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ELECTRON DISCHARGE DEVICE

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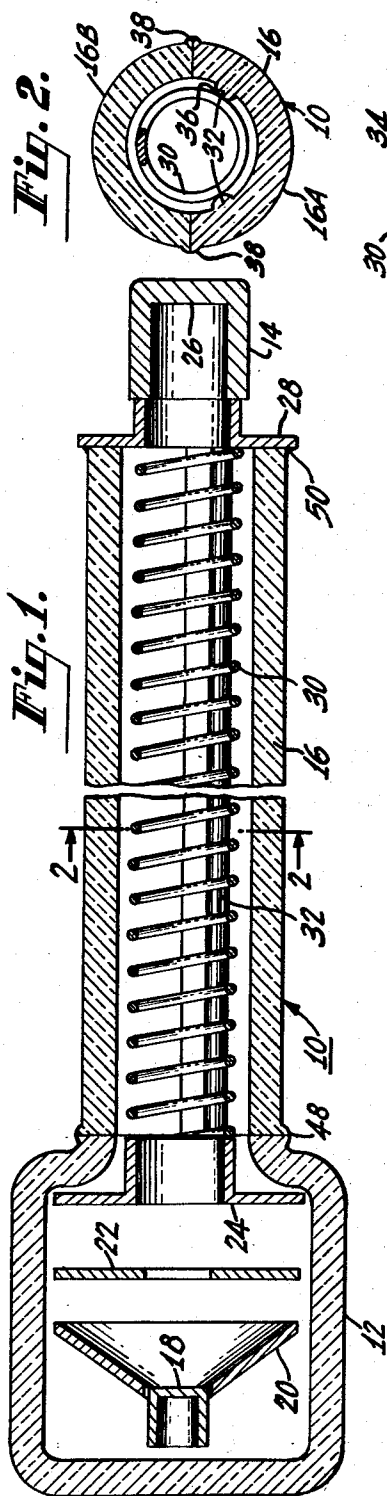
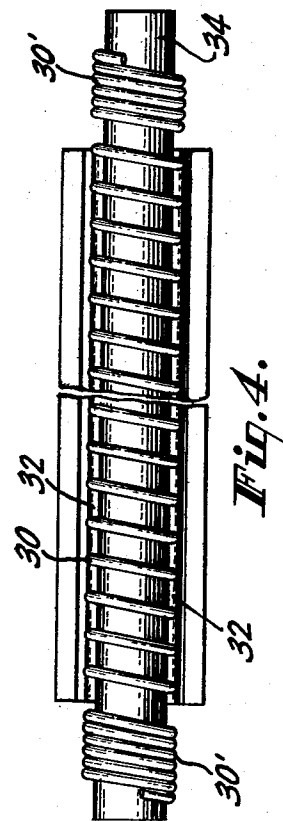
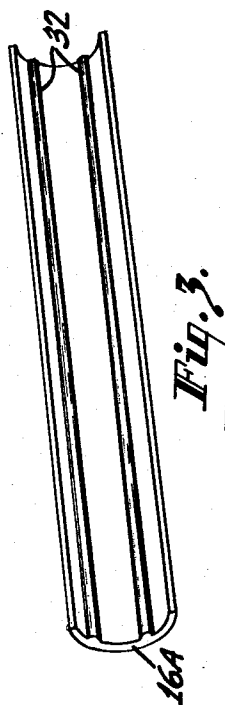
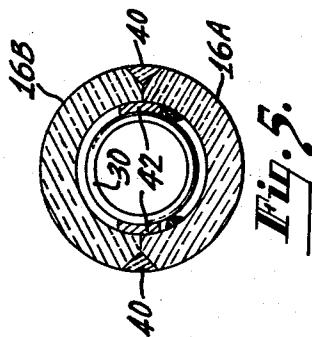
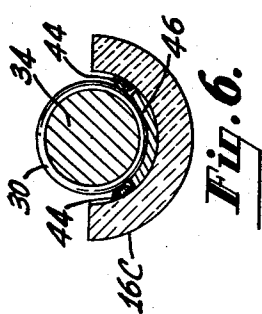
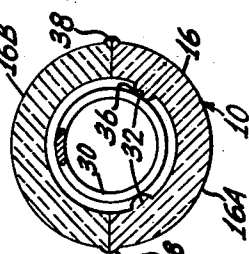


Fig. 2.



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ELECTRON DISCHARGE DEVICE

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The present invention relates to electron discharge devices, particularly helix type traveling wave amplifier tubes.

In one conventional helix type traveling wave amplifier tube, an elongated metallic helix is mounted coaxially within an elongated tubular envelope and an electron gun is mounted at one end of the helix, within an extension of the envelope, to project an electron beam coaxially through the helix to a collector at the other end thereof. RF coupling means are provided at the two ends of the helix, for coupling an RF signal to the helix to initiate traveling waves thereon for interaction with the beam, and for removing the amplified RF signal from the helix.

In order to withstand temperatures of the order of 500° C. during bake-out and other processing, the tube components must be of refractory materials. The envelope is usually made of a relatively hard low-loss glass or a high alumina ceramic. The helix is usually made of tungsten wire. In order to achieve the required electrical characteristics, it is necessary that the helix be manufactured and assembled in the envelope to a high state of precision, that is, it must be wound with uniform diameter and pitch, which must be maintained during the assembly and subsequent use of the traveling wave tube. Thus, the helix is not only wound as accurately as possible but also is secured or fixed within the envelope as close to its "as wound" condition as possible. To meet some environmental requirements, it is necessary to secure the helix in some manner that is insensitive to external force loadings. Moreover, the securing means should not degrade the electrical parameters of the traveling wave tube. For example, a reduction in gain could occur due to excessive dielectric loading of the helix by the securing means. Thus, the problem is to mount the helix as accurately and securely as possible with a minimum of dielectric loading.

Present envelope construction usually consists of an integral tube and bulb combination which mainly houses the helix and the electron gun. Two basic methods are used to secure the helix within the tube. In one method, the helix is positioned within a cage of rods, usually ceramic, which in turn is mounted within the envelope. In the other method, the helix is embedded directly in three longitudinal ridges forming part of the inner wall of a fluted glass tube. In the cage method, jigs are required to hold the rods and helix in position during assembly, which may involve applying a glazing material to the ceramic rods and heating to cause the glazing material to flow about the helix turns at the areas of contact. A variant of the cage technique is the use of spring clamps about the rods to press them against the helix. In any case, when the helix-rod assembly is inserted within the envelope there is no satisfactory way to fix the assembly rigidly in place. In the glass embedding method, the helix is placed within an internally-fluted glass tube, the assembly is heated to the softening point of the glass, and the ridges are depressed into contact with the helix, either by external jigs or by use of a partial vacuum within the tube.

In the manufacture of traveling wave tubes with these two methods, rates of shrinkage (due to rejected parts) of 30 to 50 percent are not uncommon. The reasons for these high shrinkage rates can be understood from a

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detailed explanation of the glass-embedding method. The helix is first wound on a mandrel, its ends being firmly attached to the mandrel. The helix is then cleaned and fired to set the helix to minimize spring-out upon release from the mandrel. Then the helix is released from the mandrel. As a result, the "as wound" accuracy of the helix is lost or impaired. The helix is subject to further damage by being constantly handled through various operations such as cutting to size, plating and the welding of parts to it. Then a smaller mandrel is placed within the helix and a spacer ribbon is entwined in the coils of the helix in an attempt to re-achieve the "as wound" condition and also prevent excessive seizure of the helix turns by the glass ridges as they soften and move inward to bond to the helix. The helix, mandrel and spacer ribbon are then inserted within a glass envelope tube having three internal ridges. The envelope is placed within a two-part jig having three shrinking ridges registering with the three envelope ridges, positioned within an oven, and brought to a temperature close to the softening point of the glass. It is hoped that the jig will, under the influence of gravity, move the glass the precise amount to just barely and uniformly embed the helix in the glass ridges. A typical allowable embedding depth for a .010 inch diameter helix wire would be .00075 inch plus or minus .00025 inch. After the helix is embedded in the glass, the assembly is cooled, and the mandrel and spacer ribbon are removed, as by an acid bath.

The object of the present invention is to provide a new and improved helix type traveling wave tube.

In accordance with one aspect of the present invention, the helix of a traveling wave tube is coaxially mounted in a hollow cylindrical dielectric envelope by fixing the turns of the helix to two longitudinal ridges formed on one circumferential half of the inner surface of the envelope, preferably spaced apart by an angle of about 120°, with the helix spaced from the other half of the envelope. In accordance with a further aspect of the invention, the helix is wound with uniform diameter and pitch on a mandrel, the end turns of the helix are attached to the mandrel, the assembled helix and mandrel are positioned within a first hollow substantially semi-cylindrical dielectric envelope section having two spaced longitudinal ridges on the inner surface, the turns of the helix are secured or fixed to the ridges, e.g., by a refractory cement, and the mandrel is removed from the helix. Then a second hollow substantially semi-cylindrical glass envelope section having substantially the same radius as the first section is positioned on the first section in spaced relation to the helix with the flat side surfaces of the two sections juxtaposed, and the juxtaposed surfaces are hermetically sealed together to complete a hollow envelope containing the helix securely mounted only on one half thereof.

In the accompanying drawing:

FIG. 1 is an axial section view of a traveling wave tube embodying the present invention;

FIG. 2 is a transverse section view taken on line 2-2 of FIG. 1;

FIG. 3 is a perspective view of a section of the envelope shown in FIGS. 1 and 2;

FIG. 4 is a plan view of the envelope section of FIG. 3 with the helix and mandrel positioned therein;

FIG. 5 is a section view, similar to FIG. 2, showing a step in the manufacture of the tube; and

FIG. 6 is a section view, similar to FIG. 2 with the upper envelope section omitted, showing a modification.

Referring to FIGS. 1 and 2, the numeral 10 designates an elongated traveling wave tube envelope made up of an electron gun portion 12 at one end, a collector

portion 14 at the other end, and an intermediate hollow cylindrical helix portion 16. The gun portion 12 and helix portion 16 are made of dielectric material, such as glass or ceramic, to insulate the gun electrodes and helix turns. A conventional electron gun, which may include a cathode 18, cathode shield or focusing electrode 20, accelerating electrode 22 and shield electrode 24, is mounted by known means (not shown) in the gun portion 12 in coaxial alignment with the helix portion 16. The collector portion 14 includes a cup-shaped collector 26 which is sealed to the helix portion 16, either directly or by an intermediate flanged ring 28 as shown. An elongated metallic helix 30, of uniform diameter and pitch, is coaxially mounted in fixed relation within the helix portion 16.

In accordance with one aspect of the invention, the helix 30 is rigidly secured or fixed to the dielectric helix portion 16 of the envelope at two points only on one half of each turn, with the two points preferably spaced from each other by an angle of about 120° . If the angle is much greater than 120° , the helix 30 is subject to appreciable distortion due to differential expansion and contraction of the tungsten helix and dielectric envelope section with temperature changes. On the other hand, if the angle is too small, the mounting of the helix turns is not sufficiently rigid to prevent undesirable vibration or other movement during use in the traveling wave tube. For best results, the angle should not be less than about 60° or greater than about 140° . To provide such a mount for the helix, the inner surface of the dielectric portion 16 is provided with two longitudinal ribs or ridges 32 located well within one-half of the circumference of the envelope, and preferably about 120° apart, as shown in FIG. 2. Each turn of the helix 30 is bonded to the two ridges 32, e.g., by a refractory cement.

In the example shown in FIGS. 1-3, the dielectric envelope portions 12 and 16 are made of a low-loss hard glass, which may be a borosilicate glass known as Corning 7070. The two ridges 32 in FIGS. 1-3 are formed integrally with the glass portion 16, as shown.

In accordance with another aspect of the invention, the helix portion 16 of the envelope is made in two separate hollow semi-cylindrical dielectric sections 16A and 16B to facilitate the mounting of the helix 30 within the envelope. The sections 16A and 16B are identical except for the fact that section 16A is formed with the two ridges 32 and section 16B has no ridges. The two sections may be cast or otherwise formed separately, or may be formed by making a hollow cylindrical member and dividing it by sawing it longitudinally along a diameter.

A helix 30 of tungsten wire is accurately wound in a winding lathe (not shown) on a cylindrical metal mandrel 34, and the end turns 30' are attached, as by welding, to the mandrel 34, as shown in FIG. 4. A thin layer of refractory cement 36 is applied to the ridges 32 of a fluted dielectric section 16A having substantially the same diameter at the ridges as the helix 30. The assembly helix and mandrel are then placed on the section 16A with the turns of the helix in contact with the cement-coated ridges 32, and the assembly is processed to create the desired bond of the helix to the envelope section by the cement. The cement used must have properties suitable for use in a vacuum tube, must cure at a temperature not affecting the envelope, and must be capable of withstanding temperatures attained during further manufacturing operations and tube use. For example, a cement similar to the one described in a paper by R. J. Bondley and M. E. Knoll on pages 51 and 52 of the Proceedings of the Third National Conference on Tube Techniques, September 1956, published 1958, would be suitable. This cement is a mixture of two parts of aluminum silicate, one part of freshly calcined aluminum phosphate, and enough dilute phosphoric acid to give the desired viscosity. This mixture will harden into a stone-

like mass when warmed to 125°C ., and will withstand temperatures of over 1000°C .

After the cementing operation, the end turns of the helix which were used for securing the helix to the mandrel during the preceding operation are cut off and the mandrel 34 is removed. To facilitate removal, the mandrel may have a thin coating of a material, such as copper, that can be easily removed by an acid bath.

The envelope section 16A, with the helix 30 fixed thereto, can be used as a tray for further operations and assemblies. The helix is secured in its "as-wound" condition, and can be handled by use of the tray without damage to the helix itself. Thereafter, the other section 16B of the two-part envelope portion 16 is placed on the tray section 16A with the side edges of the two sections juxtaposed, as shown in FIG. 3, and the surfaces of the juxtaposed edges are hermetically sealed together at 38. The seal may involve a fusion weld of the surfaces themselves, or a suitable vacuum tight cement or frit. For example, if the sections 16A and B are made of Corning 1723 glass, a suitable sealing material is Corning Pyroceram No. 45. As shown in FIG. 6, inward flow of the sealing material 40 may be blocked by two metal masking strips 42, of a material to which the sealing material will not adhere, inserted between the helix turns and the two envelope joints. After the seal is completed, the masking strips are removed, as by an acid bath.

FIG. 6 shows a modification wherein the integral ridges of a cement of FIGS. 1-3 are replaced by two ridges 44 of a refractory cement formed on the inner wall of a plain (unfluted) dielectric section 16C. These cement ridges 44 are bonded to the turns of the helix 30 while the latter is fixed to the mandrel 34. The ridges 44 may be made of the cement described in the Bondley and Knoll paper referred to above. The helix may be independently supported during the cementing operation by one or more metal supporting members 46 inserted between the helix turns and the envelope section 16C, to minimize the amount of cement in contact with the helix and maintain the helix accurately coaxial with the envelope. The supporting member can be omitted if the cement ridges 44 are first solidified by heat and then cemented to the helix turns.

The traveling wave tube is completed by hermetically sealing the gun portion 12 of the envelope to one end of the previously assembled helix portion 16 at 48, with the gun electrodes accurately aligned with the helix 30, and hermetically sealing the collector portion 14 to the other end of the helix portion 16 at 50. The helix 30 may be electrically connected within the envelope to either the drift tube 24 or the collector 26, or both, to permit the application of the necessary D.C. bias potential thereto. The various electrodes of the electron gun are provided with suitable external potential leads (not shown).

While the sections 16A and 16B of FIGS. 1-5 and 16C of FIG. 6 have been described as being semi-cylindrical, it will be understood that some variation from a half cylindrical shape can be used. For example, one section could be slightly more than a half cylinder and the other slightly less, as might occur if the sections are made by sawing a cylinder lengthwise. Moreover, both sections could be slightly less than a half cylinder, particularly where the two sections are sealed together by a cement. The helix 30 need not be mounted exactly coaxial with the completed helix section 16, if its turns are spaced from the cover section 16B of the envelope as described, since it is aligned with the gun electrodes during the sealing of the helix section 16 to the gun section 12.

What is claimed is:

1. A traveling wave tube comprising a hollow cylindrical dielectric envelope portion, the inner surface of said envelope portion being formed with two longitudinal dielectric ridges circumferentially spaced apart by an angle of about 120° , an elongated metallic helix positioned

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within said envelope portion with the turns thereof fixed to said ridges and spaced from the remainder of said surface, and electron gun means for projecting a beam of electrons coaxially through said helix.

2. A traveling wave tube comprising an elongated dielectric envelope portion made up of two similar hollow substantially semi-cylindrical dielectric sections having substantially the same radius sealed together along their side edges, one of said sections having two spaced longitudinal dielectric ridges on the inner surface thereof, an elongated metallic helix positioned within said envelope portion with the turns thereof supported by said ridges and spaced from the other of said sections, and means rigidly securing said helix turns to said ridges.

3. A traveling wave tube as in claim 2, wherein said securing means comprises a refractory cement.

4. A traveling wave tube as in claim 2, wherein said sections are formed of a hard, low-loss glass material.

5. A traveling wave tube as in claim 2, wherein said ridges are integrally formed as portions of said one section.

6. A traveling wave tube as in claim 2, wherein said ridges are formed of a refractory cement.

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7. A traveling wave tube comprising an elongated dielectric envelope portion made up of two similar hollow substantially semi-cylindrical dielectric sections having substantially the same radius sealed together along their side edges, one of said sections having two longitudinal ridges on the inner surface thereof spaced apart circumferentially by an angle of about 120°, and an elongated metallic helix positioned within said envelope portion with the turns thereof fixed to said ridges and spaced from the other of said sections.

References Cited in the file of this patent

UNITED STATES PATENTS

2,481,906	Chilcot et al. -----	Sept. 13, 1949
2,706,366	Best -----	Apr. 19, 1955
2,767,344	Hines -----	Oct. 16, 1956
2,806,170	Bianculli -----	Sept. 10, 1957
2,845,690	Harrison -----	Aug. 24, 1958
2,869,217	Saunders -----	Jan. 20, 1959
3,010,048	Nevins -----	Nov. 21, 1961