United States Patent

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[54] **PERIODIC PERMANENT MAGNET FOCUSED TRAVELLING WAVE TUBE**

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[52] **U.S. Cl.** **315/3.5,** 315/5.35, 335/210, 335/217

[51] **Int. Cl.**.....**H01j 25/34**

[58] **Field of Search** 315/3.5, 5.34, 5.35; 335/210, 335/211, 217

[56] **References Cited**

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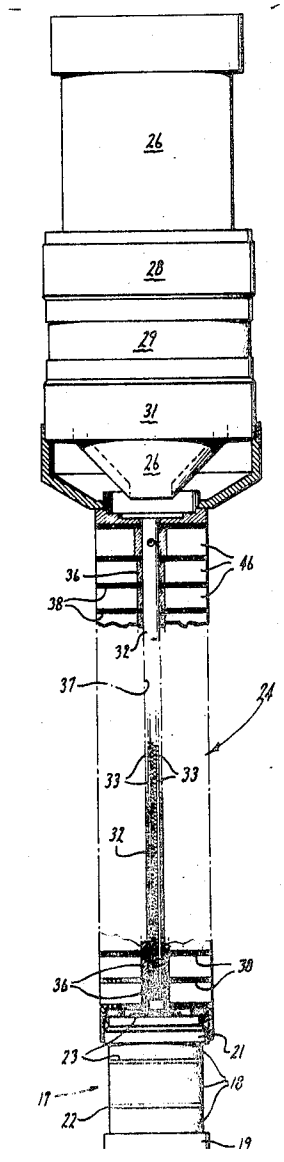
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[57] **ABSTRACT**

A travelling wave tube including an envelope, an electron source for projecting an electron beam along a predetermined path in said envelope, a collector spaced from said source for intercepting and collecting electrons in the beam, a helical conductor disposed within said envelope along the path of said beam for supporting and projecting an electromagnetic wave in coupled relationship to the beam for interaction therewith, a periodic permanent magnet focusing assembly having a succession of alternate high thermal conductivity conducting bars and magnetic plates having aligned apertures to define an envelope portion which accommodates the helix support assembly and helix and a plurality of magnet bars disposed between plates to form a succession of longitudinal magnetic fields in coupled relationship with the beam to focus the same as it travels along the envelope portion.

13 Claims, 7 Drawing Figures



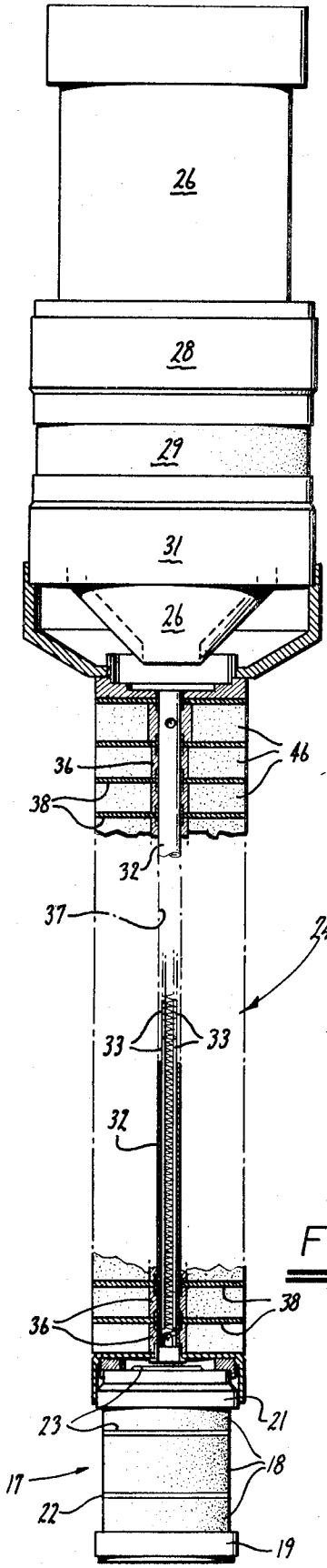


Fig. 2

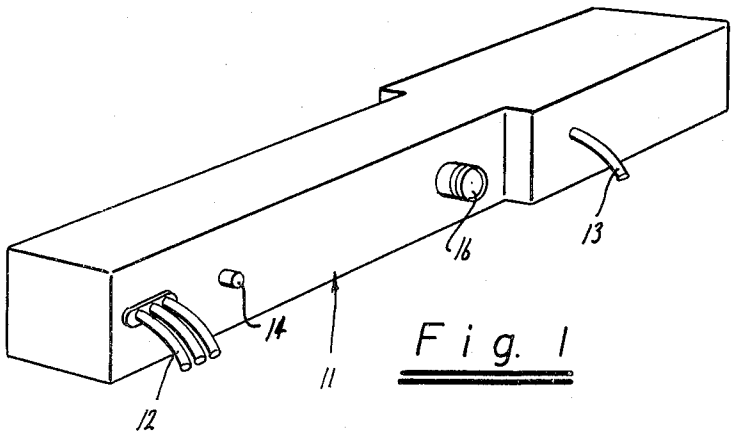


Fig. 1

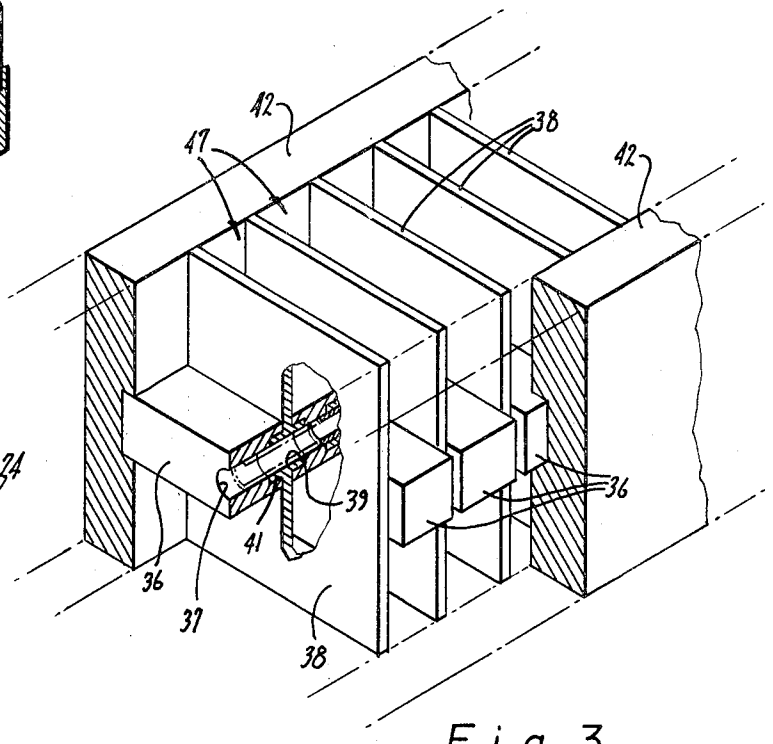


Fig. 3

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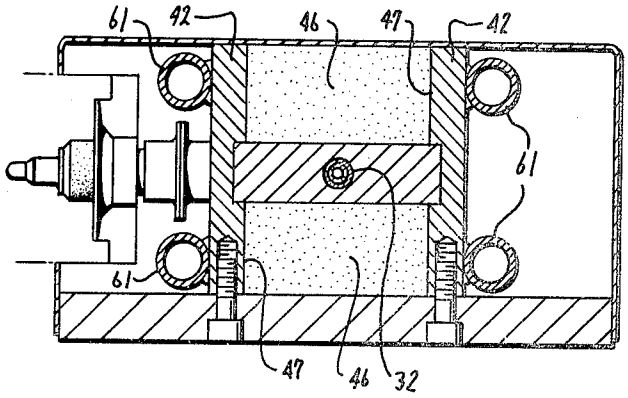


Fig. 4

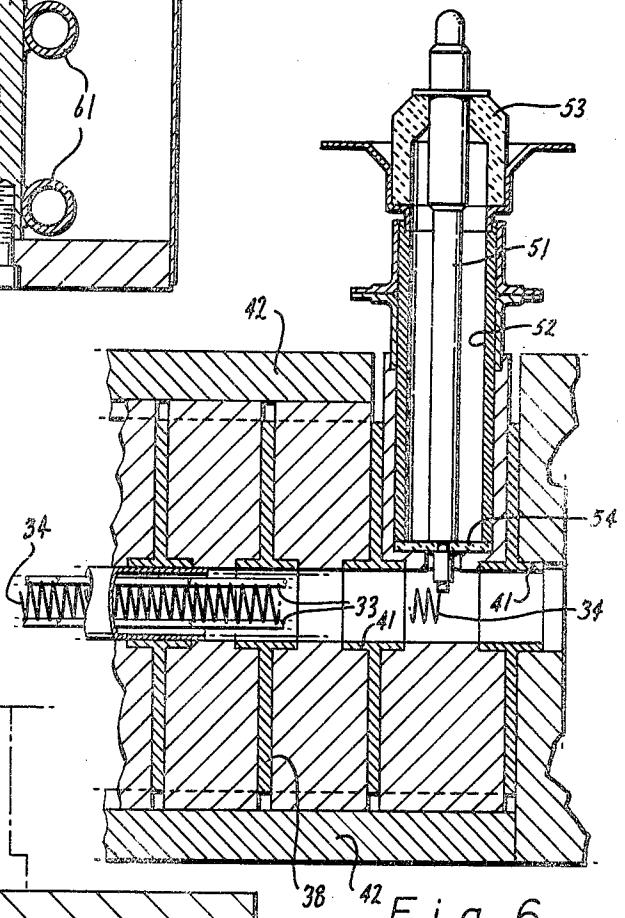


Fig. 6

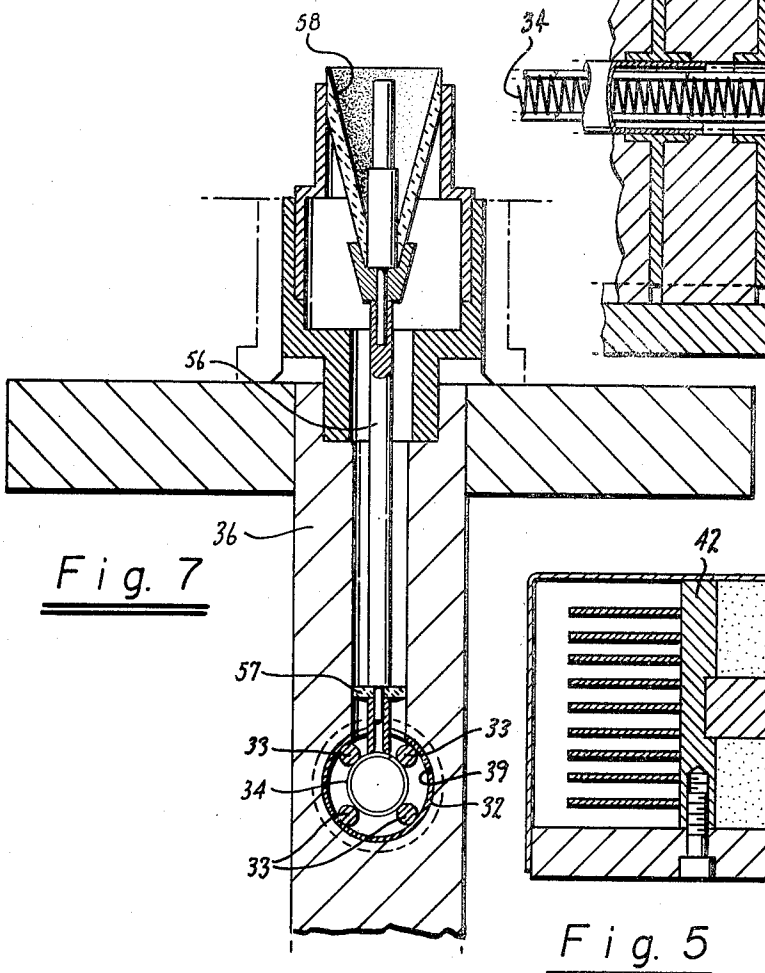


Fig. 7

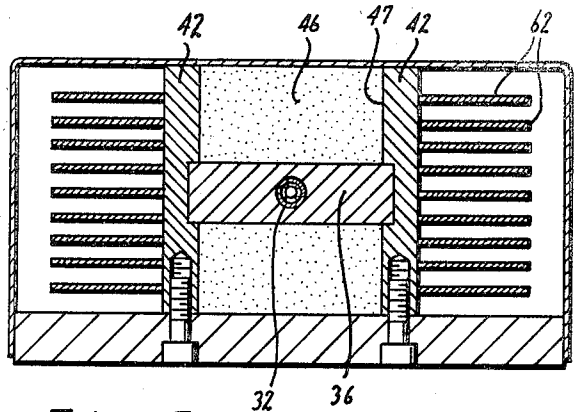


Fig. 5

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PERIODIC PERMANENT MAGNET FOCUSED TRAVELLING WAVE TUBE

BACKGROUND OF THE INVENTION

This invention relates generally to high power, periodic permanent magnet focused travelling wave tubes and more particularly to such tubes having an improved helix support and heat dissipation means.

To obtain high continuous wave (CW) power under present technology, it has been necessary to use all metal interaction circuits such as coupled cavity or metal stub supported contrawound helix structures. These structures generally result in tubes capable of operating over relatively narrow frequency bandwidths.

In many applications such as in electronic counter measures and communication systems, electron tubes capable of delivering high continuous wave power are required. Travelling wave tubes generally operate over wide frequency bandwidths. However, such tubes have in the past been limited in their power capabilities because of their inability to dissipate heat, due to RF losses in the helix windings and support, through the magnetic focusing structure. This is generally due to the low thermal conductivity of the helix and its supports, the temperature drops at the interfaces, between helix, supports and envelope, and the necessity of conducting the heat through the permanent magnet material which generally has a relatively low thermal conductivity. The failure to dissipate heat from the structure in a periodic permanent magnet focused travelling wave tube results in heating of the magnets and defocusing and additional interception of electrons which, in turn, increases heating. In the prior art, no effective means for dissipating or removing heat from the helix structures or for minimizing defocusing have been developed.

OBJECTS AND SUMMARY OF THE INVENTION

It is a general object of the present invention to provide a high power, continuous wave periodic permanent magnet focused travelling wave tube.

It is another object of the present invention to provide a periodic permanent magnet focused travelling wave tube including high thermal conductivity paths for dissipating heat from the helix structure.

It is a further object of the present invention to provide a periodic permanent magnet focused travelling wave tube including a helix support which minimizes temperature defocusing.

These and other objects are achieved by a periodic permanent magnet focused travelling wave tube in which the envelope portion surrounding the helix comprises a succession of alternate buss bars having high thermal conductivity, each of said bars including a transverse aperture and a plurality of magnetic plates each also including a transverse aperture, said bars and plates joined to one another with their apertures in alignment to form an envelope portion for receiving the helix and a plurality of permanent magnet bars disposed between adjacent plates along the envelope portion to form a succession of longitudinal magnetic fields between the apertures in said plates with the sense of the fields of adjacent magnets being reversed to reverse the fields along the electron path. In addition, means are provided for supporting the helix within said tube portion by means of longitudinally disposed insulating support rods spaced about the outer periphery of the helix and extending parallel to the longitudinal axis of the helix and a sleeve member surrounding said rods and in intimate contact with the rods and envelope portion.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view of a travelling wave tube in accordance with the present invention disposed in a housing with input, output and power terminals extending from the housing.

FIG. 2 is an elevational view of the periodic permanent magnet focused travelling wave tube incorporated in the housing of FIG. 1.

FIG. 3 is a perspective partial view showing the heat conducting bars, magnetic plates and end plate associated therewith.

FIG. 4 is a sectional view of a tube including housing showing a water-cooled periodic permanent magnet focused travelling wave tube.

FIG. 5 is a sectional view showing an air-cooled periodic permanent magnet focused travelling wave tube.

FIG. 6 is an enlarged view showing a coaxial RF input connector.

FIG. 7 is a sectional view showing a coaxial RF output connector.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 a travelling wave tube assembly **11** is shown including input leads **12** energizing the electron gun. The leads comprise heater, cathode and anode, and focusing electrode leads. The collector lead is shown at **13**. In accordance with well known principles, suitable voltages are applied to these leads to provide accelerating voltages for the gun and a collector voltage for collecting the electron beam projected by the gun. An RF input connector **14** provides input signals at one end of the travelling wave tube an an RF output connector **16** provides means for removing the amplified signal.

In FIG. 2 an elevational view partly in section of an electron tube in accordance with the present invention is shown. The tube includes an electron gun **17** comprising a plurality of ceramic rings **18** serving to support the heater **19**, anode **23** and focusing electrode **22**. In accordance with well known practice, the ceramic rings may be alumina. The electron gun projects a beam along the elongated envelope portion **24**, which beam is then collected by he collector **26**. The collector **26** is supported by the ring **28** secured to one end of the ceramic insulating sleeve **29**. The other end of the sleeve **29** is supported on the metal ring **31** secured to the tube body.

Referring to FIGS. **2** and **6**, the helix is supported within the envelope protion **24** by a sleeve **32** which is longitudinally disposed within the inside surface of the envelope **24**. A plurality of insulating support rods **33** are spaced about the outer periphery of the helix **34** and have their axes parallel to the longitudinal axis of the helix. The rods may be beryllium oxide support rods which have good dielectric characteristics and provide a heat conducting path between the helix **34** and the envelope and the sleeve **32**. The sleeve, helix

and rods may be pre-assembled and inserted into the envelope under pressure thereby providing a press fit between the parts resulting in low temperature drops at the interface between the helix and rod, between the rods and sleeve, and between the sleeve and the associated envelope portions. Thus, heat appearing at the helix due to RF dissipation and beam interception is conducted outwardly through the helix support structure to the associated envelope. The sleeve serves the additional function of restraining expansion of the envelope portion due to temperature changes whereby to make the tube relatively temperature insensitive.

In accordance with the present invention, the focusing structure defines the envelope portion which receives the sleeve and comprises a succession of alternate high thermal conducting bars **36** including an aperture **37** and a plurality of magnetic plates **38** also including an aperture **39**, FIGS. **2**, **3** and **7**. Preferably, the plates include hubs **41** which extend along the envelope portion into the adjacent apertures **37**. The ends of the hubs define magnetic poles as will be presently described. The bars **36** and plates **38** are placed adjacent to one another with the apertures in alignment and joined to one another to form a vacuum-tight elongated envelope which receives the helix support assembly including the helix support rods and sleeve. Thermal conductive end plates **42** are secured to the ends of the buss bars and plates. The high conducting buss bars and end plates may, for example, be formed of copper which has a relatively high thermal conductivity while the magnetic plates may be formed of iron having a high magnetic permeability.

The tube is periodically permanent magnet focused and is focused by inserting a plurality of magnet bars **46** in the pocket **47** formed by adjacent magnetic plates **38** and bars **36** as shown in FIGS. **4** and **5**. The magnets are arranged so that the north and south magnetic poles appear on the faces adjacent to associated magnetic plates. Furthermore, the magnets are arranged whereby alternate magnets have their fields reversed. The high permeability magnetic plates then provide a reluctance path for the magnetic fields and define magnetic poles of opposite polarity at the ends of the hubs. These fields cooperate with the electron beam to focus the same. The fields being alternate, there is provided a periodic permanent magnet focusing assembly. It is to be seen, however, that in contrast to conventional focusing assemblies in which the heat must be dissipated through the magnetic structure by conduction, the conductive bars of the present invention are in cooperative relationship with the helix through the sleeve and helix support and the heat is conducted along the high conductivity buss bars **36** to the associated end plates.

Connection is made to the ends of the helix by coaxial RF connectors. Referring to FIG. **6**, the output connector comprises a center conductor **51** supported coaxially within the conducting sleeve **52** by means of the spaced ceramic members **53** and **54** with the complete assembly suitably sealed to form a vacuum-tight connection for association with cooperating coaxial cables. In FIG. **7** an input connector is shown also including a central conductor **56** with ceramic members **57** and **58** serving to support the rod within one of the buss bars **36**. The conical window **58** is suitably sealed to the structure and a vacuum-tight input assembly is formed.

As previously described, the heat is conducted outwardly along the buss bars to the end plates. There can be associated with the end plates a plurality of conduits or tubes **61** which are adapted to receive a coolant for removing heat from the structure, FIG. **4**. On the other hand, the tube may be air-cooled. A plurality of fins **62**, FIG. **5**, are directly connected to the end plates and a means provided for circulating air past the fins to dissipate the heat from the structure.

It is thus seen that there has been provided an improved periodic permanent magnet focused travelling wave tube which employs a plurality of magnet bars in association with magnetic plates which serve to concentrate the field within the envelope portion in cooperation with the electron beam and buss bars which serve to conduct the heat outwardly from the helix to the associated heat dissipating structures. Furthermore, the tube includes a helix support assembly which restricts expansion of the tube with changes in temperature.

I claim:

1. In a travelling wave tube of the type having an envelope, an electron source for projecting an electron beam along a predetermined path in said envelope, a collector spaced from said source for intercepting and collecting the electron beam, and a helical conductor disposed within said envelope along the path of said beam for supporting and propagating an electromagnetic wave in coupled relationship to said beam for interaction therewith, the improvement including an envelope portion surrounding said helix comprising a succession of alternate high thermal conducting elongated bars having a high thermal conductivity, each of said bars including a transverse aperture, and a plurality of magnetic plates each including a transverse aperture, said bars and plates joined to one another with the apertures in alignment to form said envelope portion and a plurality of permanent magnet bars disposed between adjacent plates on each side of said longitudinal conducting bars along said envelope portion to form a succession of longitudinal magnetic fields between the apertures in said magnetic plates with the sense of the fields of adjacent magnets and plates being reversed to reverse the fields along the electron beam path, said conductive bars serving to conduct heat away from said helix along said bars and said plates serving to concentrate the field along the path of said electron beam.

2. A travelling wave tube as in claim **1** in which the aperture in said magnetic plates includes a hub extending into the apertures of the conducting bars and along the envelope.

3. A travelling wave tube as in claim **1** including heat dissipating means cooperating with the ends of said conductive bars.

4. A travelling wave tube as in claim **1** including a conductive end plate secured to each end of said conductive bars and plates to form a pocket for receiving said magnets.

5. A travelling wave tube as in claim **4** including heat dissipating means cooperating with said end plates.

6. A travelling wave tube as in claim **5** wherein said heat dissipating means cooperating with said end plates

includes a plurality of air-cooled fins extending outwardly from said end plates.

7. A travelling wave tube as in claim 5 wherein said heat dissipating means cooperating with said end plates includes a plurality of tubes in intimate contact with said plates for circulating cooling fluid for removing heat from said structure.

8. A travelling wave tube as in claim 4 including a base support secured to said end plates.

9. A travelling wave tube as in claim 8 including a cover extending over said tube and heat dissipating structure and secured to said base.

10. In a travelling wave tube of the type having an envelope, an electron source for projecting an electron beam along a predetermined path in said envelope, a collector spaced from said source for intercepting and collecting the electron beam, and a helical conductor disposed within said envelope along the path of said beam for supporting and propagating an electromagnetic wave in coupled relationship to said beam for interaction therewith, the improvement including an envelope portion surrounding said helix comprising a succession of alternate high thermal conducting bars having a high thermal conductivity, each of said bars including a transverse aperture and a plurality of magnetic plates each including a transverse aperture, said bars and plates joined to one another with the apertures in alignment to form said envelope portion and a plurality of permanent magnet bars disposed between adjacent plates on each side of said bars along said envelope portion to form a succession of longitudinal magnetic fields between the apertures in said magnetic plates with the sense of the fields of adjacent magnets and plates being reversed to reverse the fields along the electron beam path, said conductive bars serving to conduct heat away from said helix and said plates serving to concentrate the field along the path of said electron beam, and a plurality of insulating support rods spaced about the outer periphery of said helix and extending parallel to the longitudinal axis thereof, and a sleeve member surrounding said rods and in intimate contact with the envelope portion whereby to constrain linear expansion of the envelope portion and reduce distortion of the helix because of expansion of the envelope.

11. A travelling wave tube as in claim 10 including heat dissipating means cooperating with the ends of said conductive bars.

12. A travelling wave tube as in claim 10 including a conductive end plate secured to each end of said conductive bars and plates to form a pocket for receiving said magnets.

13. A travelling wave tube as in claim 12 including heat dissipating means cooperating with said end plates.

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