

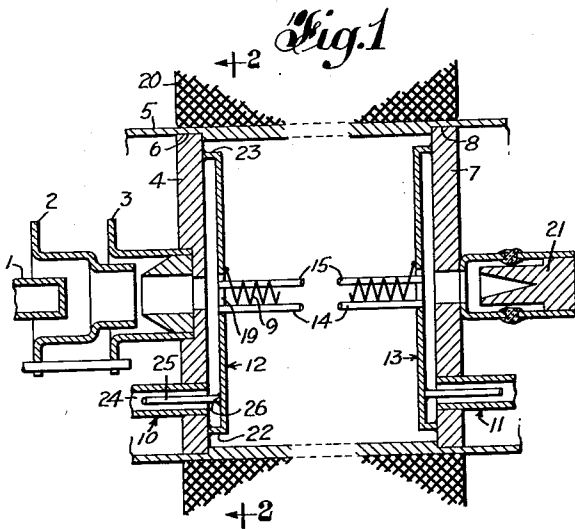
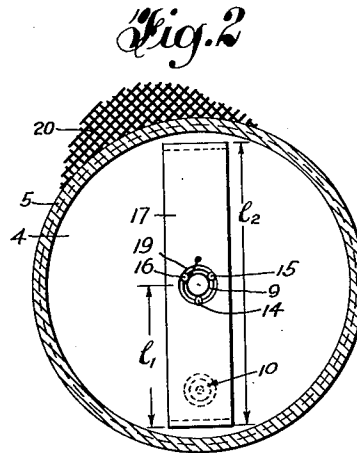
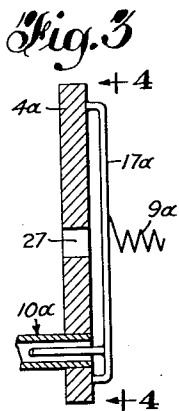
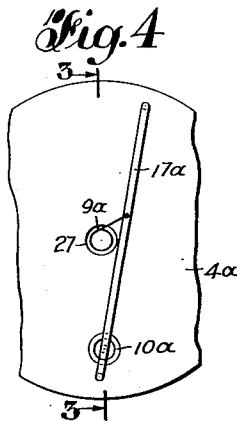
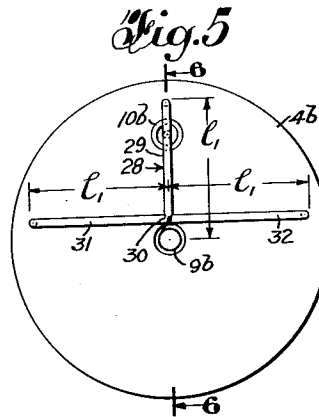
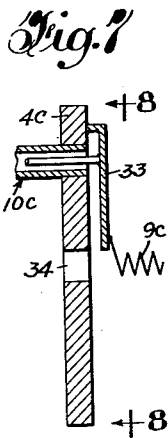
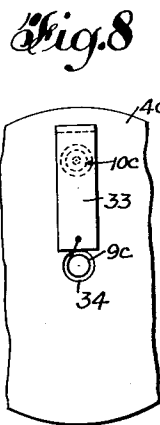
May 28, 1957

J. H. BRYANT

2,794,145

TRAVELING WAVE ELECTRON DISCHARGE DEVICES

Filed Sept. 29, 1952



$l_1 = \text{APPROX. } \frac{A}{2} \text{ OR ODD MULTIPLE}$
 $l_2 = \text{ " } \frac{A}{2} \text{ OR MULTIPLE}$

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2,794,145

TRAVELING WAVE ELECTRON DISCHARGE DEVICES

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Application September 29, 1952, Serial No. 312,155

5 Claims. (Cl. 315—3.5)

This invention relates to traveling wave electron discharge devices and more particularly to transducer or transition arrangements for matching a low impedance radio frequency line to the relatively high impedance helical line usually employed in such devices.

In my joint copending application with T. J. Marchese, Serial No. 221,862, filed April 19, 1951, for "Traveling Wave Electron Discharge Device," an impedance matching transformer is disclosed comprising a short section of an axially disposed coaxial line of high impedance, the same as that of the helical line to which the inner conductor is coupled. The opposite end of the coaxial section is shorted to establish a voltage null point. The radio frequency coaxial line of lower impedance is coupled to the coaxial section of high impedance intermediate the ends thereof at a point presenting the proper impedance match. While such a coaxial transition section makes a good impedance match it requires valuable coaxial space thus limiting the length of the helix and, therefore, the gain.

One of the objects of the present invention, therefore, is to provide an impedance matching transition at the end of the helical line which requires a minimum of axial space thereby making it possible to have a longer helix for a tube or device of given size.

One of the features of the invention is the placing of the transition section transversely of the axis of the helical line. This feature is accomplished by providing a parallel line arrangement preferably utilizing a conductive plate, which serves as an alignment plate for elements of the device disclosed in the aforesaid copending application, as one of the conductors. By providing a second conductor in substantially parallel spaced relation to the planar surface of the plate, a transmission line is provided which will propagate radio frequency energy in the TEM mode. By making this transition section of such a length as to be resonant at the operating frequency of the tube and by shorting one end thereof to establish a standing wave having a voltage null point at the shorted end and a voltage max point adjacent the helical line, it is a simple matter to couple the low impedance coaxial line to the transition section at an appropriate point between the voltage null and max points thus obtaining a proper impedance match.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a fragmentary view in longitudinal section with parts of the envelope broken away of a traveling wave electron discharge device incorporating transition sections at the ends of the helical line in accordance with the principles of this invention;

Fig. 2 is a view in elevation of the transition section as viewed along line 2—2 of Fig. 1;

Fig. 3 is a cross-sectional view similar to Fig. 1 of another embodiment, as viewed along line 3—3 of Fig. 4;

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Fig. 4 is an elevational view of the transition arrangement illustrated in Fig. 3 and as viewed along line 4—4 thereof;

Fig. 5 is an elevational view similar to Figs. 2 and 4 of still another embodiment of the invention;

Fig. 6 is a view in cross-section taken along 6—6 of Fig. 5;

Fig. 7 is a view in cross-section similar to Fig. 6 showing still another embodiment of the invention; and

Fig. 8 is a view in elevation of the transition section shown in Fig. 7 as viewed along line 8—8 of Fig. 7.

Referring to Figs. 1 and 2 of the drawings, the traveling wave electron discharge device or tube therein shown follow generally the construction disclosed in the aforementioned copending application, modified to incorporate one form of the transition sections of the present invention. The device comprises a cathode 1, focusing electrode 2 and an anode electrode 3 for the emission and forming of electrons into a beam for flow lengthwise of the tube. The three electrodes are mounted as a gun unit and supported on an alignment or partition plate 4 received in position within a metal cylinder 5 against an abutment 6 formed on the inner surface thereof. At the rear of the tube another alignment or partition plate 7 is provided which likewise is received within cylinder 5 against an abutment 8. The alignment plate 7 normally supports the R. F. terminal section particularly the R. F. output terminal and, in certain embodiments, may also support the R. F. input terminal. Supported between the two alignment plates 4 and 7 is a helical line 9 which serves to propagate the radio frequency energy from the input terminal line 10 to the output terminal line 11 by way of transition sections 12 and 13. The helical line 9 is preferably supported by dielectric rods 14, 15 and 16 which are disposed at spaced points about the helix and extend parallel to the axis of the helix. These rods 14, 15 and 16 are in turn supported at their ends in openings contained in conductors 17 and 18 of the transition sections, as indicated in Fig. 2. Centrally of these openings, which accommodate the supporting rods, is an opening 19 which receives the end of the helix, which in this embodiment is connected to the conductor 17. It will be understood, however, that the opening 19 may be considerably smaller than that shown, and in fact, may correspond to the inner diameter of the helix. It should also be understood that the rods may be of any suitable dielectric material such as glass, ceramics or quartz, and if desired, the rods may be replaced by a tube of such material.

While all of the details of the traveling wave electron discharge device have not been shown in Fig. 1, it will be understood that sufficient structure is included to illustrate the principles of the present invention. For example, the magnetic field established parallel to the axis of the helix may be established by either a permanent magnet or solenoid 20. In this connection the alignment plates 4 and 7 are preferably chosen of magnetic material so as to assist in establishing the paths of magnetic flux for axial concentration of the magnetic field. It will also be noted that the plate 7 provides a support for the collector electrode 21 disposed axially of the helix. For additional details of the tube structure reference may be had to the aforesaid copending application Serial No. 221,862.

The transition sections of the present invention employ the plates of the alignment structure as a part thereof. As shown in Figs. 1 and 2, the forward transition section comprises the plate 4 and the conductor 17. The conductor 17 is maintained in proper spaced relation with respect to the planar surface of the plate 4 to present the proper line impedance. In this embodiment both ends of the conductor 17 are shorted to the plate 4, as indicated at 22 and 23. The length of the conductor 17 is chosen

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approximately one-half wavelength or a multiple thereof of the operating frequency so as to establish a resonant section having null voltage points at the shorted ends thereof and a maximum voltage point or zone adjacent the end of the helix 9. The input terminal line 10 is in the form of a coaxial line, the outer conductor 24 of which is received in an opening contained in the plate 4 to which the conductor 24 is connected, and the inner conductor 25 is connected to the conductor 17 as indicated at 26. The R. F. energy conducted over the terminal connection 10 is propagated along the transition section in the TEM mode and is thereby coupled for propagation along the helical line 9 while one conductor of the transition section is here shown to be the alignment plate 4, it will be understood of course, that it may be a separate strip conductor if desired.

As previously pointed out, the coaxial line 10 has a relatively low characteristic impedance which for example may be in the order of 50 ohms, while the helical line 9 has a relatively high characteristic impedance, for example 300 ohms or more. The transition section 12 provides for proper matching of the terminal connection 10 by coupling the coaxial terminal 10 at a suitable point 26 between the voltage null point at 22 and the voltage max point at 19. Likewise, the coupling of the helical line at the voltage max point of the transition section 12 insures a proper impedance match therebetween.

The transition section 13 at the output end of the helical line is, in this embodiment identical, to the section 12, the transition section being coupled to the output coaxial terminal line 11 at a proper point for impedance matching. In each transition section it will be readily apparent that a minimum amount of axial space is utilized within the device for effecting the transition coupling between the coaxial terminals and the helical line. While the transition sections are shown to be at right angles to the axis of the helical line, it will be apparent that the sections need not be at right angles but may be varied therefrom depending on the structure of the device and the supporting arrangement of the alignment plates. It should also be understood that while I have shown the transition section as employing an alignment or partition plate a separate planar conductor may be provided.

Referring to Figs. 3 and 4 another embodiment of the invention is shown, wherein the strip conductor 17a of the transition section is made considerably narrower than the strip 17 of Figs. 1 and 2. The strip 17a for example, may comprise round stock in cross-section, although other cross-sectional configurations, such as rectangular, triangular and elliptical, may be employed. In this form the strip 17a is offset from the opening 27 contained in the plate 4a so that the strip is disposed adjacent to the path of the electron beam which flows through the opening 27. The helical line 9a is coupled to the strip 17a and is provided with a suitable support similarly as hereinbefore described to maintain the helix in axial alignment with the opening 27. The coaxial terminal connection 10a is made to the transition line conductors 4a and 17a similarly as described in connection with Figs. 1 and 2.

While the conductor strips 17 and 17a shown in Figs. 1 to 4 are connected at both their ends to the associated plate conductor, they need not be so arranged. For example, in Fig. 1 the upper portion of the transition strip 17 above the helical line 9 may be omitted, thereby providing, in effect, an "open" ended transition section of approximately one-quarter wavelength. Such a transition section is shown in Figs. 5, 6 and 7, 8. In this embodiment the transition section 28 is shown to comprise in addition to the planar plate conductor 4b a narrower strip conductor 29. The narrow strip 29 may be round, triangular, rectangular, oval or other cross-sectional configuration, as may be desired, and as shown is approximately one-quarter wavelength long. In order to properly support the voltage max end 30 of the strip 29 with respect to the planar surface of the plate 4b additional strips 31

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and 32 are disposed at right angles to the strip 29 and connected to or otherwise made integral with the end 30 thereof. The outer ends of the strips 31 and 32 are in turn connected to the plate 4b, approximately one-quarter wavelength from the point 30 thereby presenting a rigid three-armed structure. The point 30 is disposed adjacent the end of the helical line for coupling the R. F. energy between coaxial terminal 10b and the helical line.

While the strip conductors of the transition sections in Figs. 1 to 6 are shown supported in spaced relation to the planar surface of an associated plate conductor by means of metallic connections associated with both ends of the strip conductor this is not essential where the strip is sufficiently strong to be self-supporting from the shorted end as shown in Figs. 7 and 8. In this embodiment the conductor material of the strip 33 is of sufficient width and thickness as to be supported at one end to the plate 4c with the remainder in substantially parallel relation to the surface of the plate 4c. The high voltage "open" end is coupled to the helical line 9c adjacent the beam path 34. The coaxial terminal connection 10c is coupled to the transition section at the proper impedance matching point between the voltage null and max points of the section.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made by way of example only and not as a limitation to the scope of my invention, as set forth in the objects thereof and in the accompanying claims.

I claim:

1. In a traveling wave electron discharge device having a radio frequency coaxial line, a helical line and means to provide a beam of electrons for flow along a path axially of said helical line; a conductor in the form of a plate disposed between said helical line and said beam providing means in transverse relation to said beam path, said plate conductor having an opening therethrough in alignment with the axis of said beam path, a second conductor having a length resonant at the operating frequency at said discharge device disposed in parallel spaced relation for substantially the entire length thereof to the surface of said plate conductor, said second conductor having one end thereof connected to said plate conductor at a given point spaced from said opening to establish at said one end a voltage null point and a high voltage point adjacent said opening for coupling radio frequency energy to said helical line, means coupling the outer conductor of said coaxial line to said plate conductor and means coupling the inner conductor of said coaxial line to said second conductor intermediate said high voltage point and said voltage null point to obtain an impedance match between said helical line and said coaxial line.

2. In a traveling electron discharge device having a radio frequency coaxial line, a helical line and means to provide a beam of electrons for flow along a path axially of said helical line; a conductor in the form of a plate disposed between said helical line and said beam providing means, said plate conductor having an opening therethrough in alignment with the axis of said beam path, a second conductor disposed in parallel spaced relation for substantially the entire length thereof to the surface of said plate conductor, said second conductor having one part connected to said plate to establish a voltage null point and another part disposed adjacent said opening and at a distance from said null point to establish a high voltage point adjacent said opening for coupling radio frequency energy to said helical line, and means coupling the outer conductor of said coaxial line to said plate conductor and the inner conductor to said second conductor, both ends of said second conductor being connected to said plate conductor, the length of said second conductor being equal substantially to one half a wavelength or an odd multiple thereof of the operating frequency of said device.

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3. In a traveling electron discharge device having a radio frequency coaxial line, a helical line and means to provide a beam of electrons for flow along a path axially of said helical line; a conductor in the form of a plate disposed between said helical line and said beam providing means, said plate conductor having an opening therethrough in alignment with the axis of said beam path, a second conductor disposed in parallel spaced relation for substantially the entire length thereof to the surface of said plate conductor, said second conductor having one part connected to said plate to establish a voltage null point and another part disposed adjacent said opening and at a distance from said null point to establish a high voltage point adjacent said opening for coupling radio frequency energy to said helical line, and means coupling the outer conductor of said coaxial line to said plate conductor and the inner conductor to said second conductor, said second conductor being provided with support extensions extending laterally thereof adjacent the high voltage point, said lateral extensions being disposed in spaced relation to said plate conductor with the outer ends thereof connected to said plate conductor, the length of said lateral extensions being equal substantially to one quarter wavelength or an odd multiple thereof of the operating frequency of said device.

4. In a traveling electron discharge device having a radio frequency coaxial line, a helical line and means to provide a beam of electrons for flow along a path axially of said helical line; a conductor in the form of a plate disposed between said helical line and said beam providing means, said plate conductor having an opening therethrough in alignment with the axis of said beam path, a second conductor disposed in parallel spaced relation for substantially the entire length thereof to the surface of said plate conductor, said second conductor having one part connected to said plate to establish a voltage null point and another part disposed adjacent said opening and at a distance from said null point to establish a high voltage point adjacent said opening for coupling radio frequency energy to said helical line, and means coupling the outer conductor of said coaxial line to said plate conductor and the inner conductor to said second conductor, said second conductor comprising a flat strip with one side disposed in spaced substantially parallel relation to a planar surface of said plate con-

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ductor, the part of said strip adjacent said opening being connected to the conductor of said helical line.

5. In a traveling electron discharge device having a radio frequency coaxial line, a helical line and means to provide a beam of electrons for flow along a path axially of said helical line; a conductor in the form of a plate disposed between said helical line and said beam providing means, said plate conductor having an opening therethrough in alignment with the axis of said beam path, a second conductor disposed in parallel spaced relation for substantially the entire length thereof to the surface of said plate conductor, said second conductor having one part connected to said plate to establish a voltage null point and another part disposed adjacent said opening and at a distance from said null point to establish a high voltage point adjacent said opening for coupling radio frequency energy to said helical line, and means coupling the outer conductor of said coaxial line to said plate conductor and the inner conductor to said second conductor, said second conductor comprising a flat strip with one side disposed in spaced substantially parallel relation to a planar surface of said plate conductor, said strip having both ends thereof connected to said plate conductor, the length thereof being equal substantially to one half a wavelength or an odd multiple thereof of the operating frequency of said device, and an opening therethrough in alignment with the axis of said beam path, a portion of said strip adjacent said last mentioned opening being connected to the conductor of said helical line.

References Cited in the file of this patent

UNITED STATES PATENTS

2,403,290	Korman	July 2, 1946
2,432,057	Wheeler	Dec. 2, 1947
2,516,944	Barnett	Aug. 1, 1950
2,575,383	Field	Nov. 20, 1951
2,578,434	Lindenblad	Dec. 11, 1951
2,584,802	Hansell	Feb. 5, 1952
2,637,775	Lund	May 5, 1953

OTHER REFERENCES

Article by Kompfner, pages 124-127, Proc. I. R. E., for February 1947.