

April 28, 1959

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2,884,556

TRAVELING WAVE ELECTRON DISCHARGE DEVICE

Filed March 7, 1955

2 Sheets-Sheet 1

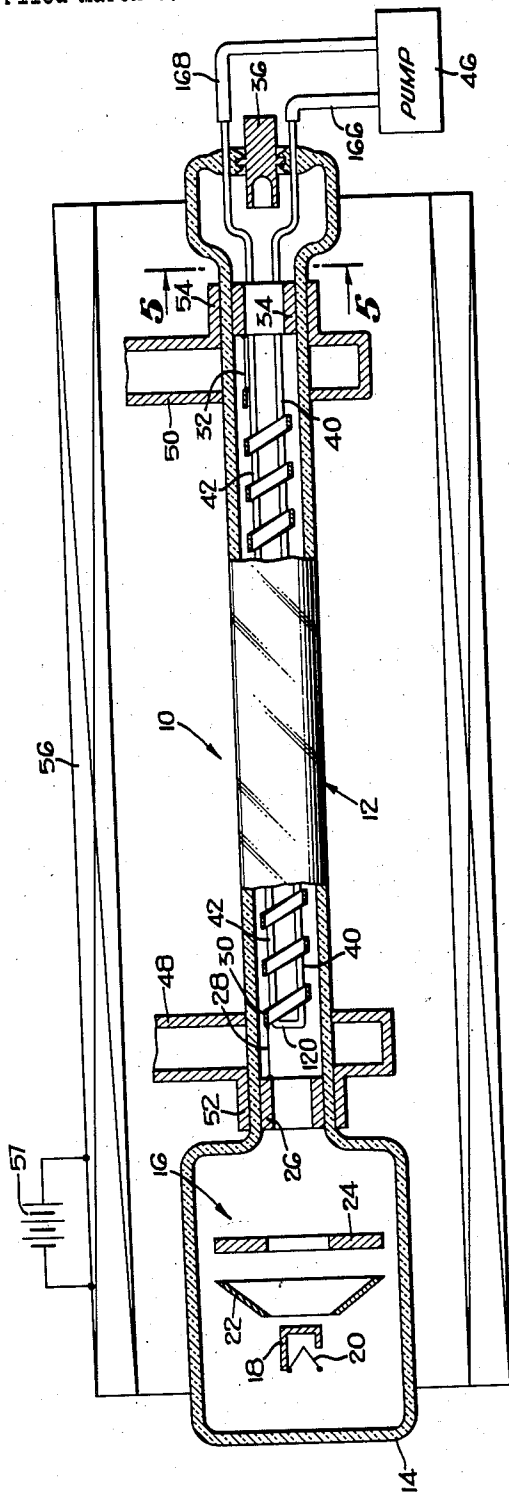


FIG. 1.

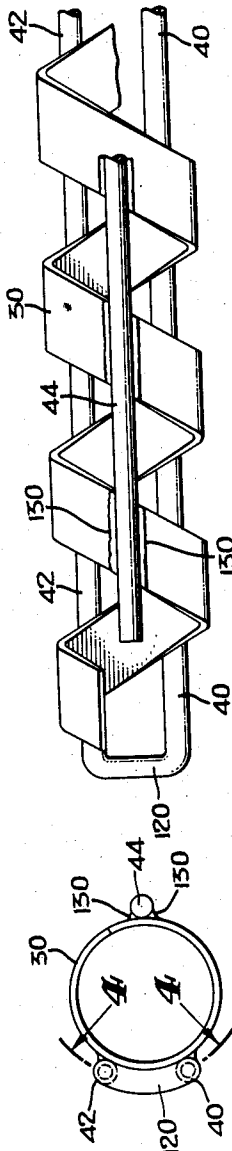


FIG. 2.

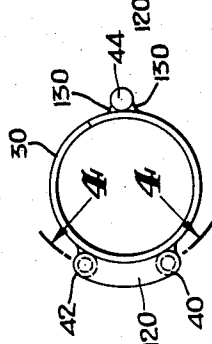


FIG. 3.

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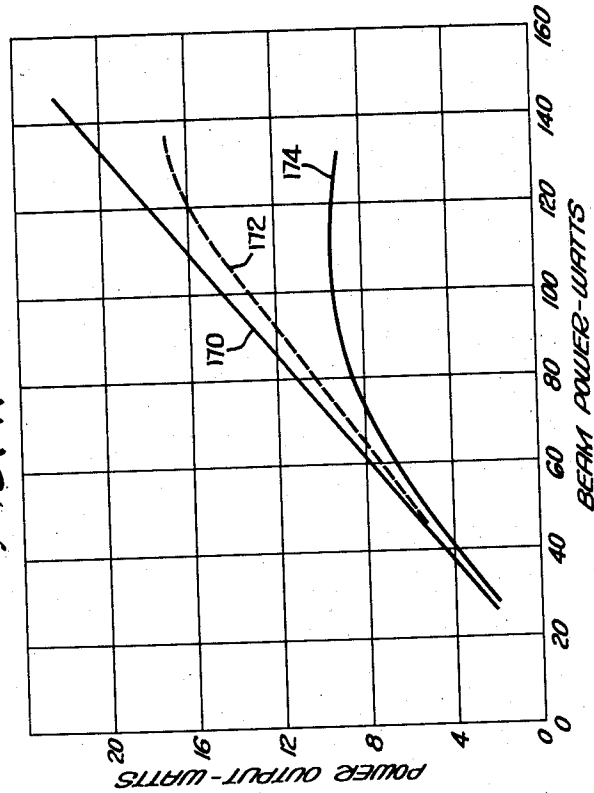
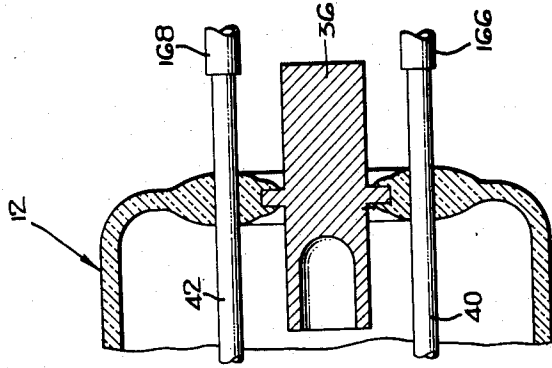
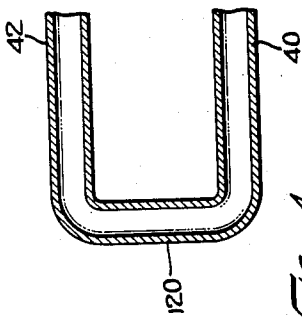
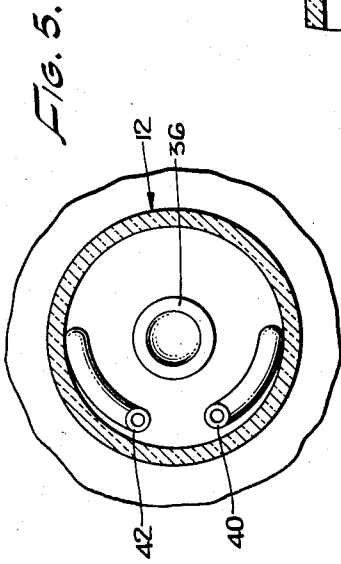
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TRAVELING WAVE ELECTRON DISCHARGE DEVICE

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2 Sheets-Sheet 2



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TRAVELING WAVE ELECTRON DISCHARGE
DEVICE

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1 Claim. (Cl. 315—3.5)

This invention relates to microwave tubes and more particularly to means for both supporting and cooling the slow-wave structure of a traveling-wave tube.

Present day traveling-wave tubes comprise an evacuated envelope, an electron gun disposed at one end of the envelope for producing an electron stream along a predetermined path and a conductive helix which is disposed about the path for propagating electromagnetic waves, whereby the electric fields of the waves may interact with the stream. It is at present the practice to support the helix within the envelope by means of more than two dielectric rods disposed lengthwise of the helix between the helix and the envelope. This practice is followed because it prevents undue dielectric loading of the helix.

Heating in relatively high-powered traveling-wave tubes is caused in part by the helix intercepting part of the current in the electron stream, but radio-frequency or R-F power dissipated in the helix at the output end of the tube is the principal cause of heating. The R-F power dissipated thus causes the temperature of the helix to rise. As the temperature of the helix rises its resistance increases substantially whereby the R-F power output of a given tube for a given beam current is severely limited.

It is therefore an object of the invention to provide a relatively high-powered traveling-wave tube.

It is another object of the invention to provide means for cooling the slow-wave structure of a traveling-wave tube.

In accordance with the invention, more than two dielectric rods are bonded to the conductive helix or slow-wave structure of a traveling-wave tube with an appropriate glass; however, one or more of these rods are constructed to have hollow centers and are employed to convey a cooling fluid to cool the helix. Although it is not obvious that from such small contacts with the helix a substantial amount of power may be dissipated in this manner, it has been found by experiment that radio-frequency power output of a given tube can sometimes be doubled.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawings in which an embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

Fig. 1 is a sectional view of a traveling-wave tube incorporating one embodiment of the present invention;

Fig. 2 is a broken-away side view of the slow-wave structure shown in Fig. 1;

Fig. 3 is an end view of the slow-wave structure of Fig. 2;

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Fig. 4 is a sectional view on the section line 4—4 shown in Fig. 3;

Fig. 5 is a sectional view of the traveling-wave tube shown in Fig. 1 on the section line 5—5 of Fig. 1;

Fig. 6 is an enlarged sectional view of the right end of the traveling-wave tube shown in Fig. 1; and

Fig. 7 is a graph showing the increase in the radio-frequency power output of a traveling-wave tube capable of being produced by practicing the present invention.

Referring to the drawings, there is shown in Fig. 1 a traveling-wave tube 10 having an elongated evacuated envelope 12 with an enlarged portion 14 at its left extremity. Within the enlarged portion 14 an electron gun 16 is shown comprising a thermionic cathode 18 which is provided with a filament 20, a frusto-conical focusing electrode 22 and an accelerating anode 24. Focusing electrode 22 has an internal surface of revolution disposed at an angle of $67\frac{1}{2}$ degrees from its axis of symmetry as is well known in the art.

Adjacent the anode 24 in the direction of electron flow from the gun 16 is disposed about the path of the electron stream path produced by the gun 16, an input matching ferrule 26, an input antenna lead 28, a conductive helix 30, an output antenna lead 32, and an output ferrule 34. A collector electrode 36 is connected to the envelope 12 at the right extremity of the tube 10.

The conductive helix 30 is supported by two dielectric or glass tubes 40, 42 and one dielectric rod 44 as shown particularly in Fig. 2. Dielectric tubes 40 and 42 only are shown in Fig. 1. The dielectric tubes 40 and 42 project through the right hand wall of envelope 12 adjacent the collector 36 and are connected to a pump 46.

The traveling-wave tube 10 is provided with a rectangular input waveguide 48 and a rectangular output waveguide 50. Input waveguide 48 has an appended sleeve 52 which is disposed about the envelope 12 co-extensive with the input ferrule 26. Output waveguide 50 has an appended sleeve 54 which is similarly disposed about the envelope 12 coextensive with output ferrule 34. A magnetic solenoid 56 is disposed concentrically about the tube 10 to constrain or confine the electron stream produced by the gun 16 and is employed by a potential source 57.

The left end of the conductive helix 30 is shown in Fig. 2 and is provided with dielectric tubes 40 and 42, which are hollow, and the dielectric rod 44, which is solid. The hollow dielectric tubes 40 and 42 are provided with a transverse connecting portion 120. An end view of the dielectric tubes 40 and 42 and the end portion 120 with the solid dielectric rod 44 and conductive helix 30 are shown in Fig. 3 with certain glass webbed portions 130 bonding the rods to the helix. The glass tubes 40 and 42 with their connecting end portion 120 may consist of continuous alumino-silicate glass tubing, which, as is well known in the art, has a low loss coefficient and dielectric constant and in addition has a thermal expansion coefficient practically the same as that of molybdenum of which the helix 30 is generally made. Discontinuities in the diameter and pitch of helix 30 cause the gain and efficiency of a traveling-wave tube to be inordinately poor because of reduced electron stream interaction which occurs when the electromagnetic wave propagated along a helix does not travel at a velocity to produce maximum amplification. The helix 30 must thus be made of a metal having a high modulus of elasticity such as tungsten or molybdenum in order that it retain its shape.

The glass webbed portions 130 may be made of any glass having a good matching thermal expansion coefficient, for example, a boro-silicate glass.

A sectional view along the section line 4—4 in Fig. 3 is shown in Fig. 4 illustrating the end connection 120. Both the tubes 40 and 42 and the solid dielectric rod 44 may alternatively be made of a refractory material such as alumina and be connected at their adjacent left ends by non-magnetic metallic tubing. The left end of the dielectric tubes 40 and 42 would be coated with or metallized with a mixture of molybdenum and manganese and plated with copper.

Fig. 5 shows the collector 36, the right hand wall of envelope 12, and the hollow dielectric rods 40 and 42. Fig. 6 is an enlarged sectional view of the right end wall of the envelope 12 showing the hollow dielectric rods 40 and 42 and the collector 36. The rods 40 and 42 are connected to hoses 166 and 168, respectively, which are in turn connected to the pump 46. The pump 46 in Fig. 1 may thus be employed to circulate a cooling fluid such as distilled water or carbon tetrachloride through the dielectric rods 40 and 42 to cool the helix 30. Heat would then be conducted from the helix 30 through the glass webbed portions 130 to the dielectric tubes 40 and 42 and the tubes would be cooled by the circulation of the cooling fluid.

Fig. 7 is a graph of the R-F power output in watts measured at the output end of a traveling-wave tube for different values of beam power in watts under different conditions. Three curves 170, 172, and 174 are shown in Fig. 7. The curve 170 may be obtained by measuring R-F power output immediately when a tube is turned on, that is, when the potential of the helix is raised to the potential where R-F amplification may be produced and the beam is projected through the helix 30. Radio-frequency energy may be introduced at the same power level into the input waveguide 48 when measurements for all three curves 170, 172, and 174 are made. Curve 170 is thus an indication of the maximum power output of which a given tube such as the tube 10 is capable.

As the tube heats and more specifically as the radio-frequency energy at the output end of the tube heats the conductive helix 30, then the radio-frequency power output of the tube 10 decreases. This is indicated by the curve 174 which may be derived from measurements of radio-frequency power output after a tube is operated for more than, say, five minutes. It is seen that for increased beam currents heating of the helix 30 substantially reduced the amplification capabilities of the tube.

The curve 172 indicates the improvement in radio-frequency power output and efficiency which may be made by practicing the present invention. By reducing

the temperature of the helix 30 its resistance is thereby reduced. By reducing its resistance the R-F power dissipated, that is, the radio-frequency power dissipated at the output end of the tube may be decreased. A good representation of the improvement both in the radio-frequency power output and the efficiency of a tube may be observed in the difference in the ordinate amplitudes of curves 174 and 172. The extraordinary increase in the R-F power is then attributable to the use of the helix cooling structures of the present invention.

What is claimed is:

A traveling-wave tube comprising: an evacuated envelope having a first and a second end; an electron gun disposed at the first end of said envelope for producing an electron stream along a predetermined path; a conductive molybdenum helix disposed about said path for propagating electromagnetic waves; three glass rods having a thermal coefficient of expansion substantially like that of said molybdenum helix and being disposed lengthwise of said helix and around the outer periphery thereof, said rods being mounted in the second end of said envelope and two of said rods being hollow throughout their entire length; a plurality of glass webbed portions having a thermal coefficient of expansion substantially like that of said rods and each coupling and supporting a different point on said helix with a different adjacent point of said rods; conduit means coupling the ends of the hollow ones of said rods at the first end of said envelope; and means for circulating a cooling liquid within said rods through said conduit, whereby heat generated in said helix is transmitted through said glass webbed portions and said rods and into the circulated cooling liquid.

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