dielectric material symmetrically arranged about the outside of said delay means and within said tube and extending parallel to said path of said electron beam, and a lossy substance having a constant cross-section over its entire length and being secured to at least one of said elongated members and extending along at least a portion of the length thereof.

10. A traveling wave tube comprising in combination, an electron source emitting an electron beam along a predetermined path; a collector of electrons arranged spaced from said electron source in the path of said electron beam; a delay means having an input end arranged in the region of said electron source and an output end arranged in the region of said collector of electrons, said delay means extending along said predetermined path of said electron beam; input means coupled to said input end of said delay means for exciting an electromagnetic wave therein; output means coupled with the output end of said delay means for collecting the energy amplified by said electron beam; and a device for attenuating the feedback from said output end to said input end comprising a plurality of elongated members formed of dielectric material symmetrically arranged about the outside of said delay means and within said tube and extending parallel to said path of said electron beam, and a strip of lossy substance having a constant cross-section over its entire length and being secured to the surface of at least one of said elongated members and extending along the greater portion of the length thereof, said lossy substance being located in close proximity to said delay means near the center portion of said strip and extending away from said delay means and out of the strong electromagnetic field of said delay means at the end portions of said strip.

11. A traveling wave tube comprising in combination, an electron source emitting an electron beam along a predetermined path; a collector of electrons arranged spaced from said electron source in the path of said electron beam; a delay means having an input end arranged in the region of said electron source and an output end arranged in the region of said collector of electrons, said delay means extending along said predetermined path of said electron beam; input means coupled to said input end of said delay means for exciting an electromagnetic wave therein; output means coupled with the output end of said delay means for collecting the energy amplified by said electron beam; and a device for attenuating the feedback from said output end to said input end comprising a plurality of elongated members formed of dielectric material symmetrically arranged about the outside of said delay means and within said tube and extending parallel to said path of said electron beam, and a

7

strip of a lossy substance having a constant cross-section over its entire length and being secured to the surface of at least one of said elongated members and extending along the greater portion of the length thereof, said lossy substance being located in close proximity to said delay means near the center portion of said strip and extending for a distance equal to at least several wave lengths at the frequency of the electromagnetic wave excited in said delay means away from said delay means and out of the strong electromagnetic field of said delay means at the end portions of said strip.

12. A travelling wave tube comprising in combination, an electron source emitting an electron beam along a predetermined path; a collector of electrons arranged spaced from said electron source in the path of said electron beam; a delay means comprising a helix of wire having an input end arranged in the region of said electron source and an output end arranged in the region of said collector of electrons, said delay means extending along said predetermined path of said electron beam; input means coupled to said input end of said delay means for exciting an electromagnetic wave therein; output means coupled with the output end of said delay means for collecting the energy amplified by said electron beam; and a device for attenuating the feedback from said output end to said input end comprising a plurality of elongated members having a dielectric constant of approximately 6 and a thickness somewhat greater than the diameter of said helix of wire, said members being formed of dielectric material symmetrically arranged about the outside of said delay means and within said tube and extending parallel to said path of said electron beam, and a strip of a lossy substance having a constant cross-section over its entire length and being secured to the surface of at least one of said elongated members and extending along the greater portion of the length thereof, said lossy substance being located in close proximity to said delay means near the center portion of said strip and extending away from said delay means and out of the strong electromagnetic field of said delay means at the end portions of said strip.

13. A travelling wave tube comprising in combination, an electron source emitting an electron beam along a predetermined path; a collector of electrons arranged spaced from said electron source in the path of said electron beam; a delay means having an input and arranged in the region of said electron source and an output end arranged in the region of said collector of electrons, said delay means extending along said predetermined path of said electron beam; input means coupled to said input end of said delay means for exciting an electromagnetic wave therein; output means coupled with the output end of said delay means for collecting the energy amplified by said electron beam; and a device for attenuating the feedback from said output end to said input end comprising a plurality of elongated members formed of dielectric material symmetrically arranged about the outside of said delay means and within said tube and extending parallel to said path of said electron beam, and a plurality of strips of a lossy substance, each strip being of constant cross-section over its entire length and being secured to the surface of one of said elongated members and extending along the greater portion of the length thereof, said strips being located in close proximity to said delay means near the center portion of said strip and extending away from said delay means at the end portions of said strips.

14. A travelling wave tube comprising in combination, an electron source emitting an electron beam along a predetermined path; a collector of electrons arranged spaced from said electron source in the path of said elec-

8

tron beam; a delay means having an input and arranged in the region of said electron source and an output end arranged in the region of said collector of electrons, said delay means extending along said predetermined path of said electron beam; input means coupled to said input end of said delay means for exciting an electromagnetic wave therein; output means coupled with the output end of said delay means for collecting the energy amplified by said electron beam; and a device for attenuating the feedback from said output end to said input end comprising three elongated, cylindrically-shaped members of the same dimensions formed of ceramic material symmetrically arranged about the outside of said delay means and within said tube and extending parallel to said path of said electron beam, and a plurality of strips of a lossy substance, each strip being of a constant cross-section and being secured to the surface of one of said elongated members and extending along the greater portion of the length thereof, said strips being located in close proximity to said delay means near the center portion of said strip and extending away from said delay means at the end portions of said strips.

15. In a travelling wave tube having an elongated delay means therein comprising a helix of wire extending from the signal input end of said tube to the signal output end thereof for producing a relatively slow electromagnetic wave as measured along the axis of said delay means, a device for attenuating the feedback from said signal output end to said signal input end comprising, in combination, a plurality of elongated members formed of dielectric material arranged within said tube and outside of said delay means and extending parallel to said delay means; and a strip formed of a lossy substance secured to at least one of said members, said strip having a uniform cross-section over its entire length and extending along the greater portion of the length thereof, said strip being in close proximity to said helix of wire at the center portion thereof and extending away from said helix of wire and out of the strong electromagnetic field generated thereby at the end portions of said strip.

16. In a traveling wave transmitting structure, in combination, a helical conductor; at least one elongated member formed of dielectric material extending in the direction of said helical conductor adjacent thereto and having a central surface portion located in close proximity to said helical conductor, said elongated member having end surface portions located farther from said helical conductor; and a solid strip of lossy substance having a uniform cross-section over its entire length and extending along the greater portion of the length of said member firmly secured at its central portion to said central surface portion of said member and at its end portions to said end surface portions of said member, respectively, whereby said strip of lossy substance is located in close proximity to said helical conductor near the central portion of the helical conductor and extends with its end portions away from said helical conductor while simultaneously being supported from end to end by said elongated member.

References Cited in the file of this patent

UNITED STATES PATENTS

2,197,123	King	Apr. 16, 1940
2,575,383	Field	Nov. 20, 1951
2,626,371	Barnett et al.	Jan. 20, 1953
2,632,130	Hull	Mar. 17, 1953
2,636,948	Pierce	Apr. 28, 1953
2,720,609	Bruck et al.	Oct. 11, 1955
2,750,529	Robertson et al.	June 12, 1956