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[54] **HELIX TRAVELING-WAVE TUBE**

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

[58] **Field of Search**.....315/3.5, 39.3, 3.6; 333/34, 35, 32, 33

[56] **References Cited**

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[57] **ABSTRACT**

A helix travelling-wave tube comprises coupling devices for matching the impedance discontinuity between the helix and the input or output elements. The coupling device is provided with a conductor tape or rod near one end of the helix across at least one pitch of the helix.

6 Claims, 4 Drawing Figures

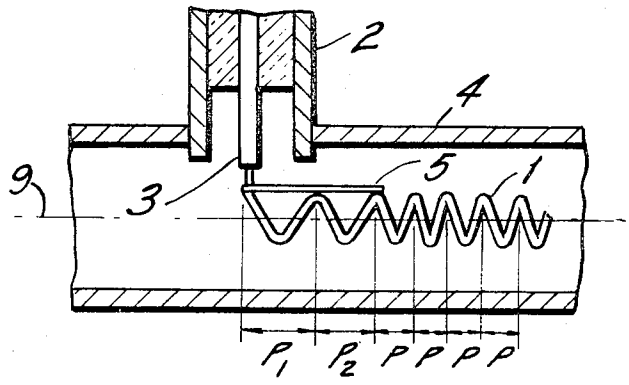


FIG. 1.

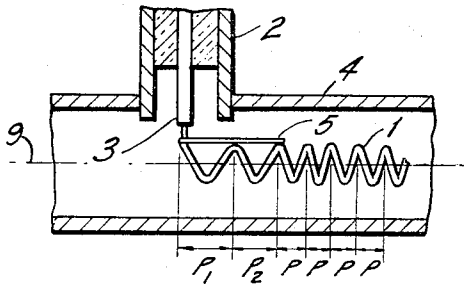


FIG. 2.

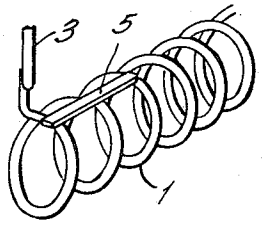


FIG. 3.

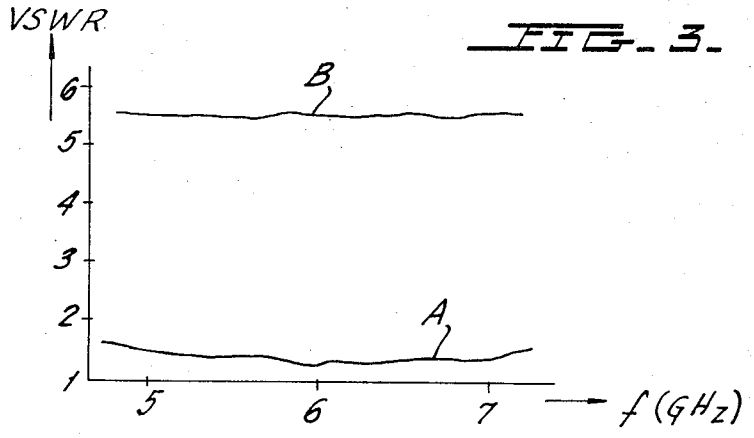
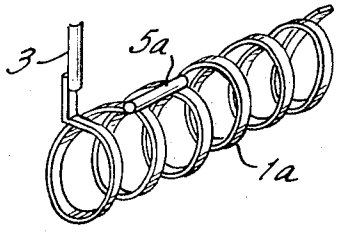


FIG. 4.



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HELIX TRAVELING-WAVE TUBE

This invention relates to travelling-wave tubes using the helix as the slow wave circuit to interact with the electron beam, and particularly, the coupling structures at input and output terminals.

BACKGROUND OF THE INVENTION

In order to operate the travelling-wave tube over a desired wide frequency band, it is necessary that the impedance of the input and output terminals are matched with that of external circuits. However, the impedance of the helix is generally higher than that of the external circuits. As a result, impedance matching means are required at the end portions of the helix to be connected to the external circuits.

It is conventional to achieve the impedance match between two transmission lines having different impedances by an intermediate transmission line whose characteristic impedance is equal to the square root of the product of the characteristic impedances of the two transmission lines and whose length is equal to one quarter of the guided wavelength at the center frequency. Based upon the principles of the intermediate transmission line, various attempts have been made relating to the coupling structure of a travelling-wave tube. Usually, the coupling structure comprises, around each of the input and the output ends of the helix, a ring-shaped electrode of the length of one-quarter wavelength at the center frequency and of an inner diameter closely fitting the helix.

However, such structures have some common deficiencies. First, since spare space should be prepared to mount and support the electrodes, it becomes difficult to make such a travelling-wave tube small. Secondly, as the operation frequency becomes higher, it turns more difficult to mount the electrode around the helix, because the gap between the inner surface of the ring electrode and the outer periphery of the helix should be extremely small. Furthermore, its characteristic tends to vary appreciably due to even the slightest mechanical shock.

BRIEF DESCRIPTION AND OBJECTS OF THE INVENTION

It is an object of the present invention to provide a travelling-wave tube having a coupling structure which is easy to assemble and which does not increase the size of the travelling-wave tube.

According to this invention, there is provided a travelling-wave tube including a helical slow wave structure and means coupled to said structure adjacent one end thereof for transmitting a high-frequency electric signal between said structure and the external circuit, wherein the improvement comprises a conductor attached to the outer periphery of said structure substantially parallel to the axis of said structure adjacent said one end, said conductor bridging at least one pitch (i.e., one revolution) of said helical structure.

BRIEF DESCRIPTION OF THE FIGURES

This invention will be described with reference to the accompanying drawings in which:

FIG. 1 shows an axial sectional view of one embodiment of this invention;

FIG. 2 is an enlarged perspective view illustrating the coupling portion at which the helix is connected to the center conductor of a coaxial cable;

FIG. 3 is a graph illustrating the matching characteristic of the embodiment of FIG. 2; and

FIG. 4 shows a perspective view of the coupling structure employed in another embodiment of this invention.

DETAILED DESCRIPTION OF THE FIGURES

Referring to FIGS. 1 and 2, there is shown a travelling-wave tube of 6 GHz band wherein one end of the helix 1 is directly connected with the center conductor 3 of coaxial cable 2 for connecting the tube to an external circuit (not shown for purposes of simplicity). The helix 1 is supported in a vacuum envelope 4 of non-magnetic metal on the center axis of the vacuum envelope 4 by conventional supporting means (not shown) of an insulating material, i.e., ceramic or quartz.

The helix 1 may be made of a molybdenum wire having a diameter of 0.2 mm and provided with a mean diameter of 2 mm and a pitch P of 0.56 mm, the pitch P being increased at the end portion. For example, the pitches P_1 and P_2 shown in FIG. 1 may be 1.3 mm and 0.9 mm, respectively.

An elongated platinum tape 5 having a rectangular cross section of 0.5 mm × 0.1 mm is attached to the helix 1 by welding and is aligned so as to be substantially parallel with the center axis 9. In the embodiment of FIG. 1, the tape 5 is mounted across the enlarged two pitches at the outer periphery of the helix 1.

Referring to FIG. 3, there is shown the matching characteristic of frequency f(GHz) versus voltage standing wave ratio (V. S. W. R.) in which curve A is for the embodiment thus described, and curve B is for the case in which this invention is not applied thereto. As is apparent from the curves A and B, this invention remarkably improves the matching characteristic over wide frequency band.

Referring to FIG. 4, there is shown another embodiment in which conductor rod 5*a* is mounted at the end portion of the tape helix 1*a*. The conductor rod 5*a* has about one pitch length, bridging the second turn and the third turn of the helix 1*a* at the end portion. Furthermore, the helix may be provided with an extended pitch portion to which the conductor rod 5*a* is mounted.

Preferably, the length of the helix bridged by the conductor, such as platinum tape 5 should be about one-quarter wavelength long along the helix at the center frequency. It is possible to achieve the best results by experimentally determining the length and the cross-sectional diameters of the conductor and the circumferential and the axial positions of the conductor relative to the helix. Furthermore, the helix as shown in FIGS. 1 and 2 may be preferably provided with the pitch tapered portions to obtain better matching characteristics.

As described above, it is unnecessary according to this invention to insert any electrodes, such as, matching rings and the like, at the end portions of the helix, and since desired coupling structures at the end portions are obtained by mounting merely a small piece of conductor at the end portions, it is very easy to as-

semble a travelling-wave tube, and also to make it small. It has been confirmed that the travelling-wave tubes for a 4 GHz band and a 6 GHz band having the coupling structures improved in accordance with this invention undergo no deterioration of the characteristics, even subjected to severe shock tests and vibration tests on the MIL Standard E-5400 of the United army.

Although there has been described a preferred embodiment of this novel invention, many variations and modifications will now be apparent to those skilled in the art. Therefore, this invention is to be limited, not by the specific disclosure herein, but only by the appending claims.

What is claimed is:

1. A travelling-wave tube including a helical slow wave structure comprising a helical wire having a plurality of turns and means coupled to said structure adjacent one end thereof for transmitting a high-frequency electric signal between said structure and the external circuit, wherein the improvement comprises a conductor attached to the outer periphery of said structure substantially parallel to the longitudinal axis of said structure and adjacent said one end, said conductor bridging at least two adjacent turns of said wire, said adjacent turns constituting one pitch of said structure.

2. A travelling-wave tube according to claim 1, wherein said signal transmitting means is a coaxial cable having a center conductor and a concentric outer conductor; the center conductor of said cable being directly connected to said one end of said structure.

3. A travelling-wave tube according to claim 1, wherein the pitch of said structure adjacent said one end is greater towards said one end than the pitch of the intermediate portion of said structure and said conductor is electrically connected to adjacent turns of the helical wire in the portion of the helical wire having the greater pitch.

4. A travelling-wave tube according to claim 1, wherein the length of said structure along the helical wire between the points at which said conductor is attached to said structure is of the order of one-quarter wavelength of said signal at the center frequency of the operating frequency band.

5. A travelling-wave tube according to claim 1 wherein said conductor has a rectangular cross-section.

6. A travelling-wave tube according to claim 1 wherein said conductor has a circular cross-section.

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