

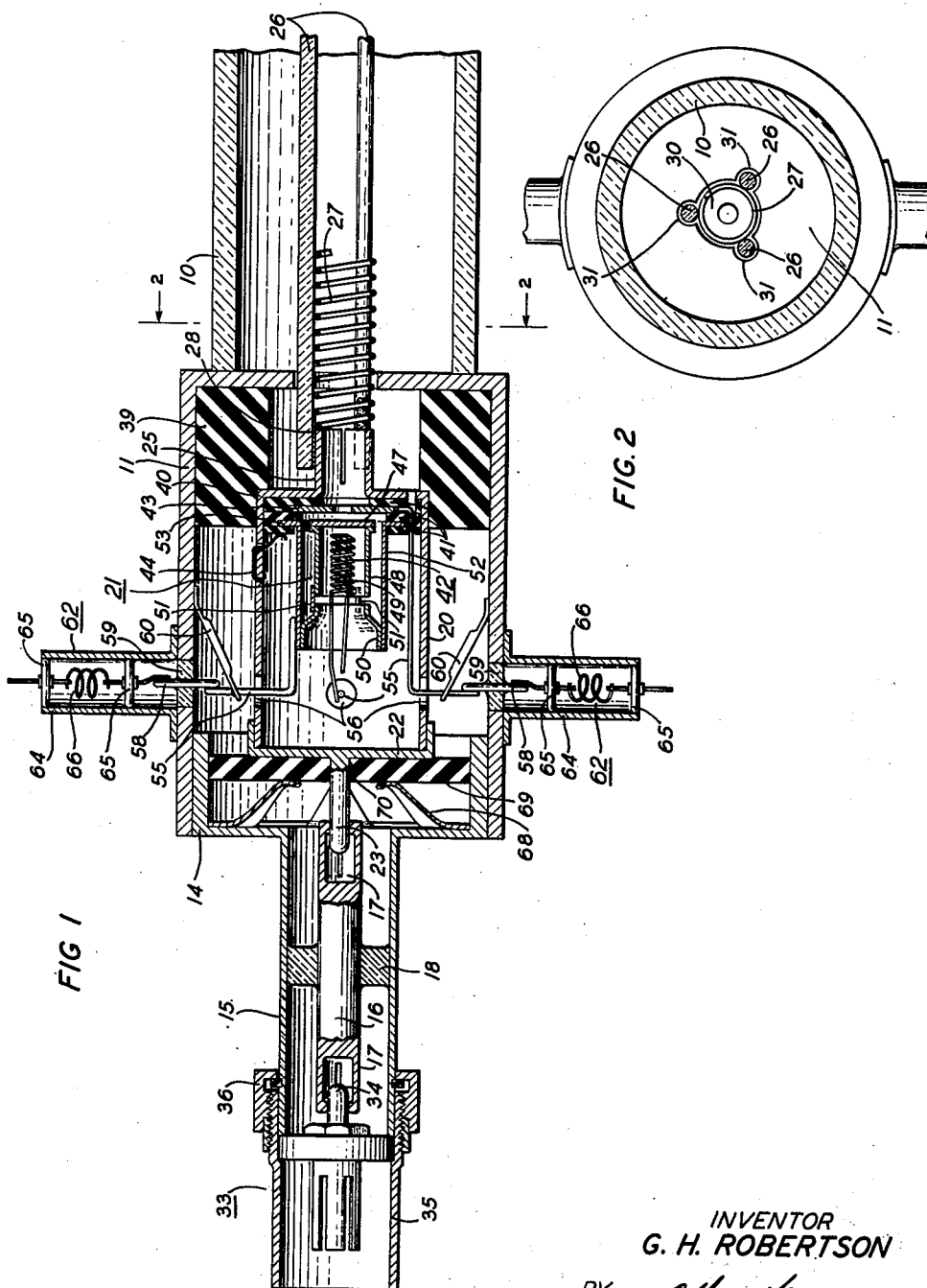
Oct. 1, 1957

G. H. ROBERTSON
ELECTRON DISCHARGE DEVICES

2,808,533

Filed Feb. 8, 1952

2 Sheets-Sheet 1



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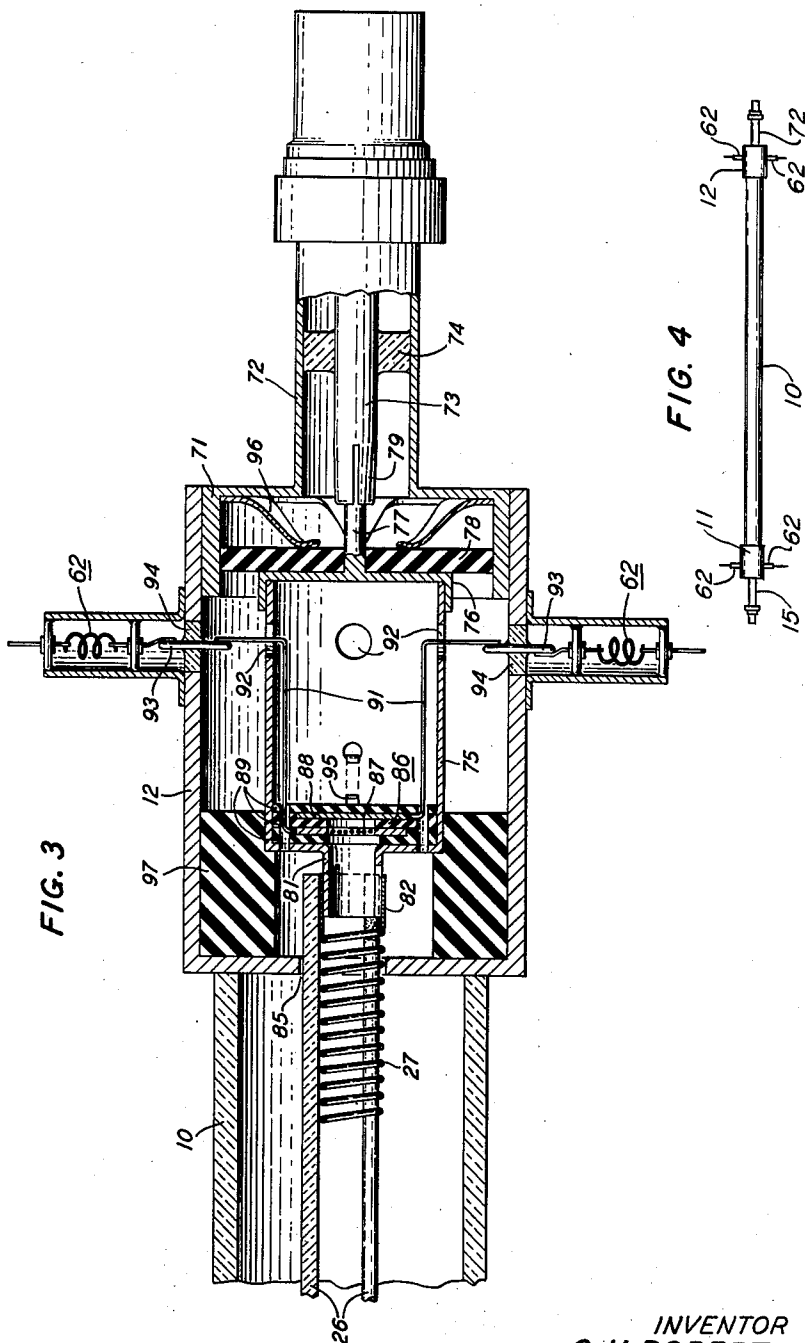
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ELECTRON DISCHARGE DEVICES

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11 Claims. (Cl. 315—3.5)

This invention relates to traveling wave tubes and more particularly to such tubes wherein coaxial input and output terminals are utilized for the transfer of high frequency energy between the tube and associated transmission systems.

In such devices the high frequency energy is introduced into the tube at the electron gun end of the tube, coupled to the helix, removed from the helix at the electron collector end of the tube, and transferred from the tube to an associated output transmission line or system.

A general object of this invention is to improve the coupling of high frequency energy between coaxial terminals and a helix of a traveling wave tube.

It is a further object of this invention to provide improved coaxial terminals wherein the electron gun and electron receiver assemblies are facily supported within the inner conductors of the coaxial terminals.

These and other objects of this invention are achieved in one specific illustrative embodiment of this invention wherein the outer conductor of the coaxial terminal comprises an outer cup-shaped member having an aperture in its base and the inner conductor of the coaxial terminals comprises an inner cup-shaped member to which the helix is connected, the helix extending through the aperture close to the edge of the base so that the edge and end of the inner cup-shaped member define a gap of high electric field intensity having a large axial component for coupling the electromagnetic energy between the transmission line defined by the helix and the transmission line defined by the inner and outer cup-shaped members of the coaxial terminal. There will also be a radial electric field between this edge and the portion of the helix directly adjacent thereto. However, this radial field will not be involved in the coupling of the high frequency energy between the coaxial terminal and the helix of the traveling wave tube.

In this specific illustrative embodiment, the electrode assemblies are positioned and supported within the inner cup-shaped member of the coaxial terminals. Thus the electron gun assembly is positioned within the inner cup-shaped member of the coaxial input terminal, and the electron collector assembly is positioned within the inner cup-shaped member of the coaxial output terminal.

It is, therefore, one feature of this invention that the helix of a traveling wave tube be electrically connected to the inner conductor of a coaxial terminal and extend closely through an aperture in a member defining a portion of the outer conductor of the coaxial terminal, the end of the inner conductor and the edge of the member adjacent thereto determining a gap having an electric field of high intensity having a large component along the axis of the helix for the coupling of electromagnetic energy between the helix and the coaxial terminal.

It is a further feature of this invention that the coaxial terminal of a traveling wave tube comprise a pair of cup-shaped members, the inner cup-shaped member being a portion of the inner conductor of the coaxial terminal and the outer cup-shaped member being a portion of the outer

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conductor of the coaxial terminal. More specifically, in accordance with this feature of this invention, an electrode assembly is supported and positioned within the inner cup-shaped member.

A complete understanding of this invention and of the various features thereof may be gained from consideration of the following detailed description and the accompanying drawing, in which:

Fig. 1 is a sectional view of a portion of a traveling wave tube illustrative of one specific embodiment of this invention showing particularly the coaxial input terminal and electron gun assembly;

Fig. 2 is a plan view taken along the line 2—2 of Fig. 1 showing particularly the gap of high field concentration defined by the helix and the outer cup-shaped member for the coupling of electromagnetic energy from the input terminal to the helix;

Fig. 3 is a sectional view of another portion of the traveling wave tube of Fig. 1 showing particularly the coaxial output terminal and the electron collector assembly; and

Fig. 4 is an external view of a traveling wave tube of which Fig. 1 is a sectional view of the input terminal and gun assembly and Fig. 3 is a sectional view of the output terminal and collector assembly.

Referring now to the drawing, the specific illustrative embodiment of this invention there depicted comprises a cylindrical ceramic tube 10 extending between two cup-shaped metallic members 11 and 12 and sealed thereto to form a portion of the envelope of the device. The tube may advantageously be of a ceramic known as F-66 Steatite and may be sealed to the metallic members by the method disclosed in application Serial No. 220,575, filed April 12, 1951, by A. J. Chick and L. J. Speck, now Patent 2,708,787, May 24, 1955. Alternatively, the tube 10 may be metallic. Cup-shaped metallic member 11, as best seen in Fig. 1, encompasses and supports the electron gun assembly and input terminal of the device, and cup-shaped metallic member 12, as best seen in Fig. 3, encompasses and supports the electron receiver assembly and output terminal of the device.

The outer conductor of the input coaxial terminal comprises the outer cup-shaped member 11, an end closure cap 14 extending across the end of the cup-shaped member 11 and hermetically sealed thereto, as by brazing, and an elongated tube 15, preferably integral with cap 14. The inner conductor of the input coaxial terminal comprises an inner conductor 16 positioned by a glass or ceramic bead 18 within the tube 15, the conductor having spring fingers 17 at each end adapted to fit over a mating conductor, and an inner cup-shaped member 20 in which is positioned the electron gun assembly 21, a closure cap 22 fitting over the end of the inner cup-shaped member 20 and having a finger 23 preferably integral therewith extending into the spring fingers 17 of inner conductor 16. A sleeve 25 extends, preferably integrally, from the base of the inner cup-shaped member and provides support for one end of the helix support rods 26 which are advantageously glazed to the sleeve. The helix 27, which may be advantageously glazed to the support rods 26, is electrically connected, as at 28, to the sleeve 25 so that a continuous electrical connection is provided from the inner conductor 16 to the helix 27.

The helix 27 and rods 26 extend through an aperture 30 in the base of the outer cup-shaped member 11, the aperture being shaped to have its edge closely adjacent the helix, as by being circular with cut-out portions 31 to allow passage therethrough of the helix support rods 26, as best seen in Fig. 2. The electromagnetic energy is guided from the external transmission line, whether of a wave guide or coaxial line type, to the coaxial input terminal by a coaxial jack 33 having its inner conductor

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34 extending into the spring fingers 17 of the inner conductor 16 and its outer conductor 35 threadedly engaged to a connecting ring 36 secured to the outside of the tube 15. The electromagnetic energy is then guided by the coaxial input terminal to the gap defined by the end of the sleeve 25 and the aperture 30 in the base of the outer cup-shaped member 11. As the sleeve 25 is electrically a part of the inner conductor of the coaxial input terminal and the base of the outer cup-shaped member 11 is electrically a part of the outer conductor of the coaxial input terminal, an electrical field of high intensity exists across this gap. This field has a component along the axis of the helix that couples the electromagnetic energy from the transmission line defined by the inner and outer conductors of the coaxial input terminal to the transmission line defined by the helix 27.

In this specific embodiment of this invention, the inner cup-shaped member 20, which is a portion of the inner conductor of the coaxial input terminal, is positioned from the outer cup-shaped member 11, which is a portion of the outer conductor of the coaxial input terminal, by a large insulating ring 39 having a dished portion 40 into which the base of the inner cup-shaped member fits. The electron gun assembly 21 is supported within the inner cup-shaped member by a plurality of insulator rings 41 which position the cathode assembly 42 and the accelerating electrode 43, certain of the rings 41 being dished to prevent transverse motion of these elements. A plurality of springs 44 bear against the insulator rings 41 and bias them against the base of the inner cup-shaped member 20.

The cathode assembly 42 advantageously comprises a disc 47 having an electron emissive coating thereon, a tubular heater cup 48 across which the disc 47 extends, a heater element 49 within the heater cup 48, a base member 50 to which the heat shield is connected by a plurality of strips 51, and a cylindrical heat shield 52 having a flanged portion 53 held in a dished portion of one of the insulator rings 41, the cylindrical heat shield 52 being secured at its base, as by welding, to the base member 50.

Leads 55 are connected to the cathode assembly 42, the accelerating electrode 43, and the ends of the heater element 49 and extend through apertures 56 in the inner cup-shaped member 20. Positioned in the outer cup-shaped member 11 opposite each of the apertures 56 is a terminal pin 58 extending through a glass or ceramic bead 59. The direct current connections to the elements of the electron gun assembly are provided by connecting the leads 55 to the terminal pins 58, getters 60 also being advantageously connected between the leads 55 and the inner wall of the outer cup-shaped member 11 and being burned out during the processing of the device. A high frequency filter 62 is connected between the terminal pins 58 and the outer cup-shaped member 11 to prevent passage of the radio frequency power to the direct current supplies and comprises a shell 64 positioned with its base on the outer cup-shaped member 11, a pair of button condensers 65 electrically connected between the terminal pin 58 and the shell 64, and a choke 66 between the capacitances 65 and comprising a few turns of wire within the shell 64.

The inner cup-shaped member 20 is held in position by a spring washer 68 in the closure cap 14; the washer 68 bears against an insulating annulus 69 having a central aperture 70 therein for passage of the finger 23 there-through, thereby biasing the inner cup-shaped member 20 against the large insulator ring 39 and the base of the outer cup-shaped member 11.

The coaxial output terminal, as best seen in Fig. 3, similarly comprises an outer conductor defined by the outer cup-shaped member 12 and a closure cap 71 therefor, the closure cap having a tubular portion 72 integral therewith, and an inner conductor defined by conductor 73 within the tubular portion 72 and separated there-

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from by a glass or ceramic bead 74, an inner cup-shaped member 75, and a closure cap 76 therefor. A finger 77, preferably integral with the closure cap 76, extends through an insulator annulus 78 and into mating spring fingers 79 on the end of conductor 73. A sleeve 81 preferably integral with the inner cup-shaped member 75, supports the other end of the helix support rods 26. Advantageously, the sleeve 81 is slotted to fit closely within a metallic ring 82 secured, as by glazing, to the rods 26. The helix 27 is connected to the ring 82 so that electrical connection to the sleeve 81 is secured thereby. Thus, in the assembling of the device, the helix and support rods may be assembled as a separate unit, secured to the inner cup-shaped member 20 of the coaxial input terminal, and inserted within the device. Connection may then be made to the inner cup-shaped member 75 of the coaxial output terminal without requiring any brazing or glazing process, as the slotted portions of sleeve 81 will act as spring fingers and bear against the ring 82.

The base of the outer cup-shaped member 12 has an aperture 85 therein shaped so that the helix 27 is closely adjacent the edge of the base of the member 12, the shape being similar to that of aperture 30, as seen in Fig. 2. Coupling of the electromagnetic energy from the transmission line defined by the helix 27 to the transmission line defined by the inner and outer cup-shaped members, which comprise the inner and outer conductors of the coaxial output terminal, is thus achieved by the electrical field of high intensity existing across the predominantly axial gap between the end of the sleeve 82 and the edge of aperture 85 in the outer cup-shaped member 12.

Positioned within the inner cup-shaped member 75 is the electron receiving assembly 86 which comprises a suppressor electrode 87 and a collector electrode 88, these electrodes being held in place by dished insulators 89. Leads 91 extend from the suppressor and collector electrodes through apertures 92 in the inner cup-shaped member 75 to terminals 93 extending through glass or ceramic beads 94 sealed in the outer cup-shaped member 12. A lead conductor also advantageously extends from the terminal 93 to the cup-shaped member 75 to apply a direct current potential to the helix 27. Filters 62 are secured to the terminals 93 external to the envelope of the device.

A plurality of springs 95 hold the insulators 89 and suppressor and collector electrodes in position within the inner cup-shaped member 75, and a spring washer 96 bears against the insulator annulus 78 and biases the inner cup-shaped member 75 against an insulator ring 97 on the base of the outer cup-shaped member 12. As only three external leads need be brought out from the electron receiver assembly within the inner cup-shaped member 75, one aperture in the outer cup-shaped member 12 opposite an aperture 92 in the inner cup-shaped member 75 can have an exhaust tubulation secured therein for evacuating the device.

While the invention has been described with reference to a specific embodiment wherein the two outer cup-shaped members are separate and joined by an insulating tube, it is to be understood that they may be joined by a metallic tube and that the two outer cup-shaped members and the metallic tube may all be integral. Such a metallic envelope has the advantage of providing shielding for the helix interaction space.

Reference is made to application Serial No. 270,599, filed February 8, 1952, by G. H. Robertson and E. J. Walsh, now Patent No. 2,765,421, issued October 2, 1956, and application Serial No. 270,721, filed February 8, 1952, by J. R. Pierce, now Patent 2,761,915, issued September 4, 1956, wherein are described related inventions.

It is to be understood that the above-described arrangements are illustrative of the application of the principles

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of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An electron discharge device comprising a helix, a coaxial terminal, means for transferring electromagnetic energy between said helix and said terminal, said means comprising an outer hollow member comprising a portion of the outer conductor of said terminal and an inner hollow member comprising a portion of the inner conductor of said terminal within said outer hollow member, said helix being electrically connected to one of said hollow members, the end of said one hollow member defining with the other of said hollow members a gap having therein an electric field in an axial direction in said helix, and an electrode assembly positioned within said inner hollow member.

2. An electron discharge device comprising an envelope, a coaxial terminal extending through said envelope at each end thereof, a cylindrical member electrically attached to the outer conductor of each of said terminals, said cylindrical members each having an end plate thereacross with an aperture therein, a helix extending in said envelope through said apertures closely adjacent the edge of said end plates therein, means within said cylindrical members electrically connecting said helix to the inner conductor of each of said coaxial terminals and defining therewith a gap having an axial electric field therein, electron gun means positioned in one of said cylindrical members opposite one end of said helix for projecting a stream of electrons along said helix, and electron receiving means positioned opposite the other end of said helix in the other of said cylindrical members.

3. An electron discharge device comprising an envelope, a coaxial terminal extending through said envelope, a cylindrical member electrically attached to the outer conductor of said terminal, said cylindrical member having an end plate with an aperture therein, a helix extending in said envelope and extending through said aperture closely adjacent the edge of said plate therein, means within said cylindrical member electrically connecting said helix to the inner conductor of said coaxial terminal and defining therewith a gap having an electric field therein in the direction of the axis of said helix, and electrode means positioned within said cylindrical member opposite one end of said helix.

4. An electron discharge device comprising a helix, electron gun means for projecting a stream of electrons along said helix, means for coupling electromagnetic energy to said helix, said last-mentioned means comprising an outer hollow member comprising a portion of the outer conductor of a coaxial terminal and having a base with an aperture therein, and an inner hollow member within said outer hollow member, said helix being connected to said inner hollow member and extending through said aperture closely adjacent the edge of said base in said aperture, the end of said inner hollow member defining a gap with said edge of said base in said aperture and means supporting said electron gun means within said inner hollow member.

5. An electron discharge device comprising a helix, a coaxial terminal, and means for transferring electromagnetic energy between said helix and said terminal, said means comprising an outer hollow member comprising a portion of the outer conductor of said terminal, said outer hollow member having a base with an aperture therein, and an inner hollow member positioned within said outer hollow member and comprising a portion of the inner conductor of said terminal, said helix being electrically connected to said inner hollow member and extending through said aperture adjacent the edge of said base therein, and an electrode assembly supported within said inner hollow member.

6. An electron discharge device comprising an outer cup-shaped member having a base and an aperture cen-

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trally therein, an inner cup-shaped member located within said outer cup-shaped member, electron gun means supported within said inner cup-shaped member and insulated therefrom, a helix connected to said inner cup-shaped member, means supporting said helix from said inner cup-shaped member, said helix extending through said aperture closely adjacent said base, a coaxial terminal having an inner conductor connected to said inner cup-shaped member and an outer conductor connected to said outer cup-shaped member, and electron receiver means adjacent the opposite end of said helix from said electron gun means.

7. An electron discharge device comprising an envelope, a pair of coaxial terminals positioned at opposite ends of said envelope, each of said terminals comprising an inner and an outer conductor, an outer cylindrical member connected electrically to the outer conductor of each of said terminals, a plate extending across each of said outer cylindrical members having a central aperture therein, an inner cylindrical member positioned within each of said outer cylindrical members and electrically connected to said inner conductors of said terminals, a helix extending within said envelope through each of said apertures and electrically connected to each of said inner cylindrical members, electron gun means positioned within one of said inner cylindrical members adjacent one end of said helix, and electron receiver means positioned within the other of said inner cylindrical members adjacent the other end of said helix.

8. A traveling wave tube comprising an envelope, a helix extending in said envelope, a coaxial terminal, an outer cup-shaped member having an aperture centrally in the base thereof and comprising a portion of the outer conductor of said terminal, an inner cup-shaped member axially positioned within said outer cup-shaped member and comprising a portion of the inner conductor of said coaxial terminal, means supporting said helix from said inner cup-shaped member, said helix extending through said aperture closely adjacent said base, insulating means supporting said inner cup-shaped member from said outer cup-shaped member, an electrode assembly within said inner cup-shaped member, and insulating means supporting said electrode assembly within said inner cup-shaped member.

9. A traveling wave tube comprising an envelope, a helix extending within said envelope, a coaxial terminal at each end of said envelope, an outer cup-shaped member at each end of said envelope and comprising a portion of the outer conductors of said terminals, each of said outer cup-shaped members having an aperture centrally in the base thereof, an inner cup-shaped member within each of said outer cup-shaped members and comprising a portion of the inner conductors of each of said terminals, the axes of said helix and said cup-shaped members being coincident, means supporting said helix from said inner cup-shaped members, said helix extending through said apertures closely adjacent the edge of said base therein, each of said inner cup-shaped members defining with said edges a gap having an electric field therein having a component in the direction of the axis of said helix, an electron gun insulatingly positioned in one of said inner cup-shaped members for projecting a stream of electrons along said helix, and electron receiving means positioned in the other of said cup-shaped members.

10. A traveling wave tube comprising a pair of outer cup-shaped members, a cylindrical member therebetween, a coaxial terminal closure cap across the end of each of said outer cup-shaped members, said outer cup-shaped members, cylindrical member, and coaxial terminal closure caps defining the envelope of said device, said outer cup-shaped members having an aperture centrally in the base thereof and being electrically connected to the outer conductors of said coaxial terminal closure caps, an inner cup-shaped member within each of said outer cup-shaped members and electrically connected to

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the inner conductors of each of said coaxial terminal closure caps, means supporting said helix from said inner cup-shaped members, said helix extending through said aperture closely adjacent the edge of said base, electron gun means insulatingly supporting within one of said inner cup-shaped members for projecting a stream of electrons along said helix, and electron receiving means positioned within the other of said inner cup-shaped members.

11. A traveling wave tube comprising a pair of conducting outer cup-shaped members, each of said members having an aperture axially in the base thereof, a tubular member between said outer cup-shaped members, a conducting closure cap across the end of each of said outer cup-shaped members, said closure cap comprising a coaxial sleeve portion, a conducting inner cup-shaped member within each of said outer cup-shaped members, means electrically connecting said inner cup-shaped members to the inner conductors of said coaxial sleeve portions, means supporting said inner cup-shaped members from said outer cup-shaped members comprising a dished insulating ring on the base of said outer cup-shaped members and a spring washer biasing said inner cup-shaped

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members against said insulating rings, a helix extending in said tubular member and through said apertures closely adjacent the edge of said bases therein, means supporting said helix from said inner cup-shaped members, the axes of said helix, said inner, and said outer cup-shaped members being coincident, electron gun means positioned in one of said inner cup-shaped members for projecting a stream of electrons along said helix, and electron receiving means positioned in the other of said inner cup-shaped members.

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