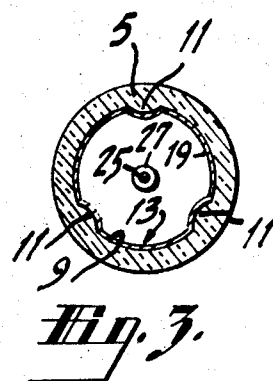
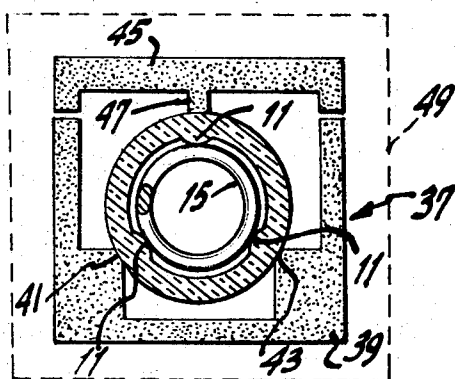
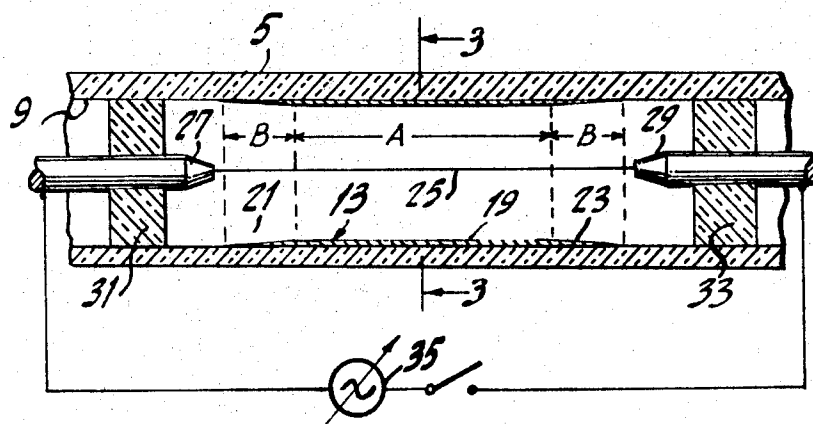
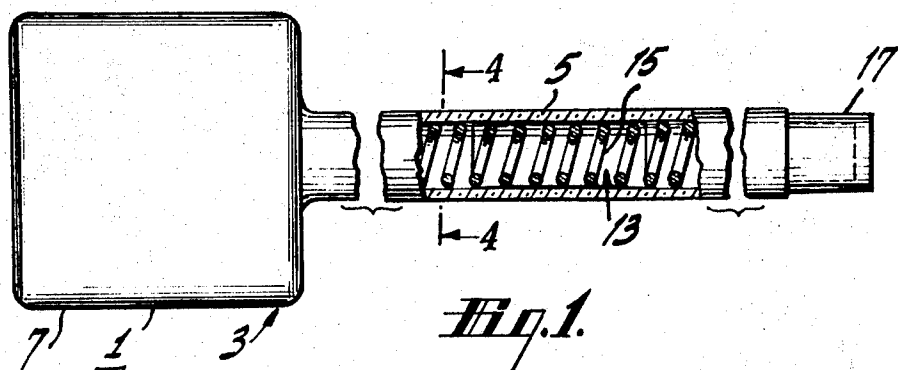


Dec. 1, 1970

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3,544,832

TRAVELING WAVE TUBE WITH EVAPORATED NICKEL ATTENUATOR  
COATING AND METHOD OF MANUFACTURE THEREOF  
Filed July 18, 1968



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1

3,544,832

## TRAVELING WAVE TUBE WITH EVAPORATED NICKEL ATTENUATOR COATING AND METHOD OF MANUFACTURE THEREOF

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Filed July 18, 1968, Ser. No. 745,929

Int. Cl. H01j 25/34

U.S. Cl. 315—3.5

11 Claims

### ABSTRACT OF THE DISCLOSURE

A traveling wave amplifier tube is provided with an attenuator in the form of a thin resistive evaporated metal coating of precisely controlled thickness on the inner wall of the glass envelope, and the helix is mounted within the envelope in firm contact with the attenuator coating. The attenuator coating comprises a central region of uniform thickness merging with end regions smoothly tapered to zero thickness. An envelope with three longitudinal ribs is shown, with the helix slightly embedded in the ribs. The attenuator coating is formed by plating a precise amount of nickel, for example, on a tungsten wire of given length, mounting the coated wire coaxially in the envelope and passing an electric current through the wire for a time sufficient to evaporate nearly all of the nickel from the wire and onto the wall. Due to end cooling and geometry effects, the ends of the wall coating are tapered to zero thickness, with the overall length of the attenuator coating somewhat less than the length of the wire.

### BACKGROUND OF THE INVENTION

The present invention relates to a traveling wave amplifier tube with an improved attenuator and a method of manufacture thereof.

A conventional traveling wave amplifier tube comprises an elongated glass envelope containing an elongated metal helix, an electron gun for projecting an electron beam through the helix for traveling wave interaction therewith, means for coupling waves to be amplified to the helix at one end and for coupling amplified waves from the helix at the other end. In order to attenuate or absorb waves reflected at the couplings and thereby prevent undesired oscillation, a portion of the helix or the adjacent envelope wall is provided with a resistive or lossy member called an attenuator. Various forms of attenuators have been used, such as shaped graphite coatings. In order to produce a tube with good stability and minimum voltage standing wave ratio, the attenuator must be designed to provide the optimum total amount of attenuation and also a gradual tapering of R.F. loss as the traveling wave passes from the non-lossy region into the attenuated region. Sharp gradients or discontinuities in the attenuation will cause unwanted reflection of waves. At a given wavelength, the lossiness of a film or coating of material is a complex function of its resistance. Very little loss will be measured if the resistance is very low or very high.

### SUMMARY OF THE INVENTION

An annular thin resistive evaporated metal attenuator coating of precisely controlled thickness is provided on a portion of the inner glass wall of the envelope of a traveling wave tube, and an elongated metal helix is mounted in the envelope in firm contact with the coating. The attenuator coating preferably comprises a central portion

2

of substantially uniform thickness merging with end portions smoothly tapered to zero thickness at the ends thereof. The attenuator coating may be formed by uniformly depositing on a wire highly refractory metal, such as tungsten or molybdenum, a precise amount of a suitable metal, such as nickel, mounting the wire coaxially within a tubular glass envelope in the region at which the attenuator coating is desired, then passing an electric current through the wire for a time sufficient to evaporate nearly all of the nickel from the wire onto the envelope wall. Due to end cooling and geometry effects, this process produces an attenuator coating having end portions that are tapered to zero thickness.

### BRIEF DESCRIPTION OF THE DRAWING

In the drawing,

FIG. 1 is a side view, partly in longitudinal section, of a traveling wave tube embodying the present invention;

FIG. 2 is an enlarged fragmentary view of the attenuator portion of the envelope of FIG. 1, with apparatus for depositing the attenuator coating;

FIG. 3 is a transverse section view taken on line 3—3 of FIG. 2; and

FIG. 4 is a transverse section taken on line 4—4 of FIG. 1, with apparatus for embedding the helix in the envelope wall.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1 and 4 illustrate a traveling wave amplifier tube 1 having a glass envelope 3 comprising an elongated helix portion 5 and an enlarged electron gun portion 7. The inner wall 9 of the helix portion 5 is preferably formed with three integral longitudinal ribs 11 (FIG. 4). A predetermined annular portion of the inner wall 9 is provided with a very thin resistive attenuating coating 13 of a suitable metal, such as nickel, as described more in detail below. An elongated metal helix 15, e.g. of tungsten, extends along the interior of the helix portion 5 with the turns of the helix embedded slightly in the three ribs 11. The end of the helix portion 5 opposite the gun portion 7 is sealed to a beam collector 17. An electron gun (not shown) within the gun portion 7 is adapted to project an electron beam through the helix 15 for traveling wave interaction with waves thereon. The conventional input and output wave couplers and magnetic beam focusing structure have been omitted, for clarity.

FIGS. 2 and 3 illustrate the details of the attenuator coating 13, with exaggerated thickness. The coating 13 comprises a central portion 19 of substantially uniform thickness and length A merging with end portions 21 and 23 of length B which taper smoothly in thickness to zero thickness at the free ends. Since the boundaries of these portions are not sharp, they are shown by dashed lines on the drawing.

The attenuator coating 13 may be formed on the inner wall 9 of the envelope in the following manner. A length of fine tungsten wire is first electroplated with a precise weight per unit length of the metal to be used for the coating 13. This wire is cut to a predetermined length, which is usually slightly longer than the length of the desired coating. The cut section 25 of coated wire is then attached to the ends of two massive electrodes 27 and 29 and mounted coaxially within the envelope section 5 by ceramic bushings 31 and 33, as shown in FIGS. 2 and 3. The electrodes are connected to a variable AC source 35 for electrically heating the wire 25. An electric cur-

3

rent is passed through the wire 25 for a time sufficient to evaporate nearly all of the metal coating thereon from the wire to the inner wall 9 of the envelope portion 5. If the temperature of the heated wire were uniform along its entire length, the evaporated coating 13 would be uniform for the length of the wire, beyond which it would taper gradually to zero thickness due to the finite spacing between the wire and the envelope wall. However, the massive electrodes remain cool, thus producing a temperature gradient near each end of the wire which not only reduces the rate of evaporation from the end portions of the wire, but also prevents some of the coating from being evaporated at all. It has been found in practice that the shortening effect of end-cooling more than balances the lengthening effect of the geometry, resulting in the approximate condition shown in FIG. 2, wherein the total effective length of the attenuator coating 13 is somewhat less than the exposed length of the wire 25. In one example, for use in the A-1301 traveling wave tube, a 5 mil wire 25 had an exposed length of 1.5 inches and a nickel coating of 15.0 micrograms per cm., and the total effective length of the coating on an inner wall having a diameter of about 0.15 inch was about 1.35 inches. The height of the ribs 11 in this example was 10 mils. The length of the wire and coating density necessary to produce an attenuator coating 13 having the determined empirically. The method of forming the attenuator coating inherently produces the smoothly tapered ends that reduce wave reflections to a minimum.

FIG. 4 shows an apparatus for embedding the helix 15 slightly in the ribs 11 of the helix portion 5. The helix 15, which is only slightly smaller than the initial inscribed diameter of the envelope ribs 11, is inserted within the envelope after the attenuator coating 13 has been formed. The envelope is positioned within a two-part jig 37 made up of a channel-shaped base 39, having two internal ledges or ribs 41 and 43, and a cover 45 having a single longitudinal ledge or rib 47. The three ribs 41, 43 and 47 are located opposite the three ribs 11 in the envelope portion 5, as shown, and are positioned so that when assembled with the envelope portion 5 they produce a small separation between the cover 45 and base 39. The jig 37 and assembled envelope and helix are placed within an oven, schematically shown by dashed lines 49, and heated to a temperature sufficient to soften the glass and allow the weight of the cover 45 and envelope helix assembly to move the ribs 11 toward the helix 15. The turns of the helix 15 are slightly embedded (one or two mils) into the ribs, thus forming shallow depressions therein which prevent subsequent lateral movement of the turns. In this process, the helix turns opposite the attenuator coating 13 also becomes embedded in the metal-coated ribs 11 by depressing the thin attenuator coating.

The invention has been described with nickel as the metal of the attenuating coating 13, because nickel has been used and proven to be very satisfactory in providing a smoothly tapered, adherent, lossy layer in a traveling wave tube having good stability and low voltage standing wave ratio for waves traveling along the helix. The method used makes it possible not only to precisely control the total amount of attenuation provided, but also to produce smoothly tapered end portions with vanishingly thin ends which avoid reflections. While nickel is believed to be the best metal to use, it is believed that other selective transition metals would give satisfactory results. The metal should be one whose vapor pressure is high enough to permit easy evaporation in the coating process but low enough to prevent volatilizing during operation of the tube, and it should not be too electrically conductive (such as copper or silver) for use as an attenuator. Thus, it is believed that any of the metals scandium, titanium, vanadium, chromium, cobalt, rhodium, palladium and platinum could be used in place of nickel with suitable choice of coating density on the wire 25 for the resistivity

4

of the metal used. Another highly refractory metal, such as molybdenum, could be used in place of tungsten for the wire 25. A glass envelope having a cylindrical inner wall could be used in place of the envelope portion 5 having ribs 11. In this case, the apparatus of FIG. 4 could be used to form the equivalent of the ribs 11 on the inner wall.

What is claimed is:

1. A traveling wave amplifier tube comprising an elongated glass envelope containing an elongated conductive helix having the outermost portions of the turns thereof in firm contact with the inner wall of said envelope, an electron gun for projecting an electron beam through said helix for traveling wave interaction therewith, and an attenuator contacting said helix in a region intermediate the ends thereof, said attenuator comprising an annular thin resistive evaporated metal coating of precisely controlled thickness and length on said inner wall, said metal being selected from the group consisting of scandium, titanium, vanadium, chromium, cobalt, nickel, rhodium, palladium and platinum.

2. A traveling wave tube as in claim 1, wherein the inner wall of said envelope is formed with longitudinal ribs, and said helix is slightly embedded in said ribs.

3. A traveling wave tube as in claim 1, wherein said metal coating comprises a central portion of substantially uniform thickness merging smoothly with end portions smoothly tapered in thickness to zero thickness at the ends of the coating.

4. A traveling wave tube as in claim 1, wherein said metal is nickel.

5. In the manufacture of a traveling wave tube comprising an elongated glass envelope containing an elongated metal helix and an annular evaporated metal attenuator coating of precisely controlled thickness and length on the inner wall of said envelope; the method of depositing said coating on said envelope comprising the steps of: uniformly depositing a precise amount of a first metal selected from the group consisting of scandium, titanium, vanadium, chromium, cobalt, nickel, rhodium, palladium and platinum on a fine wire of a highly refractory second metal, mounting said wire coaxially within said glass envelope in the region at which said coating is desired; and then passing an electric current through said wire for a time sufficient to evaporate and deposit nearly all of said first metal from said wire and onto said envelope wall region.

6. The method of claim 5, wherein said first metal is nickel.

7. The method of claim 6, wherein said first metal is deposited on a predetermined length said wire by electroplating.

8. The method of claim 5, wherein said wire is mounted at its ends during said evaporation step on two massive electrodes, so that temperature gradients along the end portions of said wire due to end cooling effects cause a smooth tapering of the thickness of the end portions of said coating from a given thickness along the middle portion of the coating to zero thickness at the ends thereof.

9. The method of claim 7, wherein the length of said wire is at least equal to the length of the coating desired.

10. The method of claim 7, wherein the length of said wire is greater than the length of the coating desired.

11. The method of making a travelling wave tube comprising an elongated glass envelope containing an elongated metal helix embedded in the inner wall of the envelope, and an annular nickel attenuator coating of precisely controlled thickness and length on said inner wall, comprising the steps of:

(a) uniformly depositing a precise amount of nickel on a fine wire of tungsten;

(b) mounting said wire coaxially within said glass envelope in the region at which said coating is desired;

(c) then passing an electric current through said wire for a time sufficient to evaporate and deposit nearly

5

all of said nickel from said wire and onto said envelope wall region;  
 (d) inserting an elongated metal helix within said coated envelope; and  
 (e) then heating said envelope and embedding the outermost portions of the helix turns slightly in said coated inner wall.

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