

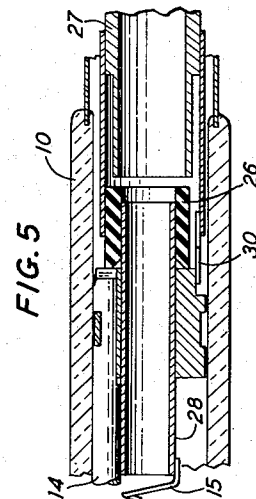
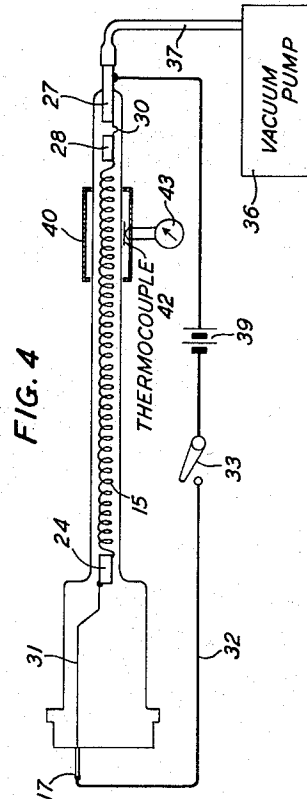
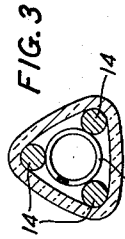
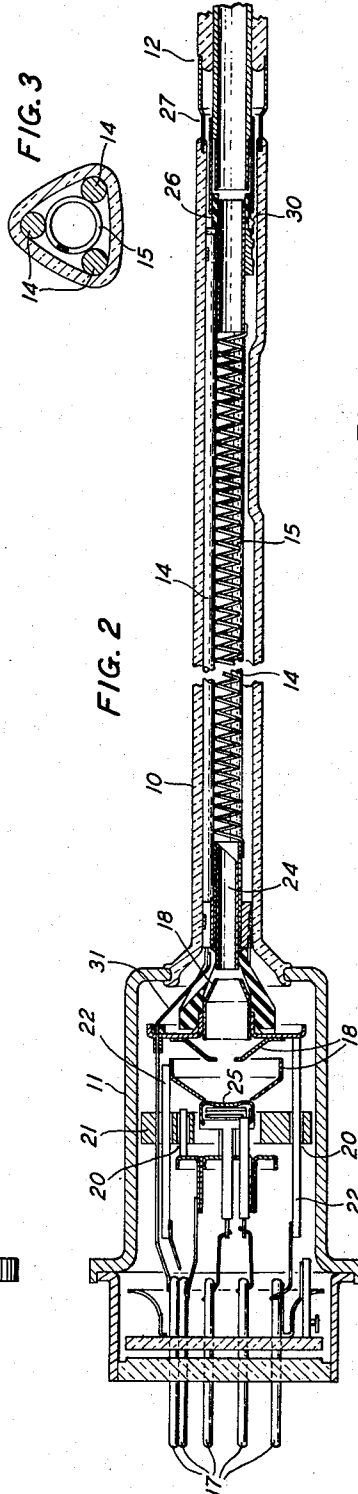
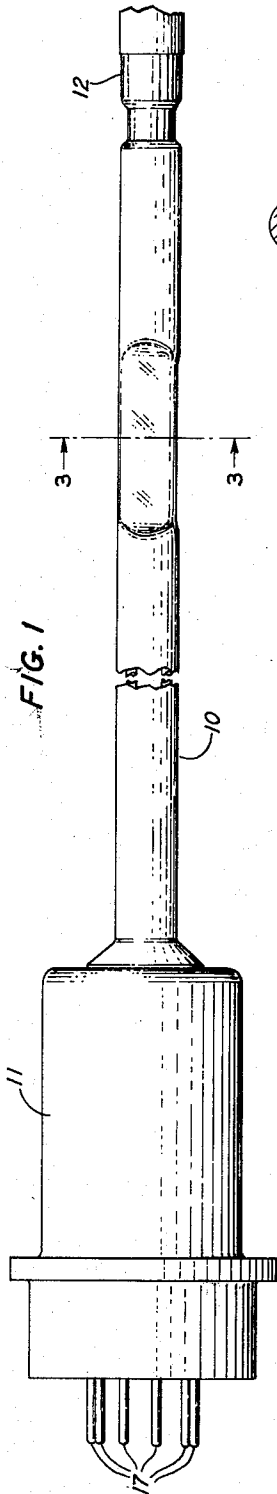
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MANUFACTURE OF TRAVELING WAVE TUBES

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MANUFACTURE OF TRAVELING WAVE TUBES 5

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Application October 21, 1953, Serial No. 387,362 10

2 Claims. (Cl. 316—18)

This invention relates to traveling wave tubes and more particularly to the manufacture of such tubes.

It has been found that traveling wave tubes having very small helices for operation at frequencies of the order of thousands of megacycles, such as in the range of 4,000 to 11,000 megacycles or higher, exhibit a fading of output power after the tube had been operated for a few minutes. This power fade, as more fully discussed in my application Serial No. 387,361 filed October 21, 1953, is caused by increase in the resistive loss on the helix above that intrinsic to the helix and the attenuation deposited thereon. This increase results from heating of helix due mainly to radio frequency power traveling along the helix transmission line in excess of the transmission capacity of the helix. This excess power on the transmission line occurs adjacent the output end as the radio frequency voltage and power on the helix increase exponentially along the helix.

As disclosed in the above-mentioned application, a proper balance can be found at high frequencies between output power, gain and efficiency, all of which are related to the helix size, by having the portion of the glass envelope adjacent the output or electron collector end of the tube in intimate contact with the helix support rods over a significant portion of their area.

It is desirable, however, that the glass envelope be collapsed onto the helix support rods only adjacent the output end and that it not be in contact at any point with the wires of the helix itself extending between support rods, as discussed in the above-mentioned application.

It is a general object of this invention to facilitate the manufacture of traveling wave tubes.

Further it is an object of this invention to provide an improved method for collapsing a limited and predetermined portion of an elongated glass envelope onto the helix support rods of a traveling wave tube.

It is another object of this invention to prevent undue thermal strain in the glass envelope of a traveling wave tube between the collapsed and uncollapsed portions.

It is a still further object of this invention to provide an improved method for outgassing helices of traveling wave tubes. More specifically, it is an object of this invention to provide a method of outgassing helices that is easily controllable, efficient, and reduces the number of tubes damaged during outgassing of the helices.

These and other objects of this invention are attained in a specific illustrative embodiment in which a helix mounted on helix support rods is slid into an elongated glass envelope portion to make a close fit therewith. A continuous current path is provided through the helix when positioned in the traveling wave tube by a lead electrically connecting the input end of the helix to one of the thermal pins in the base of the tube and a fuse wire electrically connecting the output end of the helix to the electron collector of the traveling wave tube. To collapse predetermined portions of the glass envelope onto the helix support rods in accordance with an aspect of this invention, a current is passed through the helix along

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this direct current path while the tube is being evacuated. This current will heat the glass but will not sufficiently soften the glass to allow the atmospheric pressure to collapse the glass onto the support rods. A reflecting cylinder is positioned around the glass to give the additional temperature rise needed to soften the glass sufficiently to allow the pressure differential to deform it and collapse it onto the support rods. The heat reflecting cylinder may be long enough to deform the entire length desired or may be moved along the helix to attain any desired length of collapse of the glass envelope.

Either following the collapse of the glass envelope or prior thereto but without the heat reflecting cylinder encompassing the envelope, a current is passed through the helix to outgas the helix. By providing the heat for outgassing the helix by passing a current through the helix, rather than by the prior techniques of inductive heating the helix, more efficient and safer outgassing of the helix may be attained as better control of the heating of the helix is possible.

When the helix has been outgassed, the envelope is evacuated, a short high current passed through the helix to burn out the fuse that provided the continuous current connection from the helix to the electron collector and the envelope is sealed.

It is a feature of this invention that, in the manufacture of traveling wave tubes, a wire helix is connected to the collector assembly by a fuse wire and that a first current be passed through the helix sufficient to heat the helix but insufficient to burn out the fuse wire and that subsequently a second current be passed through the helix sufficient to burn out the fuse wire.

It is a further feature of this invention that a current be passed through the helix during the manufacture of a traveling wave tube to heat the helix and the glass envelope encompassing the helix, that the envelope be evacuated, and that a heat reflecting cylinder be positioned around the glass envelope adjacent the portion to be collapsed onto the helix support rods to provide the additional heat necessary to soften the glass sufficiently to allow collapse under the differential pressure existing on the glass envelope.

It is another feature of this invention that the helix of a traveling wave tube be outgassed by passing a current through the helix and a path including a fuse wire within the traveling wave tube and that the fuse wire be burned out following the outgassing the helix.

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

Fig. 1 is an external view of a traveling wave tube having a portion of the elongated glass envelope collapsed onto the helix support rods;

Fig. 2 is a sectional view of the tube of Fig. 1 showing the tube in the process of manufacture after the glass envelope portion has been collapsed but before the helix fuse wire has been ruptured;

Fig. 3 is a sectional view of the helix and collapsed envelope portion taken along the line 3—3 of Fig. 1;

Fig. 4 is a schematic representation of the circuit and equipment employed in the collapsing of the glass envelope in accordance with an aspect of this invention; and

Fig. 5 is an enlarged sectional view of the output end of the helix support rods and the electron collector showing particularly the fuse wire connecting the helix and the electron collector during the manufacture of the traveling wave tube in accordance with the processes of this invention.

Turning now to the drawing, Fig. 1 is an external side view of a traveling wave tube having a portion of the elongated glass tubing 10 between the electron gun assem-

bly 11 and the collector assembly 12 collapsed onto the helix support rods 14, as seen best in Fig. 3. The electron gun assembly 11 may be of any known type; however, for reasons set forth below, a current path is provided from the helix 15 through the gun assembly to one of the terminal pins 17 in the base of the assembly. The particular gun depicted in Fig. 2 comprises a plurality of electrodes 18 which are mounted by support pins 22 which extend through apertures 20 in the insulating ring 21. These electrodes are positioned coaxially by a mandrel, not shown, which assures proper alignment of the parts. When so mounted a glaze is positioned in the apertures 20 in the insulating ring 21 and around the support pins 22 to which the electrodes 18 are connected and the pins 22 are then glazed to the insulating ring 21. This mandrel is then withdrawn. To assemble the helix to the gun another mandrel extends through both and the helix connected to the gun by welding telescoping tabs on the gun assembly to portions of an aligning sleeve 24 on the helix assembly. The electron collector assembly is connected to the helix assembly before the latter is connected to the gun assembly. However, as best seen in Fig. 5 an insulating ring 26 is interposed between the electron collector cylinder 27 and an inner support ring 28 bonded to the inner surfaces of the support rods. The cathode 25 of the gun is then positioned in the gun and helix assembly, appropriate connections made to the bore pins, the bore sealed to one end of the tube envelope and the collector assembly to the other end of the tube envelope.

In accordance with one aspect of this invention a fuse wire 30 is initially connected between the collector cylinder 27 and the ring 28 to which the helix is electrically connected. There is thus, as shown diagrammatically in Fig. 4, a direct current path at this time through the tube comprising one of the terminal pins 17, a lead 31 connecting this pin to the aligning tube 24, the helix 15, ring 28, fuse wire 30, and collector cylinder 27. To collapse a portion of the glass envelope 10 onto the helix support rods to enable power operation of a traveling wave tube at high frequencies, as described in the above-mentioned application, a current is passed through this path which is shown in Fig. 4 as being closed by a conductor 32, a switch 33, and a battery or voltage source 34. At the same time the envelope of the tube is exhausted, as by a vacuum pump 36 connected by rubber tubing 37 to the collector cylinder 27. The heat generated by the current in the helix 15 is sufficient to soften the glass of the envelope 10 but not to the point where the glass will collapse under the pressure differential existing between the atmosphere and the evacuated envelope. In accordance with an aspect of this invention a heat reflecting cylinder 40 having a bright inner surface is placed around the envelope at a point where it is desired to collapse the glass. The heat reflected back upon the glass by the cylinder 40 is then sufficient to give the additional temperature rise needed to soften the glass to allow the atmospheric pressure to collapse the glass onto the helix support rods 14.

The total distance of this collapse is very slight, being of the order of less than a mil as the helix support rods are preferably slid into the envelope 10 with a close fit. It is, therefore, important that the amount of heat and the collapse of the glass be carefully controlled to prevent too great a collapse which would result in the glass being in contact with the helix itself. As more fully discussed in the above-mentioned application, if the glass is contiguous to the helix, it provides a low dielectric path for the electromagnetic energy on the helix. Energy is then shunted through this path instead of passing through the center of the helix where interaction of the electromagnetic wave energy and the electric beam is attained. When the glass is in contact with the helix, the degree of coupling and the efficiency of the tube are, therefore, reduced.

I have found it desirable to control the collapse of the glass envelope by positioning a thermocouple 42 within

the reflector 40 and preferably in contact with the envelope 10. The leads of the thermocouple may be brought out through apertures in the reflector 40 and connected to a suitable meter or indicating device 43.

By heating the entire glass envelope 10 due to the current through the helix 15 while at the same time applying the additional heat needed to collapse the glass only at limited areas the temperature differential between the collapsed and the uncollapsed portions of the glass is minimized with a resultant reduction in thermal stress in the glass. Advantageously the ends of the reflecting cylinder 40 are partially closed further to confine the heat to the desired area of collapse.

The reflecting cylinder 40 may be of sufficient length to collapse the entire portion of the glass envelope desired to be collapsed or may be smaller and be moved along the envelope to collapse successive parts of the envelope.

After the glass is collapsed along the desired length of the envelope 10, the reflecting cylinder 40 is removed and, in accordance with another aspect of this invention, a current is passed through the direct current path identified above and best seen in Fig. 4. This current serves to outgas the helix. Priorly helices have been heated by inductive coupling to a high frequency generator. This technique however has not only been awkward and inefficient, but has been exceedingly difficult to control resulting in a large number of rejected tubes. By passing a direct current through the helix itself, outgassing of the helix can be attained with very accurate control on the heating of the helix and damage to the helix or the tube during this outgassing can, therefore, be prevented.

After the helix has been outgassed and evacuated, the fuse wire 30 is burnt out by application of a short high current to the helix, and the current path through the tube is removed. The lead 31 and terminal pin 17 to which it is connected may be utilized during the operation of the tube for applying a direct current voltage to the helix, as is known in the art, or may be unconnected in the operating circuit. The tube envelope is then sealed, as by closing off the open end of the collector cylinder 27.

While in the above description the outgassing occurs after the collapsing of the portion of the glass envelope, I have found that the order in which these two steps of the process occur is not important and that the helix may advantageously be outgassed first. In this case the outgassing current is applied to the helix while the envelope is being evacuated but before the reflecting cylinder has been placed around the envelope. After a sufficient time for outgassing the reflecting cylinder is positioned around the envelope without interrupting the current or removing the tube from the pump, and the glass collapsed. Following this the current is removed, the tube sealed, and the fuse wire ruptured, as described above.

In one specific illustrative embodiment wherein the helix was first outgassed and wherein the helix 15 was of 0.010 inch molybdenum wire, an outgassing current of 2.89 amperes is applied to the helix for about 30 minutes, raising the temperature of the helix to about 760° C. throughout the entire length of the helix. The heat reflector was then positioned around the helix and the same current employed for collapsing the glass onto the helix. The heat reflector raises the temperature of the glass envelope to about 625° C., and the collapse occurs in about ¼ minute. The current was then turned off, the helix cooled to room temperature and a current of approximately 4 amperes applied to the helix to rupture or burn out the fuse wire 30, which was a 0.006 inch platinum wire, though other fuse wires known in the art may be employed. The tube is then sealed.

It is to be understood that the above-described arrangements are merely illustrative of the application of the principles of this invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

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What is claimed is:

1. In the manufacture of traveling wave tubes, the process for obtaining a controlled collapse of an elongated glass envelope portion onto helix support rods comprising the steps of slidably inserting helix support rods to which a helix has been attached into an elongated glass envelope, evacuating said envelope, passing a current through said helix sufficient to heat said helix and said envelope but insufficient of itself to soften the glass enough to cause atmospheric pressure to collapse the glass onto the helix support rods, reflecting the heat from said helix back upon said envelope adjacent the portions thereof to be collapsed to provide the additional temperature rise sufficient to soften the glass for collapse thereof, and discontinuing the collapse of said glass after said glass has collapsed onto said helix support rods and before said glass is contiguous to said helix.

2. In the manufacture of traveling wave tubes, the process for obtaining a controlled collapse of an elongated glass envelope portion onto helix support rods comprising the steps of slidably inserting helix support rods to which a helix has been attached into an elongated glass envelope, evacuating said envelope, passing a current

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through said helix and a wire in series therewith and electrically connecting said helix to the electron collector of the traveling wave tube, said current being sufficient to heat said helix and said envelope but insufficient of itself to soften the glass enough to allow atmospheric pressure to collapse said glass onto the helix support rods, reflecting the heat from said helix back upon said envelope adjacent the portions thereof to be collapsed to provide the additional temperature rise sufficient to soften the glass for collapse thereof, discontinuing the collapse of said glass after said glass has collapsed onto said helix support rods and before said glass has collapsed onto said helix, and subsequently passing a current through said helix sufficient to rupture said wire.

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