

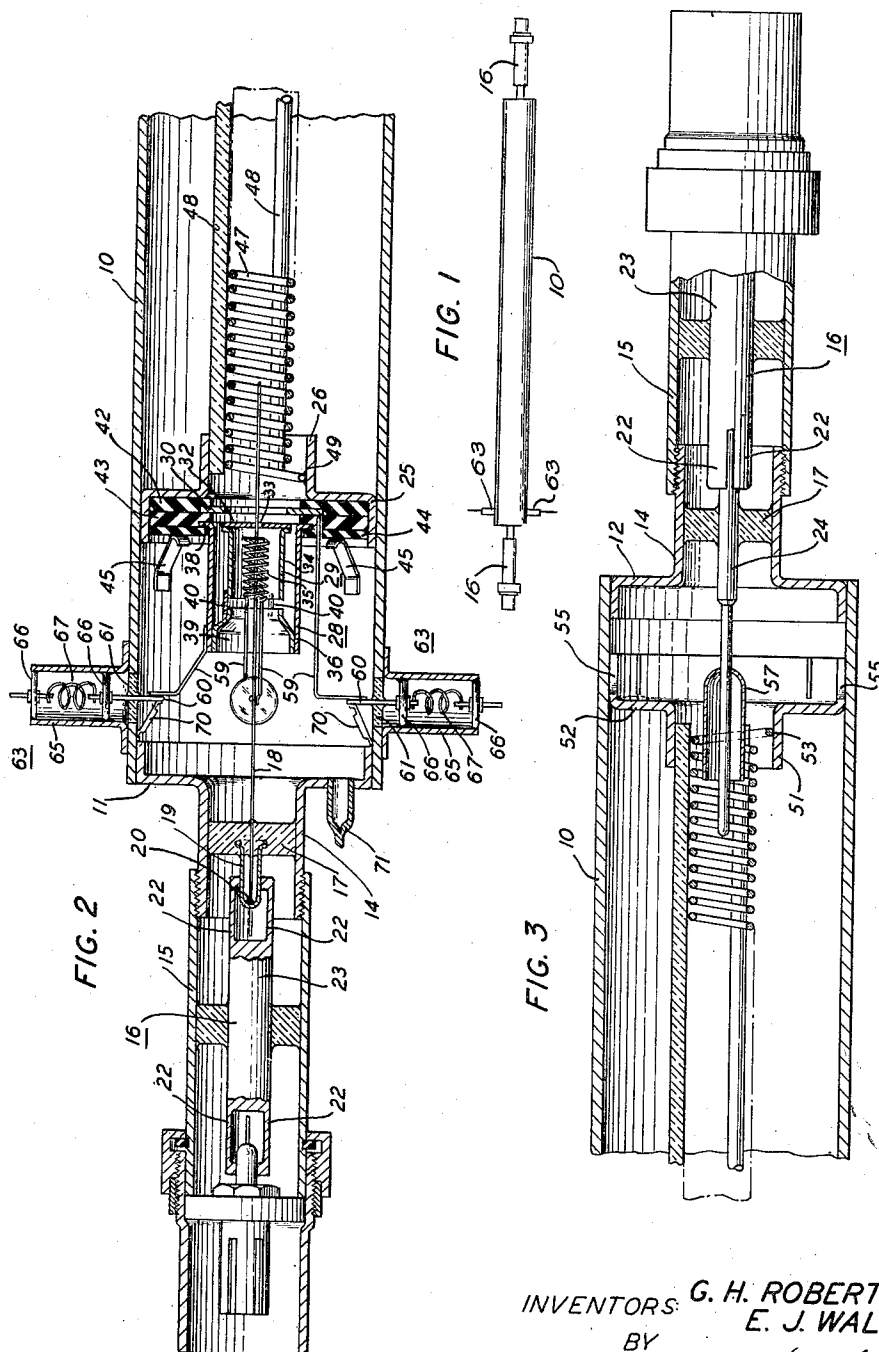
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ELECTRON DISCHARGE DEVICES

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ELECTRON DISCHARGE DEVICES

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This invention relates to electron discharge devices and more particularly to such devices known as traveling wave tubes wherein a high frequency signal is amplified by the interaction of the electromagnetic wave associated therewith and the electromagnetic wave associated with an electron beam traveling adjacent thereto.

Such devices employ a helical conductor to guide the high frequency signal within the device, the electron beam being projected along the helical conductor. At the frequencies at which such devices are utilized, the high frequency signal may be introduced through a coaxial input terminal and removed from the device, after amplification, through a coaxial output terminal. The high frequency signal from the coaxial input terminal must therefore be coupled to the helix of the traveling wave tube and then coupled to the coaxial output terminal.

An object of this invention is to provide improved input and output coaxial terminals for a traveling wave tube. More specifically, it is an object of this invention to improve the coupling of the high frequency signal to the helix of the traveling wave tube from coaxial input and output terminals.

A further object of this invention is to mount and support the electron gun and electron collector assemblies from the coaxial input and output terminals, respectively, in an improved manner facilitating the fabrication of traveling wave tubes employing coaxial input and output terminals.

These and other objects of this invention are achieved in one specific illustrative embodiment of this invention wherein the envelope of a traveling wave tube comprises a metallic outer cylinder defining a portion of the envelope of the tube and end caps across each end thereof, the caps having windows, e. g., vitreous beads, transparent to the passage of microwave energy sealed therein. Wires extend coaxially through the vitreous beads into the envelope thus defined. In accordance with a feature of this invention, the wires define the inner conductor of the coaxial terminals and the envelope the outer conductor thereof. Metallic cup members are secured within the envelope to the interior wall of the cylinder and have each a sleeve attached thereto to which the helix is electrically connected. The wires extend through the helix so as to project therein for a few turns of the helix.

In this specific embodiment, the electron gun comprises a cathode and an accelerating electrode supported within one of the cup-shaped members, the cathode having an aperture centrally in the emissive surface thereof through which the wire defining the inner conductor of the coaxial input terminal extends. The aperture may be made of sufficient diameter so that the wire does not contact the emissive surface or an insulating button may be placed in the aperture, the wire extending through the insulating button and being positioned thereby.

Further in this specific embodiment of this invention, the electron collector is a cup-shaped electrode supported by the wire extending through the cap vitreous bead and defining the inner conductor of the coaxial output termi-

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nal, the wire projecting axially within the helix for a few turns thereof.

Thus, in this specific embodiment of the invention, the inner conductors of the coaxial input and output terminals extend within the helix for a short distance, the helix being electrically connected to the outer conductors of the terminals. Each wire and the helix define a gap in which the wire acts as a probe. As the wire extends past the end of the sleeve to which the helix is connected, the gap has an electric field of high intensity therein extending axially in the helix, enabling the electromagnetic wave energy being transmitted along the coaxial terminals to be coupled to the transmission circuit defined by the helix of the traveling wave tube.

It is therefore one feature of this invention that the helix of the traveling wave tube be electrically connected to the outer conductor of the coaxial terminal, the inner conductor of the terminal being a wire extending into the helix so that a gap of high field concentration having a large axial component is defined between the wire and the end of the outer conductor connected to the helix whereby coupling of the high frequency energy is attained between the helix and the terminal.

In accordance with a further feature of this invention, the outer conductor of the coaxial terminals is cup-shaped and has a sleeve portion to which the helix is electrically attached, the wire defining the inner conductor of the helix extending through the sleeve portion. More specifically, in accordance with this feature of this invention, the cathode and accelerating electrode are positioned within the cup-shaped outer conductor, the cathode having an aperture in its emissive surface through which the wire defining the input inner conductor extends.

It is a further feature of this invention that the collector electrode be supported by the wire defining the inner conductor of the output terminal and be electrically connected thereto so that maximum extraction of energy to the output circuit may be attained.

In accordance with a still further feature of this invention, the coaxial terminals are axially aligned with the helix of the traveling wave tube and define closure end caps for the envelope thereof. More specifically, it is a feature of this invention that the envelope of the traveling wave tube comprise a metallic cylinder and closure end caps having a central conductor therethrough, the closure end caps defining the coaxial terminals of the traveling wave tube.

It is a further feature of this invention that the cup-shaped members having sleeve portions to which the helix is connected are supported and positioned by the outer cylindrical metal envelope to which they are electrically connected, and the electrical distance from the sleeve portions to the coaxial terminals is determined by the positioning of the cup-shaped members in contact with the envelope, whereby the cup-shaped members may be positioned a predetermined electrical distance from the coaxial terminals to attain optimum impedance transformation between the helix and the external coaxial systems, the optimum electrical distance being determined by the frequency or range of frequencies of operation.

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, Fig. 1 of which is an external view of a traveling wave tube illustrative of one specific embodiment of this invention and Figs. 2 and 3 are sectional views of portions of the tube of Fig. 1, Fig. 2 being a sectional view of the input terminal and electron gun assembly and Fig. 3 being a sectional view of the output terminal and electron collector assembly.

Referring now to the drawing, the specific illustrative embodiment of this invention depicted comprises a metal-

lic cylinder 10 forming a portion of the envelope of the traveling wave tube. End closure caps 11 and 12 are hermetically sealed, as by brazing, to the ends of the cylinder 10, each of the caps 11 and 12 having a nose portion 14 to which is threadedly engaged the outer conductor 15 of a coaxial connecting jack or plug 16. A glass or ceramic bead 17 is advantageously sealed within the nose portion 14 to complete the vacuum tight envelope of the traveling wave tube. A thin wire 18 is sealed axially within the glass or ceramic bead 17 of end closure cap 11 and extends into a cap 19 to which it is electrically secured, as by solder 20. Spring fingers 22 at the end of the inner conductor 23 of the coaxial connecting jack 16 encompass the cap 19. Similarly a wire 24, advantageously considerably larger than wire 18, extends axially through the glass bead 17 of end closure cap 12 and is sealed thereto, the spring fingers 22 of the inner conductor 23 of the coaxial connecting jack 16 similarly encompassing the end of the wire 24.

Adjacent the end closure cap 11 is a cup-shaped support member 25 secured, as by brazing or welding, to the outer cylindrical envelope 10. The base of the support member 25 is apertured and a sleeve 26, advantageously integral therewith, is dependent therefrom. Positioned and supported within the cup-shaped support member 25 is the electron gun assembly 28 which may advantageously comprise a cathode 29 and an accelerating electrode 30. The cathode 29 comprises a disc 32 having a small aperture 33 axially therein and an electron emissive coating thereon, a heater cup 34 across the end of which the disc 32 extends, a heater element 35 positioned within the heater cup 34, an outer cylindrical heat shield 36 having flanged portion 38 advantageously in the plane of the disc 32, a base member 39 secured, as by welding within the base of the cylinder 36 at the opposite end from the flanged portion 38, and a plurality of support strips 40 supporting the heater cup 34 from the base member 39. An insulator washer 42 is positioned on the base of the support member 25. The accelerating electrode 30 is between the insulator 42 and an insulator washer 43 while the flanged portion 38 of the cathode cylinder 36 is between the insulator 43 and a third insulator washer 44. A plurality of springs 45 advantageously welded to the inner wall of the envelope cylinder 10 bears against the insulators and sandwiched accelerating electrode and flange. Insulators 42 and 44 are advantageously slightly dished to receive the accelerating grid 30 and flanged portion 38 to prevent lateral motion of these members.

The helix 47 of the traveling wave tube is secured, as by being glazed thereto, to a plurality, as three, of insulating rods 48 which in turn are secured, as by glazing, to the inner surface of the sleeve 26 of cup-shaped support member 25. The one end of the helix 47 is electrically connected to the sleeve 26, as at 49. The other end of the insulating helix support rods 48 is secured, as by brazing, to the inner surface of a sleeve 51 of a cup-shaped member 52 to which the other end of the helix 47 is electrically connected, as at 53. The cup-shaped member 52 is similar to the cup-shaped member 25 but is advantageously secured to the envelope cylinder 10 by a plurality of spring fingers 55 rather than by being brazed or welded thereto to allow for the different thermal expansions of the envelope 10 and the insulating rods 48. A cup-shaped electron collector 57 is supported by the wire 24 within the cup-shaped member 52.

Direct-current connections are made to the heater element 35, cathode 29 and accelerating electrode 30 by individual leads 59 connected to each of these elements and to terminal pins 60 extending through a glass or ceramic bead 61 in the envelope cylinder 10. A high frequency filter 63 is connected between the terminal pins 60 and the envelope cylinder 10 external to the envelope to prevent passage of radio frequency power to the direct-current supplies and comprises a shell 65 positioned with its base on the envelope cylinder 10, a pair of button capaci-

ties 66 electrically connected between the terminal pin 60 and the shell 65 and a choke 67 between the capacitances 66 and comprising a few turns of wire.

Getters 70 may advantageously be connected between the terminal pins 60 and the inner wall of the envelope 10 and burned out during the processing of the device. An exhaust tubulation 71 is advantageously provided in the end closure cap 11.

In the operation of traveling wave tubes in accordance with this specific embodiment of this invention, the electromagnetic energy is guided by the external wave guide or coaxial line system to the coaxial jack 16 and thence to the coaxial input terminal comprising the closure cap 11 and the wire 18. The wire 18, which defines the inner conductor of the coaxial input terminal, extends through the cathode 29 and specifically through the heater element 35 and the aperture 33 in the cathode disc 32 and axially within the helix 47 for a short distance, advantageously extending past the end of the sleeve 26 a short distance. An insulating coating may be advantageously applied to the central portion of the wire 18 where it extends through the heater element 35 and the aperture 33 in the cathode disc 32. Also if desired for mechanical support, an insulator button may be positioned within the aperture 33 in the cathode disc 32 to aid in accurately aligning the wire 18.

The outer conductor of the coaxial input terminal is defined by the closure cap, the cylinder 10, the cup-shaped support member 25 and the sleeve 26 thereof. The sleeve 26 may extend along the rods 48 so as to encompass a few turns of the helix 47, the helix being electrically connected to the sleeve 26. The wire 18 and the helix 47 thus define a gap in which the wire 18 acts as a probe, the gap having an electric field of high intensity therein with a large axial component whereby the electromagnetic energy is coupled from the coaxial system to the transmission circuit defined by the helix 47.

Similarly, the output coaxial terminal is defined by nose portion 14 of the end closure cap 12 and the wire 24. The outer conductor of the coaxial output terminal is thus the closure cap 12, the envelope 10, the cup-shaped member 52 and sleeve 51 thereof. The helix 47 may extend within the sleeve 51, and the wire 24 extends a short distance past the end of the encompassing sleeve 51. Coupling to the output coaxial terminal is attained by the high field developed around the end of the wire 24 and the portion of the helix adjacent thereto. As the electron stream projected by the electron gun assembly 28 is modulated by the electromagnetic wave energy guided by the helix and the electron stream impinges on the collector 57 supported by the wire 24, radio frequency energy may be extracted from the electron beam as well as from the electromagnetic wave guided by the helix.

Advantageously, in the operation of this embodiment of this invention, the envelope 10 and thus the helix 47 are at ground potential. The cathode 32 is maintained negative with respect to the helix while the accelerating grid 30 will be positive with respect to the cathode 32. The collector 57 is also advantageously maintained positive with respect to the helix 47 so that secondary electrons will be confined within the cup of the collector and not impinge on the helix. However, the collector may advantageously be operated at the same direct-current potential as the helix or at a slightly lower potential if the secondary emission problem is not important. The particular values of voltages employed would depend on the frequency range of operation as the frequency is determined in part by the potential difference between the helix and the cathode. The particular values of voltage would also depend on the current density, the desired gain and the particular output power and other operational criteria.

The electrical length of the path from the coaxial input terminal defined by the nose portion 14 to the gap defined by the wire 18 and the sleeve 26 to which the helix 47 is connected can be varied to obtain the optimum im-

pedance match between the external system and the helix. In this specific embodiment of this invention this may be done during the fabrication of the device by varying the position along the envelope 10 at which the cup-shaped member 25 is secured thereto, as by welding or brazing. The point at which the cup-shaped member 25 will be secured to the envelope 10 for optimum impedance transformation will depend on the desired frequency, or frequency range, of operation. Similarly optimum impedance transformation between the helix 47 and the output coaxial system can be obtained by positioning the cup-shaped member 52 with the envelope 10, by the spring fingers 55, at the optimum electrical distance from the output nose portion 14 for the frequency of operation.

In the fabrication of the specific illustrative embodiment of this invention depicted in the drawing and described above, the helix 47, helix support rods 48 and cup-shaped members 25 and 52 are advantageously assembled first as a unit and then slid into the cylinder 10 and the cup-shaped member 25 secured, as by welding, to the inner wall of the cylinder. The closure cap 12 in which has priorly been sealed the window 17 is then hermetically positioned across the end of the cylinder 10, as by being brazed thereto. The insulator washers 42, 43 and 44, accelerating electrode and priorly assembled cathode assembly 28 are positioned with the cup-shaped member 25, being automatically centered thereby and by the disc portions of the washers 42 and 44. The spring fingers are then attached to the inner wall of the cylinder 10, as by welding, and bias the sandwiched washers and electrodes in position. After the leads 59 have been attached to the terminal pins 60 and the getters positioned across the pins 60 and the envelope 10, the end closure cap 11 is hermetically sealed across the end of the cylinder 10, as by being brazed thereto. The wire 18 is priorly sealed in the window 17 in the end closure cap 11 and extends through the aperture 33 in the cathode surface 32 when the end closure cap 11 is in place. The envelope is exhausted through the tubulation 71, which may then be sealed off.

Reference is made to application Serial No. 270,598, filed February 8, 1952, by G. H. Robertson and application Serial No. 270,721, filed February 8, 1952, by J. R. Pierce wherein are described related inventions.

It is to be understood that the above-described arrangements are illustrative of the application of the principles 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. A traveling wave tube comprising an envelope, a helix extending within said envelope, electron gun means for projecting a stream of electrons along said helix, said gun means including a cathode having an emissive surface and an aperture in said surface, and a coaxial input terminal defining a portion of said envelope, said terminal comprising a wire inner conductor extending through said aperture and projecting axially into said helix a short distance and a cylindrical outer conductor having a portion through which said helix extends and to which said helix is electrically connected, the ends of said inner conductor and said outer conductor portion defining a gap having an electric field of high intensity for coupling wave energy from said coaxial input terminal to said helix.

2. A traveling wave tube comprising an envelope, a helix extending within said envelope, electron gun means for projecting a stream of electrons along said helix, said gun means including a cathode having an emissive surface on one side thereof, an aperture in said surface, and heater means adjacent the other side of said cathode, a coaxial input terminal defining a portion of said envelope comprising a wire inner conductor extending through said heater means and through said aperture and projecting

axially within said helix a short distance and a cylindrical outer conductor to which said helix is electrically connected, said cylindrical outer conductor having a cup-shaped portion, and means positioning said electron gun means in said cup-shaped portion.

3. An electron discharge device comprising an envelope, a helix extending within said envelope, electron gun means for projecting an electron stream along said helix, a coaxial output terminal, said terminal comprising an inner conductor projecting into said helix and an outer conductor encompassing said inner conductor and electrically connected to said helix, the end of said inner conductor defining with said helix a high electric field intensity gap for coupling wave energy from said helix to said coaxial output terminal, and a collector electrode supported by said inner conductor in the path of said electron stream.

4. An electron discharge device comprising an envelope and a helix extending within said envelope, said envelope comprising a cylindrical member and a coaxial terminal across each end of said cylindrical member, said coaxial terminals each comprising an outer conductor to which said helix is electrically connected and a wire inner conductor projecting axially a short distance within said helix past the ends of said outer conductor, the ends of said wire inner conductor and said helix defining gaps having high electric field intensities for the coupling of wave energy between said coaxial terminals and said helix.

5. An electron discharge device in accordance with claim 4 wherein said cylindrical member is of a conducting material and defines a portion of the outer conductors of each of said coaxial terminals.

6. A traveling wave tube comprising an envelope, a helix within said envelope, electron gun means for projecting a stream of electrons along said helix, said gun means comprising a cathode including a member having an emissive surface on one side thereof, an aperture in said member, and a heater adjacent said member to the other side thereof, a coaxial input terminal defining a closure for one end of said envelope and comprising a wire inner conductor extending through said heater means and said aperture and projecting axially a short distance within said helix and an outer conductor to which said helix is electrically connected, said outer conductor including a cylindrical cup-shaped portion, means positioning said electron gun means in said cup-shaped portion, a coaxial output terminal defining a closure for the other end of said envelope and comprising a wire inner conductor projecting axially a short distance into said helix and a cylindrical outer conductor encompassing said inner conductor and electrically connected to said helix and a collector electrode supported by said inner conductor in the path of said electron stream.

7. A traveling wave tube comprising an envelope, said envelope comprising a cylindrical member and a coaxial terminal across each end of said member, a helix extending in said envelope, the axis of said helix being coincident with the axis of said envelope, electron gun means for projecting a stream of electrons along said helix, said electron gun means comprising a cathode having an emissive surface on one side, an aperture through said surface, and a heater element adjacent said cathode to the other side thereof, one of said coaxial terminals comprising a wire inner conductor extending through said heater element and said aperture and projecting axially a short distance into said helix and a cylindrical outer conductor encompassing said inner conductor and including a cup-shaped portion to which said helix is electrically connected, means positioning said electron gun means in said cup-shaped portion whereby said electron gun means is supported and aligned by said cup-shaped portion, the other of said coaxial terminals comprising an inner wire conductor projecting axially a short distance into said helix and an outer cylindrical conductor encompassing said inner conductor and including a cup-shaped portion

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to which said helix is electrically connected, means for supporting said helix from said cup-shaped portions of said terminals, and a collector electrode supported in the path of said electron stream by said inner conductor of said other coaxial terminal.

8. A traveling wave tube in accordance with claim 7 wherein said envelope cylindrical member is of a conducting material and defines a portion of the outer conductors of each of said coaxial terminals, said cup-shaped portions being electrically connected to and positioned by said envelope.

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