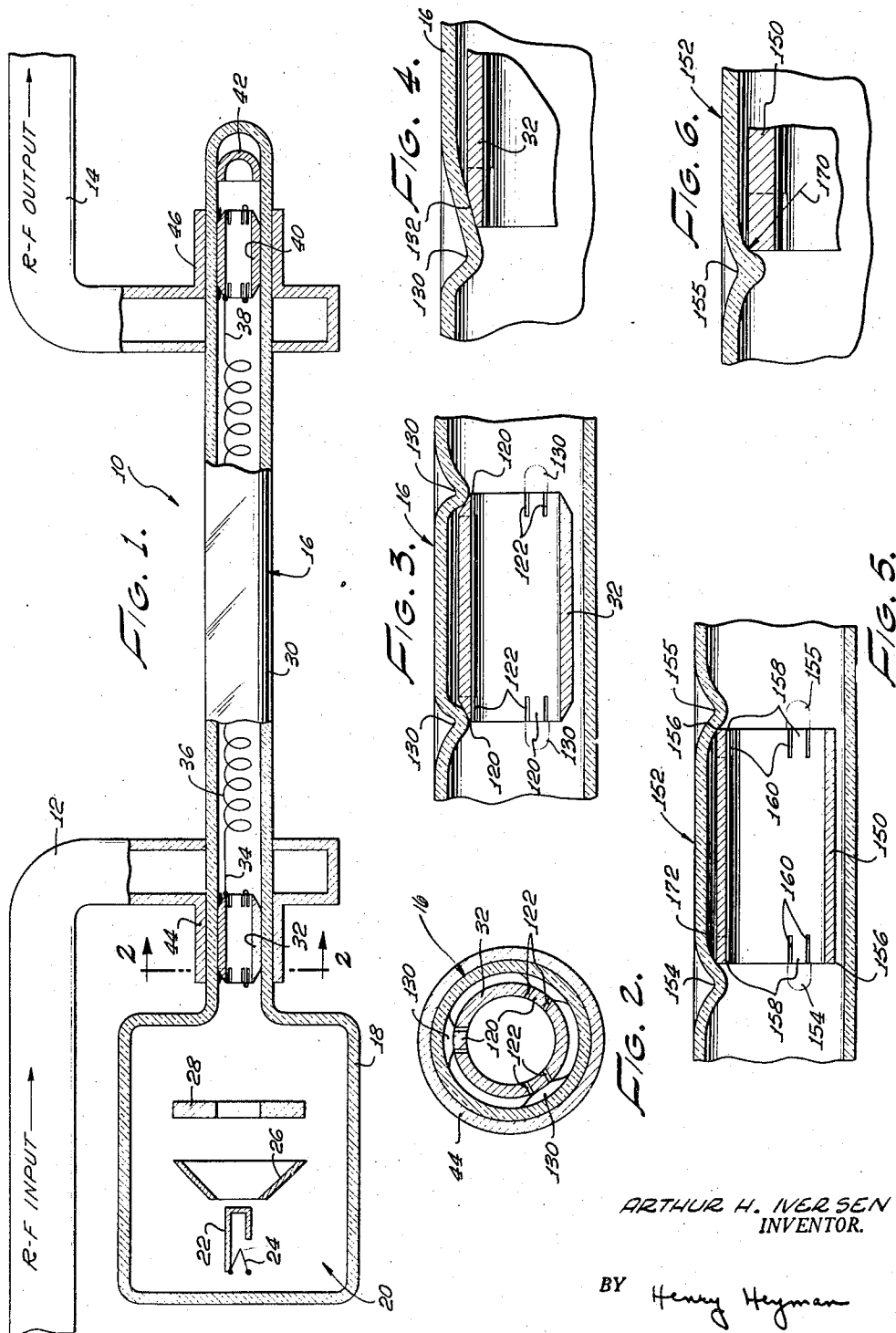


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A. H. IVERSEN
ELECTRON DISCHARGE DEVICE

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ELECTRON DISCHARGE DEVICE

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This invention relates to electron tubes and more particularly to means whereby a hollow metallic cylinder may be securely mounted within a hollow dielectric cylinder.

In a microwave tube, such as a traveling-wave tube, a conductive cylinder called a matching ferrule is employed within the envelope of the tube adjacent an electron gun to prevent the loss of electromagnetic energy by radiation from a waveguide which is disposed about the envelope. In many cases, it is desirable to restrain the radial and axial movement of the ferrule within the envelope by making a plurality of indentations in the envelope about its circumference at each end of the ferrule. It is necessary, however, to heat the ferrule by induced currents to volatilize gases occluded by the ferrule which are constantly removed while evacuating the envelope. This and other methods of heating generally cause the envelope to break due to the different thermal expansion coefficients of the envelope and the ferrule. To make matters worse, the envelope in the above described "out-gassing" process is maintained at room temperature.

It is therefore an object of the invention to provide a mechanically strong vitreous support for a metallic cylinder.

It is another object of the invention to provide an envelope support for the matching ferrule of a microwave tube.

In accordance with the invention, a matching ferrule for a traveling-wave tube is disposed within the tube envelope between a plurality of indentations in the envelope. The ferrule is axially slotted at its ends on each side of each indentation. A cantilever beam spring action of the portions of the ferrule engaged with the indentations is then produced, whereby the differential thermal expansion between the ferrule and the envelope produced by heating the ferrule is prevented from breaking the envelope.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawing in which several embodiments of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawing is for the purpose of illustration and description only, and is not intended as a definition of the limits of the invention.

Fig. 1 is a sectional view of a traveling-wave tube in which the mechanical support of the present invention is incorporated;

Fig. 2 is a sectional view on the section line 2—2 in Fig. 1;

Fig. 3 is an enlarged broken section of a portion of the traveling-wave tube shown in Fig. 1;

Fig. 4 is an enlarged broken-away section of the portion of the traveling-wave tube of Fig. 1 shown in Fig. 3;

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Fig. 5 is a broken section of a traveling-wave tube illustrating an alternative embodiment of the present invention; and

Fig. 6 is an enlarged broken-away section of the portion of the traveling-wave tube shown in Fig. 5.

Referring to the drawing, there is shown in Fig. 1 a traveling-wave tube 10 having a rectangular input waveguide 12 and a rectangular output waveguide 14. The traveling-wave tube 10 is provided with an evacuated envelope 16 which may be made of glass having an enlarged portion 18 at its left end. Within the enlarged portion 18, there is shown an electron gun 20 comprising a cathode 22 which is provided with a filament 24, a frusto-conical focusing electrode 26, and an accelerating anode 28. Focusing electrode 26 has a frusto-conical internal surface of revolution disposed 67½ degrees from its axis of symmetry.

In the direction of electron flow from the gun 20, there is shown disposed within the elongated portion 30 of the envelope 16 an input matching ferrule 32 which is connected over an antenna lead 34 to a conductive helix 36 which is employed to propagate electromagnetic waves at a velocity substantially less than the velocity of light. Conductive helix 36 is in turn connected over an antenna lead 38 to a conductive output ferrule 40. At the end of the elongated portion 30 of the envelope 16, a collector electrode 42 is positioned to intercept the stream of electrons.

A conductive sleeve 44 is disposed about a portion of the elongated portion 30 of the envelope 16 coextensive with input ferrule 32. The conductive sleeve 44 is disposed adjacent the left side of the input waveguide 12. A conductive sleeve 46 is similarly positioned adjacent output waveguide 14 coextensive with output ferrule 40.

A sectional view of the tube 10 is shown in Fig. 2 taken on the section line 2—2. In Fig. 2, the conductive sleeve 44 is disposed on the outside of the envelope 16 which is in turn disposed contiguous to the circumference of the matching ferrule 32 which has three cantilever beam extensions or tongues 120 disposed 120 degrees apart at each end, only the left end of the matching ferrule 32 being shown in Fig. 2. The cantilever tongues 120 are produced by slotting the input ferrule 32 at six places 122. This is better illustrated in Fig. 3 where input ferrule 32 is shown with the envelope 16 which has six indentations 130, only four of which are indicated in Fig. 3 due to the section of the traveling-wave tube 10 selected. The tongues 120 in addition to the remaining portion of the envelope are beveled as indicated by 132 (see also Fig. 4). This is done in order to prevent the envelope from breaking when the tube 10 is out-gassed. Envelope breakage is prevented for a number of reasons. Firstly, the energy represented by the differential thermal expansion is taken up by the cantilever springs formed by the tongues 120. Secondly, the beveled surfaces 132 make the energy transfer a gradual one. Thirdly, heat is conducted away from the ferrule 32 at the point where the tongues 120 are in contact with the envelope 16. Fourthly, the slots 122 prevent the circulation of circularly induced electric currents directly within the tongues 120, whereby the envelope 16 may be kept relatively cool at the indentations 130. This is important because when a relatively high vacuum is maintained within the envelope 16, soft heated spots, such as the indentations 130, may "suck in" or collapse and ruin the vacuum seal.

The exact structure of the envelope 16 near the indentations 130 is shown in Fig. 4. By having the end of the input ferrule 32 beveled as indicated by 132, the indentations 130 in the envelope need not be made so deep that a direct axial stress will be imposed against it by the axial

expansion of input ferrule 32. This is important in that the smaller the radius of the bend in a glass, the weaker the glass is, that is, the smaller its ultimate strength. The input ferrule 32 is in fact mounted within the envelope 16 by placing it concentrically within the envelope and subsequently making the indentations 130. Only two indentations need be made and only two cantilever tongues 120 need be employed. However, a more secure mechanical support may be provided for the ferrule 32 when three cantilever tongues 120 are used and three indentations 130 in the envelope 16 are employed at each end of the ferrule 32. The output ferrule 40 is constructed in a manner similar to input ferrule 32 with a plurality of indentations in the envelope 16 disposed about it.

Fig. 5 shows an alternative embodiment of the invention where a matching ferrule 150 is shown within an envelope 152. The envelope has a plurality of indentations 154 and 155 disposed about each end of the ferrule 150 similar to the indentations 130 in the envelope 16. The indentation 154 is however disposed around a substantially right angle turn or bend in the ferrule 150 at the edge 156. The ferrule 150 has tongues 158 similar to the tongues 120 of input ferrule 132 and provided by slots 160 similar to the slots 122 in input ferrule 32. However, due to the right angle edge 156 of the ferrule 150 and the lack of a beveled edge such as the edge 132, it is necessary to produce indentations 154 before the ferrule 150 is inserted within the envelope 152. This requirement is made in order to avoid the production of a right angle or small radius turn in the inside surface of the envelope 152 at the sharp edges 156 of the ferrule 150. The right end of the ferrule 150, however, must necessarily be supported or restrained from axial and radial movement by making indentations 155 after the ferrule 150 is inserted within the envelope 152. This causes the envelope 150 to have an unusually small radius which is indicated by an arrow 170 in Fig. 6 where an enlarged broken-away section of the right-hand portion of the ferrule 150 and the envelope 152 with the indentation 155 is shown. The axial expansion of the ferrule 150 may cause the envelope to break at 155 when a beveled end or beveled surface 132 is not provided on the input ferrule 32 or when a slanting surface such as a surface 172 is not provided inside the envelope 152. The slanting surface 172 near the indentation 154 in Fig. 5 serves the same purpose as that of the beveled surface 132 on the ends of the input ferrule 32. The sloping surface 172 however cannot be made when the ferrule 150 is disposed within the envelope. Hence, the indentations 154 are made by heating the envelope 152 and making the indentations 154 with a pointed tool. This is true because the glass will flow around the corners 156 of the ferrule 150 in spite of what may be done to prevent it from happening.

A sturdy ferrule support may thus be obtained by practicing the present invention and a ferrule may be heated for out-gassing purposes without fear of breaking the dielectric or glass envelope disposed about it, breakage being a current problem because of the thermal expansion of the ferrule.

What is claimed is:

1. In an electron tube, a mechanical support comprising a hollow dielectric cylinder having a plurality of indentations disposed about its circumference in a plane intersecting said dielectric cylinder, and a hollow metallic microwave matching ferrule cylinder having a predetermined length disposed within said dielectric cylinder having one end touching said dielectric cylinder only at said indentations, means for restraining the radial and axial movement of the metallic cylinder within said vitreous cylinder at the other end of said metallic cylinder, said metallic cylinder having a plurality of slots extending axially into said metallic cylinder for an axial distance which is short with respect to said length from the one end of said metallic cylinder adjacent said indentations, said slots being disposed on both sides of each of said

indentations whereby said slots provide a radial supporting tension in a manner such that said dielectric cylinder is not fractured when said metallic cylinder is heated by radio frequency currents.

2. In an electron tube, a mechanical supporting structure comprising a hollow vitreous cylinder having a plurality of indentations disposed about its circumference in a plane intersecting its length, and a hollow metallic microwave matching ferrule cylinder having at least one beveled end disposed within said dielectric cylinder, said beveled end touching said vitreous cylinder only at said indentations, means for restraining the radial and axial movement of the metallic cylinder within said vitreous cylinder at the other end of said metallic cylinder, said metallic cylinder having a plurality of slots extending axially into said metallic cylinder from the one end of said metallic cylinder adjacent said indentations, said slots being axially short compared to the length of said metallic cylinder and being disposed on either side of each of said indentations, whereby said slots provide a radial supporting tension in a manner such that said vitreous cylinder is not fractured when said metallic cylinder is heated by radio frequency currents as for purposes of outgassing said electron tube.

3. In combination, in a traveling-wave tube of the character including slow-wave structure means for propagating traveling waves therealong, a vitreous evacuated envelope having a plurality of indentations disposed about its circumference at a point along its length, and a hollow metallic cylinder microwave matching ferrule for said slow-wave structure means disposed within said evacuated envelope having at least one end touching said evacuated envelope only at said indentations, means for restraining the radial and axial movement of the metallic cylinder within said envelope at the other end of said metallic cylinder, said metallic cylinder having a plurality of slots extending axially into said metallic cylinder from the one end of said metallic cylinder adjacent said indentations for a distance which is short compared to said predetermined length, said slots being disposed on both sides of each of said indentations whereby said slots provide a radial supporting tension in a manner such that said vitreous envelope is not fractured when said metallic cylinder is heated by radio frequency currents as for purposes of outgassing said traveling-wave tube.

4. A microwave tube comprising an evacuated glass envelope, a slow-wave structure means disposed there-within, an electron gun disposed at one end of said envelope for producing an electron stream, a waveguide disposed about said envelope adjacent one side of said waveguide, said envelope having a plurality of indentations disposed about its circumference at each end of said sleeve, and a conductive microwave matching ferrule for said slow-wave structure means disposed within said envelope between the circumferential indentations at each end of said sleeve and coextensive with said sleeve and having its ends touching said envelope only at said indentations, said conductive ferrule having a plurality of slots which are short compared to the length of said ferrule extending axially into said conductive ferrule from each end of said conductive ferrule adjacent said indentations, said slots being disposed on either side of each of said indentations whereby said slots provide a radial supporting tension in a manner such that said glass envelope is not fractured when said conductive ferrule is heated by radio frequency currents as for purposes of outgassing such microwave tube.

5. A traveling-wave tube comprising an evacuated glass envelope, a slow-wave structure disposed therewithin, an electron gun disposed at one end of said envelope for producing an electron stream, a rectangular waveguide disposed about said envelope, a conductive sleeve disposed about said envelope adjacent one side of said waveguide, said envelope having a plurality of indenta-

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tions disposed about its circumference at each end of said sleeve, and a conductive microwave ferrule terminating at the end of said slow-wave structure and having beveled ends disposed within said envelope between said circumferential indentations coextensive with said sleeve and having its ends secured by said envelope at said indentations, whereby the radial and axial movement of the metallic cylinder with respect to the vitreous cylinder is restrained, said conductive ferrule having a plurality of slots extending axially into said conductive ferrule from each of its ends, said slots being axially short compared to the length of said ferrule and being disposed on each side of each of said indentations to prevent the differential thermal expansion between said conductive ferrule and said envelope from breaking said envelope.

6. An electron tube comprising a hollow dielectric cylinder, a slow-wave structure disposed within and along the length of said hollow dielectric cylinder, a plurality of protuberances extending inwardly from the inside surface of said dielectric cylinder in at least one plane perpendicular to the longitudinal axis of said dielectric cylinder, a hollow metallic cylinder forming a microwave matching ferrule for terminating said slow-wave structure con-

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strained within said dielectric cylinder and having at least one of its ends touching said dielectric cylinder only at said protuberances, means including said protuberances for restraining the radial and axial movement of said metallic cylinder within said dielectric cylinder, said metallic cylinder being beveled on at least one end and having a plurality of slots extending axially into said metallic cylinder from the beveled end, said slots being axially short compared to the length of said metallic cylinder and being disposed on both sides of each of said protuberances adjacent said slotted end of said metallic cylinder to prevent the differential thermal expansion between the metallic cylinder and the dielectric cylinder from breaking the dielectric cylinder when the metallic cylinder is heated by radio frequency currents as for purposes of outgassing said electron tube.

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