May 5, 1959 N. W. ROBINSON ET AL 2,885,592

TRAVELLING WAVE TUBE

Filed Oct. 4, 1954

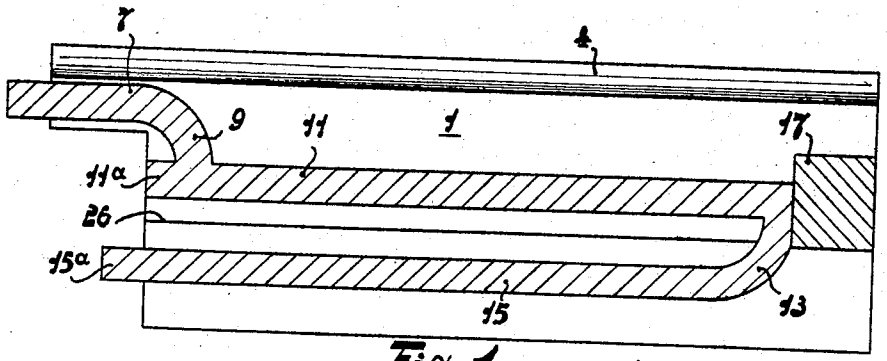


Fig. 1

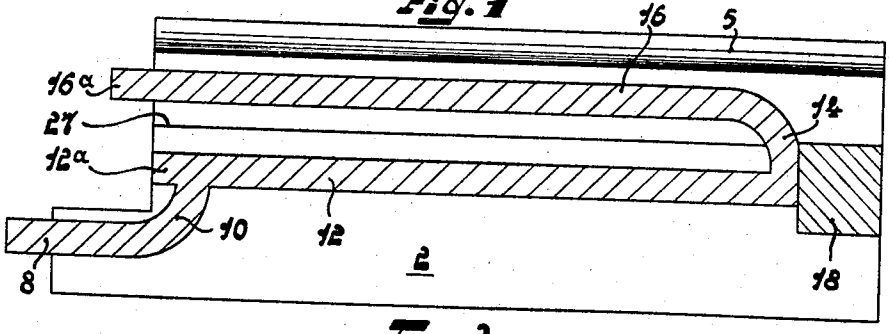


Fig. 2

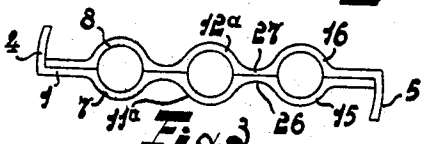


Fig. 3

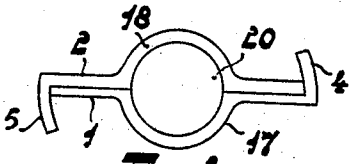


Fig. 4

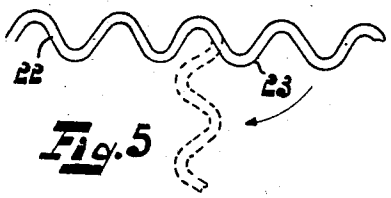


Fig. 5

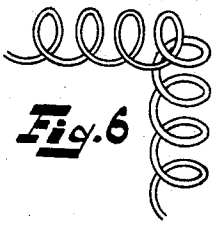


Fig. 6

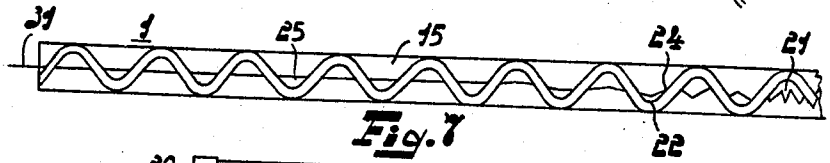


Fig. 7

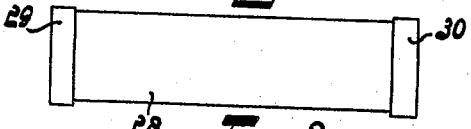


Fig. 8

INVENTOR
Norman Wright Robinson
Harry Guy Flood
BY
AGENT

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TRAVELLING WAVE TUBE

Norman Wright Robinson, Carshalton Beeches, and Harry Guy Flood, West Wickham, England, assignors, by mesne assignments, to North American Philips Company, Inc., New York, N.Y., a corporation of Delaware

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2 Claims. (Cl. 315—3.6)

This invention relates to travelling wave tubes.

According to the invention, a travelling wave tube comprises a conductive helix, means to generate an electron beam and to direct the beam along and within the conductive helix, and a helical conductor (first helical conductor) being a continuation of one end of the conductive helix and bent at an angle to the conductive helix at said end to permit of said means being closely adjacent said end and having a portion providing a gradual transition between the helical conductor and a straight portion. This provides a simple construction in which the drift space between the electron-gun and the conductive helix is negligible while the losses due to the bend are comparatively low and may, for example, be about 2 db.

For convenience of reference, throughout this specification the term "conductive helix" is to be understood to mean a conductor of helical form through which electrons are intended to pass, any continuation at an end of the conductive helix, if in helical form, being referred to by the term "helical conductor."

Said transitional portion may gradually increase in pitch with increasing distance from the conductive helix, measured along the helical conductor, and said angle may lie between 85 and 95 degrees; said angle may conveniently be 90°. After said bend, the axis of the helical conductor may follow a smooth curve to extend parallel to that of the conductive helix. The loss due to the gradual curve is less than that occasioned if a second comparatively sharp bend is used.

Preferably each end of the conductive helix is similarly continued, the other end of the conductive helix being continued by a second helical conductor bent at an angle to the conductive helix to permit passage of the electrons of the beam to a collector electrode. The conductive helix and the helical conductor(s) may be supported by insulating means in a continuous aperture provided within a casing, for example a supporting insulating helix may be provided which is in contact with the conductive helix and the helical conductor(s) substantially at one point in each turn of the conductive helix and the helical conductor(s). The continuous aperture may be provided by channels in two metal plates between which the insulating means is clamped, channels also being provided in the two plates for clamping in position the means for generating and directing the beam.

If the conductive helix has n_1 turns, the supporting helix n_2 turns and the senses of the helices are similar, there will be $(n_1-n_2)/n_1$ contacts per turn of the conductive helix. If the senses are opposite there will be $(n_1+n_2)/n_1$, contacts per turn of the conductive helix. The word "point" used in relation to the support in this specification is not to be interpreted to be a mathematical point. Thus where an insulating helix is used as a

support, the size and nature of the points of support will be determined by the nature of the surfaces at each point, e.g. on whether the insulating and conductive helices are or are not perfectly circular in cross-sections taken through the point of contact.

Each of the straight portions of the conductors may be gradually increased in cross section with increase in distance from the transitional portion until it is the desired size for connection to the inner conductor of a co-axial line, the outer conductor of which is adapted to be secured to the associated channels in the casing to form a continuation thereof. If both ends of the conductor are similarly terminated in this manner, a particularly useful travelling wave tube is provided matched at each end into a co-axial line and the travelling wave tube, which is essentially a wide-band tube, is thus matched directly and without further restriction to wide-band circuits.

If both ends of the conductive helix are similarly continued and after said bend the axes of the helical conductors follow smooth curves such that both straight portions extend away from the associated transitional portions in the same direction. In this way, all the direct-current and low-frequency supplies may be led into the tube at one end and the higher-frequency connections may be made at the other end of the tube.

The collector electrode may be supported from the casing, for example, with the use of an insulator secured to the casing. The casing may be enclosed within a hollow, cylindrical, gas-tight envelope through the end surfaces of which electrical connections are led.

The invention will now be described with reference to one embodiment thereof shown in the accompanying diagrammatic drawing, given by way of example, in which:

Figure 1 is a plan view of one part and Figure 2 is a plan view of the second part of a two-part casing for use in a travelling wave tube according to the invention;

Figures 3 and 4 are views of the ends of the casing when the two parts shown in Figures 1 and 2 are fitted together;

Figure 5 is a detail view illustrating one operation in the manufacture of the tube;

Figure 6 is a detail view including part of the conductive helix;

Figure 7 is a detail view of part of the tube; and

Figure 8 is a view of the completed tube.

Referring now to the drawing, a travelling wave tube comprises two metal plates, **1** (Figure 1) and **2** (Figure 2). The plates **1** and **2** are stamped from metal plate, during which process channels are provided in the stampings **1** and **2** so that when the stamping **2** is fitted over the stamping **1**, by rotation about its upper edge, a continuous aperture of circular section is enclosed within the stampings **1** and **2**. The stamping **1** comprises a curved lug **4** and the stamping **2** comprises a curved lug **5**. Channels **7** and **8** form a first part of the continuous aperture parallel to the lugs **4** and **5**, channels **9** and **10** form a second part, each of channels **9** and **10** following a smooth curve, and constitute a junction between the channels **7** and **8** and channels **11** and **12** which form a third part parallel to the first part, smoothly curving channels **13** and **14** form a fourth part, initially at right angles to the third part, and channels **15** and **16** form a fifth part parallel to the third part.

The ends of the channels **11** and **12** are extended at **11***a* and **12***a* beyond the perpendicular junctions with the channels **9** and **10** and at the other ends beyond the junctions with the channels **13** and **14** lead into larger channels **17** and **18**. Channels **15** and **16** extend beyond

the edges of the front portions of the plates **1** and **2** at *15a* and *16a*.

The continuous aperture contains and supports securely in position insulating means, here an insulating helix, which in turn supports and maintains in position a conductor. In the channels **9, 10; 11, 12** and **13, 14** the conductor has the form of a regular helix and in channels **7, 8** and **15, 16** the helix gradually increases in pitch to become straight. The part of the conductor secured within the channels **11, 12** is the conductive helix and the continuations of the conductor at the ends of the conductive helix are helical conductors. The channels **17** and **18** accommodate and secure in position an electron gun assembly **20** (Figure 4) for producing a beam of electrons and directing them substantially centrally along the third part of the continuous aperture and the extension *11a, 12a* thereof, beyond which extension is provided a cup-shaped collecting electrode (not shown). The manner in which the insulating helix and the conductive helix and the helical conductors may be manufactured is described in our co-pending application Serial No. 328,582, filed December 30, 1952, now U. S. Patent No. 2,757,310. It will be appreciated that the portions of gradually increasing pitch may readily be wound at the same time and from the same conductor as the conductive helix and the helical conductors. The insulating helix and the conductive helix, the helical conductors and the portions of gradually increasing pitch are initially wound on straight mandrels. The insulating helix is then bent to the required shape. Figure 5 shows the manner in which the insulating helix may be bent so that the longitudinal centre line is bent through an angle of 90°. The insulating helix **22** is heated at the bend **23** so that part of the insulating helix bends in the direction of the arrow. The conductive helix and the helical conductors may be inserted into the insulating helix by a gentle relative twisting movement of the conductor and the insulating helix by which operation the conductor slides between the turns of and into position within the insulating helix. Figure 6 shows one junction between the conductive helix and a helical conductor and the preferred manner in which the conductor is bent at the junction to avoid obstruction of the path of the electron beam. The bending of the insulating helix in the manner shown in Figure 5 gives adequate support at the junction. The straight portions of the conductor may be integral with the wire of the conductive helix or the straight portion may be secured to the helical conductors separately and in conductive manner.

Figures 3 and 4 are views from opposite ends of the casing constituted by the parts **1** and **2** with the conductor (not shown), the insulating helix (not shown) and the electron gun **20** in position.

Figure 7 shows the channel **15** with the portion **24** of gradually increasing pitch forming a transition between the helical conductor in the channel **16** and the straight portion **25**. The straight portion **25** is gradually increased in cross-section for example, by electro-deposition, until it is the desired size at its end **31** to form, or to be joined directly to, an inner conductor of say, a 75 ohm co-axial line.

When the conductor and its insulating support have been placed in position and the electron gun **20** accurately aligned to produce an electron beam to travel centrally of and within the conductive helix in channel **11**, the stamping **2** is placed upon the stamping **1** and the two secured together, for example, by soldering or deformation of the edges of the plates. Slits **26** and **27** are provided in the stampings to prevent interaction between the conductors in the channels **11, 12** and **15, 16** and these slits are sealed up with solder or the edges thereof are deformed together.

The free ends (**31** as shown in Figure 7) of the conductor are then soldered to the inner conductors of two co-axial lines and connection made between the outer conductors of the co-axial lines and the extensions *15a* and *16a*.

The stampings **1** and **2** secured together and containing the electron gun **20**, the insulating helix and the conductor are then placed within a hollow cylindrical envelope part **28** (Figure 8) to which are secured end pieces **29** and **30** through which electrical connections are led. The envelope **28, 29, 30** is gas-tight and the lugs **5** and **6** are secured to the part **28** to prevent rotation or other movement within the part **28**.

The envelope **28, 29, 30** is then pumped, sealed, and gettered.

In one practical embodiment of the tube described with reference to the drawing, the insulating helix was made from glass rod of 1 mm. diameter and the conductive helix and helical conductors were wound with 92 turns per inch from copper wire of 0.1 mm. diameter on a mandrel of 1 mm. diameter. The transition from the helical conductor to the straight conductor was effected in 46 turns in a distance of 25 mms. in channels **15** and **16** and also in 46 turns in a distance of 25 mms. in channels **7** and **8**. The outer dimensions of the tube were 1 inch in diameter and 9 inches long and the tube was suitable for operation at a wavelength of about 3 cms. The loss due to each right-angled bend at the junctions of the conductive helix and the helical conductors was about 2 db.

Preferably, the connections to the electron gun, the collector electrode and the getter are brought out at the electron gun end of the tube and the connections to the conductor are brought out at the collector electrode end of the tube. The input is preferably connected to the conductor in channels **15** and **16** since here the signal will be relatively feeble and reflections more serious so that a more gradual transition along the straight portion of the conductor to the maximum cross section is desirable.

The construction described with reference to the drawing is compact due to the recognition that, with a suitable diameter and pitch, the longitudinal axis of a helical conductor may be bent through a right angle with little loss, and presents the desirable feature that a wide-band travelling wave tube is matched at both input and output ends in a wide-band manner to wide-band co-axial lines.

It will be obvious that the regularity of the conductive helix must be maintained in order to avoid out-of-phase interaction with the electron beam but that regularity of the helical conductors is not so important.

What is claimed is:

1. A travelling-wave electron discharge device comprising a metal housing including a pair of abutting metal plates having matching channels defining three substantially parallel interconnected hollow tubes, a conductive helix in one of said tubes and insulated from said metal plates, means to project an electron beam along the axis of the helix, a first helical conductor in another of said tubes and insulated from said metal plates coupled to one end of said helix and having a curvature permitting the free passage of the electron beam therethrough and providing a gradual change in impedance between the conductor and the helix, and a second helical conductor in the third of said tubes and insulated from said metal plates coupled to the other end of said helix and having a smooth curvature permitting the free passage of an electron beam therethrough and providing a gradual change in impedance between that conductor and the helix.

2. An electron tube as set forth in claim 1, wherein an insulating helix supports the conductive helix within the first channel.

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5

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