

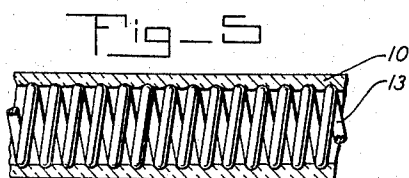
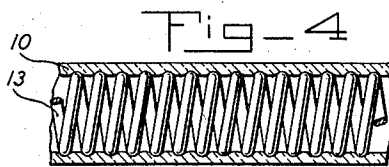
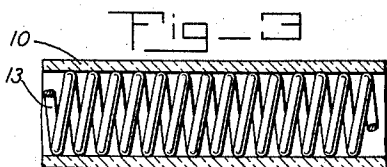
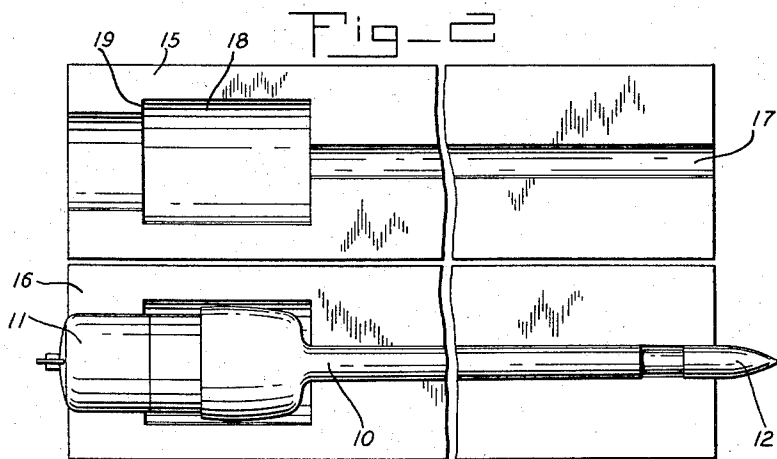
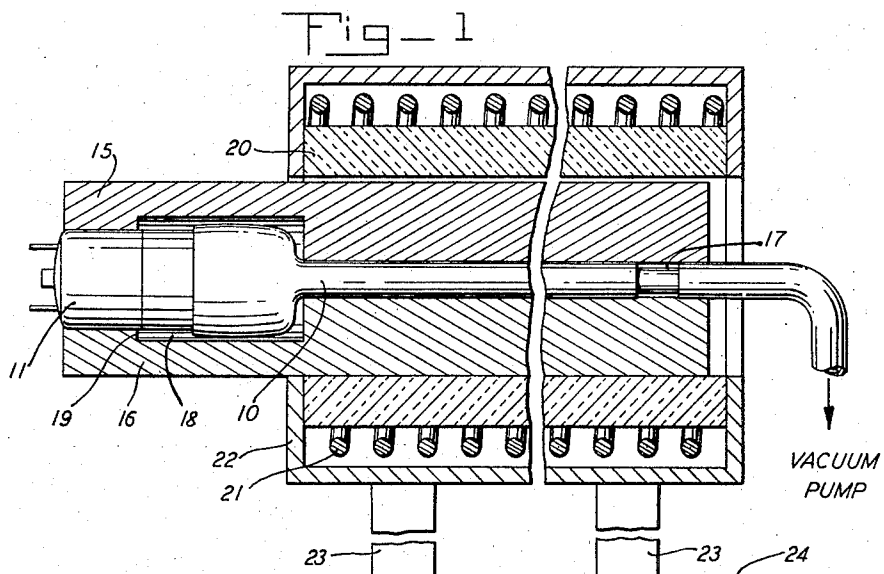
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TRAVELING WAVE TUBE AND METHOD OF CONSTRUCTING THE SAME

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TRAVELING WAVE TUBE AND METHOD OF CONSTRUCTING THE SAME

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6 Claims. (Cl. 315—3)

The present invention relates to traveling wave tubes and the method of their construction.

In its broadest sense, a traveling wave tube is a device which provides for the continuous interaction between an electron beam and an electromagnetic wave so that the latter is amplified. In order that such interaction be obtained, the electromagnetic wave must, in some manner, be retarded, or slowed so that its phase velocity will be approximately the same as the speed of the electrons in the beam. Several retarding or slow-wave structures have been employed; the most common however being a metal helix whose diameter and pitch are set to produce the desired axial phase velocity of an electromagnetic wave propagated therealong. A commonly employed arrangement has the helix in supporting contact with the interior wall of an elongated tubular glass body at one end of which an electron gun is disposed so as to direct an electron beam along the axis of the helix, and at the other end of which a metallic collector for the electrons is disposed. Since the structure of the helix is an elongated one, care must be observed in the fabrication thereof to assure that the desired pitch and diameter will be maintained throughout its entire length so as to accordingly provide the proper phase relationship between the electromagnetic wave and the electron beam. It may be mentioned, at this point, that theoretically, it would be desirable to reduce the phase velocity of the electromagnetic wave as it moves nearer the collector or output end of the traveling wave tube for, as energy is transferred from the electron beam to the electromagnetic wave, a correlated decrease in the electron velocity necessarily follows. This consideration has been, for the most part, merely a theoretical one to the present time, because, from a practical standpoint, it has been exceedingly difficult merely to avoid sudden shifts in the phase of the traveling electromagnetic wave and a consequent reduction in the gain or amplification obtainable. This electronic difficulty has stemmed predominantly from physical problems encountered in the mounting of the helix within the glass body. Even when the most accurate techniques of forming the helix itself and of sizing the inside of the tubular glass body are employed, slight dimensional aberrations still remain, so that the helix, upon insertion, does not evenly contact the tubular glass body, but instead, makes only intermittent, random contact therewith. Since the dielectric constant and permeability of glass are different than those of free space, or in other words, a vacuum, slight variations in the phase velocity of the electromagnetic wave propagated on the described structure result to cause the aforementioned reduction of the amount of amplification theoretically obtainable.

It is an object of the present invention to provide a traveling wave tube constructed so that continuous interaction between an electron beam and an electromagnetic wave will be optimized.

A feature of the invention relates to an improved method of assembling a traveling wave tube which embodies a helical slow wave structure so that precise con-

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trol of the phase velocity of the propagated wave can be obtained.

A further feature also relates to the method of assembling a traveling wave tube of the mentioned type which enables the utilization of higher "bake out" temperatures than heretofore used during the evacuation of the tube, so that ultimately a cleaner, more highly evacuated tube is obtained.

Another feature relates to the method of construction of a traveling wave tube which facilitates the attainment of precise alignment between the electron gun, the helical slow wave structure, and the collector.

Yet a further feature relates to a traveling wave tube structure that not only enables the attainment of maximum gain but which is particularly rugged so as to be able to withstand a high degree of shock or vibration.

Other objects and features of the invention, as well as the advantages stemming therefrom, will be made more apparent from a perusal of the following description of the accompanying drawing wherein:

Fig. 1 is a central sectional view of an apparatus with which the method of construction of a traveling wave tube in accordance with the present invention can be carried out.

Fig. 2 is an elevational view of a completed traveling wave tube associated with separable portions of the apparatus shown in Fig. 1,

Fig. 3 is a fragmentary sectional view of a portion of the traveling wave tube at an intermediate stage of its fabrication,

Fig. 4 is a view similar to Fig. 3, but at a larger stage of the tube fabrication, and

Fig. 5 is a view similar to Fig. 4 illustrating a modified result obtained by a specific deviation in one step of the fabricating method or process.

A traveling wave tube embodying the present invention includes an elongated, tubular glass body 10 which mounts on electron gun 11 at one end and a collector 12 at the other, each, of course, being sealed in vacuum tight relation to the body. As shown best in Fig. 3, the glass body 10 is enlarged somewhat to mount the electron gun 11 but it is to be expressly understood that neither such enlargement nor the details of the electron gun 11 or the collector 12 form part of the present invention, and will accordingly not be described in detail. Any electron gun or collector that can be sealed to a glass body can be employed.

In accordance with the present invention a metal helix 13 is disposed within the glass body 10 intermediate the electron gun 11 and collector 12 and, as shown in Fig. 4, is embedded in the glass. More specifically, the wire that forms the helix 13 is embedded a predetermined amount into the glass, this amount remaining constant through its entire length, as is illustrated in Fig. 4 referred to. The embedding of the helix 13 in the glass body 10 is obtained by shrinking the glass on the helix as will be described in detail hereinafter. When the glass is carefully shrunk onto an accurately formed helix, an electromagnetic wave can be propagated over the entire helix with no noticeable change in its phase velocity. Furthermore, shock or vibration will not cause a change in this constant phase velocity. It will be observed that the partial embedding of the helix 13 in the glass body 10 will increase the attenuation, but since a certain amount of attenuation is required in a traveling wave tube to preclude oscillation, this increase in attenuation merely reduces the amount of "aquadag" or other lossy material that need be applied to the exterior of the glass body.

If a decrease in the phase velocity of a propagated electromagnetic wave is desired, the shrinking process referred

to may be slightly modified so that a gradual, predetermined variation in the degree of shrinking and the resultant embedding of the helix 13 in the glass body 10 can be obtained. This modification is shown in Fig. 5, the variation in the amount of embedding being exaggerated for purposes of illustration.

The method of constructing or fabricating a traveling wave tube with a constant phase velocity helix 13, as illustrated in Fig. 4, will first be described. Essentially the method includes first the formation of a substantially straight piece of glass tubing whose inner diameter is substantially constant. It has been found that these requirements are well met by tubing as normally supplied by any good glass manufacturer, but in the absence of such well-formed tubing, the required length and diameter tubing can be formed by shrinking on a mandril in a glass lathe.

A helix of constant pitch and diameter is then inserted into the glass tubing, as shown in Fig. 3, and the tubing is then sealed with the helix inside and is subsequently evacuated by suitable connection to a vacuum pump. During the evacuation, heat is applied evenly to the glass tubing to raise its temperature high enough so that the glass becomes viscid. After the tubing has been at a certain temperature for a certain length of time, it will be pulled inwardly by the internal vacuum to shrink onto the helix, as shown in Fig. 4. Glass, as is known well to all glass blowers, is viscid over a relatively wide temperature range and the precise temperature and time here desired will depend upon the particular glass employed, its geometry and other factors. Generally, a high temperature approaching close to the melting point of the glass is to be avoided as the shrinking proceeds too fast to enable accurate control of the amount. It has been found that a glass with a melting point of approximately 750° C., and an annealing point of 475° C. can be heated to 650° C. to enable the shrinking to proceed at a reasonable and readily controllable rate.

During the shrinking process, the helix acts somewhat in the fashion of a mandril so that small variations in the internal diameter of the glass tubing at the beginning of the process are eliminated in its latter stages. More specifically, if it is assumed that the internal diameter of the glass tubing is slightly larger at one point than at others before the shrinking begins, it will be apparent that the shrinking, which proceeds evenly, will cause the smaller diameter portions of the tubing to first engage the exterior of the helix leaving the larger diameter portions spaced slightly outwardly from the respective part of the helix. Subsequently, however, this portion of the glass which is not in contact with the helix can shrink inwardly more readily than that which is in contact with the helix and therefore is impeded in further inward shrinking movement. Thus, upon completion of the shrinking process, even contact of the glass with the helix is provided throughout its whole length.

Since the glass is raised to a viscid state during the shrinking process, the glass tubing is externally encompassed and supported during the shrinking process to prevent bending or other deformation thereof. In fact, if the tubing is slightly bowed or bent prior to the shrinking operation such support by an axially straight member will straighten the tubing to thus assure proper axial traverse of the helix by an injected electron beam.

If, during the shrinking process, the heat is applied so that a temperature gradient exists lengthwise of the tubing, greater shrinking will occur at the hotter end thereof, and the gradual amount of variation in the shrinking as illustrated in Fig. 5 will result.

Preferably the method, as above described, is carried out simultaneously with the evacuation of an assembled tube so that two distinct evacuating operations are rendered unnecessary. After a helix 13 has been inserted into the glass body 10 of the tube so as to rest therein substantially as illustrated in Fig. 3, an electron gun 11 is sealed to the enlarged end of the glass body. There-

after, the other end of the tube is brought into sealing engagement with a metal tabulation whose interior is in communication with a vacuum pump as indicated in Fig. 1. As shown in this figure, a matching pair of semi-cylindrical blocks 15, 16 of carbon are placed around the tube. These blocks 15, 16 when brought into facing contact, form a small bore 17 that is adapted to closely encompass the glass body 10 which surrounds the helix 13. The described bore 17 is enlarged adjacent one end as indicated at 18 so as to encompass the electron gun 11, and a small inturned shoulder 19 is formed at the end of the blocks 15, 16 so as to closely engage the exterior of the gun and to maintain the same precisely aligned with the remainder of the tube body 10. A furnace that includes a cylindrical piece of refractory material 20 adapted to encompass the carbon blocks 15, 16 and arranged to be heated by passing current through a surrounding coil 21 of wire is moved into position over the carbon blocks. The furnace also includes an exterior metal casing 22 having supporting legs 23 depending therefrom so as to enable support upon a flat surface as indicated at 24. The furnace thus supports the carbon blocks 15, 16 and the blocks in turn support the tube body 10 through the described close engagement therewith.

After the vacuum pump has been started and the evacuation of the traveling wave tube has proceeded a considerable amount, the furnace coils 21 are energized by the application of current thereto and the temperature of the glass body 10 of the traveling wave tube is raised to the desired temperature of 650° C. This temperature is maintained until the required amount of shrinking of the glass on the helix is attained; this normally requiring about fifteen minutes. Thereafter, the temperature may be reduced to approximately 450° C. while the evacuation is completed and the tubulation subsequently pinched off as indicated in Fig. 2, such pinched off tubulation then serving as the collector 12 of the traveling wave tube.

Since the tube is "baked out" at an elevated temperature during evacuation, the finished product is a cleaner, more highly evacuated structure. This cleanliness can be further enhanced by activation of the cathode in the electron gun 11 during the later stages of the evacuation process and also by the firing of a suitable "getter," as is conventionally utilized during evacuation of the described type of tubes. However, it should be emphasized that the need for such a "getter" is much less prominent when a tube is "baked out" at the described temperature.

It will be apparent that a mere shifting of the furnace axially of the blocks 15, 16 to the right as viewed in Fig. 1 so that a portion of the helix lies without the furnace will cause a temperature gradient to exist lengthwise of the blocks to thus achieve the graduated type of shrinking illustrated in Fig. 5.

It will also be apparent that apparatus other than that shown can be used in carrying out the described method utilized in the construction of the improved traveling wave tube of the present invention. Furthermore, various alterations and modifications in the method itself may be made without departing from the spirit of the present invention. Accordingly, the foregoing description is to be considered merely as exemplary and not in a limiting sense, and the scope of the invention is indicated by the appended claims.

I claim:

1. A traveling wave tube comprising a generally tubular glass body, an electron gun at one end of said body and adapted to direct a beam of electrons axially therethrough, a collector at the opposite end of said body adapted to collect the electrons from said gun, a metal helix within said body intermediate its ends adapted to propagate electromagnetic waves at a rate such that interaction with the electron beam is obtained, said tubular glass body being shrunk on said helix an amount graduated lengthwise thereof.

2. The method of constructing a traveling wave tube

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having a helix within a tubular glass body which comprises inserting the helix into the tubular glass body so that the helix is closely confined and supported solely by the glass body, sealing the glass body at one end, evacuating the sealed glass body through the other end thereof, heating the sealed glass body during such evacuation so that the glass shrinks upon the helix, and then sealing the other end of the glass body after a predetermined amount of evacuation has occurred.

3. The method of constructing a traveling wave tube having a helix within a tubular glass body which comprises inserting the helix into the tubular glass body so that the helix is closely confined and supported solely by the glass body, sealing the glass body at one end, supporting the sealed glass body in a manner such that its exterior is closely engaged, evacuating the sealed glass body through the other end thereof while it is closely supported, heating the glass body during the evacuation to a temperature such that the glass becomes viscid and shrinks onto the helix, and then sealing the other end of the glass body after a predetermined amount of evacuation has occurred.

4. The method of constructing a traveling wave tube having a helix within a tubular glass body which comprises inserting the helix into the tubular glass body, sealing the glass body, supporting the sealed glass body in carbon blocks arranged to closely engage the glass body, evacuating the sealed glass body, and heating the carbon blocks during such evacuation so that the glass body supported thereby is raised evenly to a temperature such that the glass becomes viscid and shrinks onto the helix.

5. The method of constructing a traveling wave tube having a helix within a tubular glass body which com-

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prises inserting the helix into the glass body so that the helix is closely confined and supported solely by the glass body, sealing the glass body, evacuating the sealed glass body, and heating the sealed glass body during such evacuation in a manner such that a predetermined temperature gradient exists lengthwise of the glass body so that a graduated amount of shrinking thereof onto the helix results.

6. The method of constructing a traveling wave tube having an electron gun, a metal helix, a collector and a tubular glass body which comprises inserting the metal helix into the tubular glass body, mounting the electron gun at one end of the glass body in sealing relation therewith, mounting the collector at the other end of the glass body in sealing relation therewith, evacuating the sealed glass body through an opening in the collector, heating the glass body during such evacuation to a temperature such that the glass becomes viscid and shrinks onto the helix, and closing the opening in the collector after a predetermined amount of evacuation has occurred.

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