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HELIX TYPE TRAVELLING WAVE TUBES

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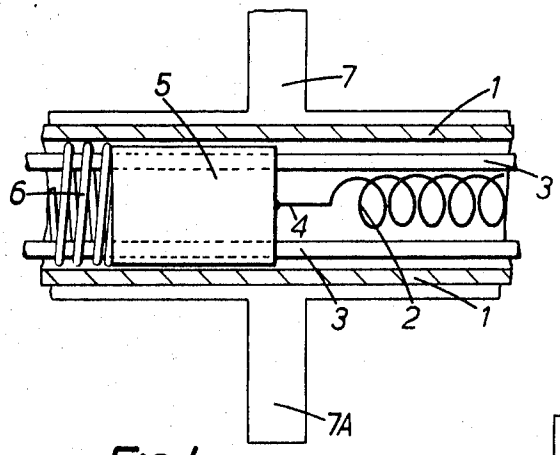

FIG. 1.
PRIOR ART

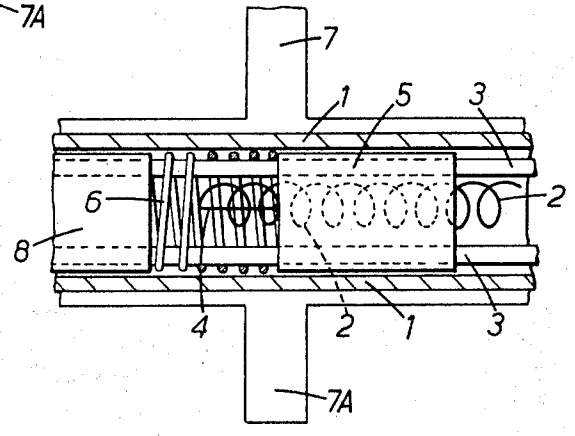

FIG. 2. PRIOR ART

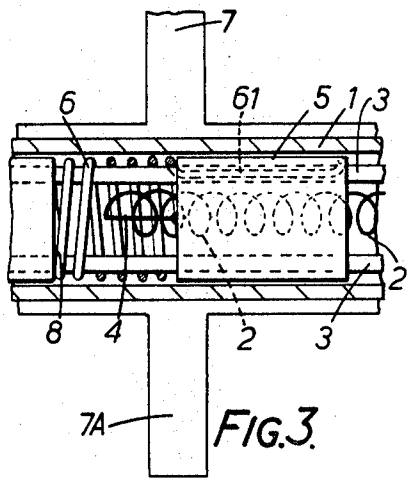

FIG. 3.

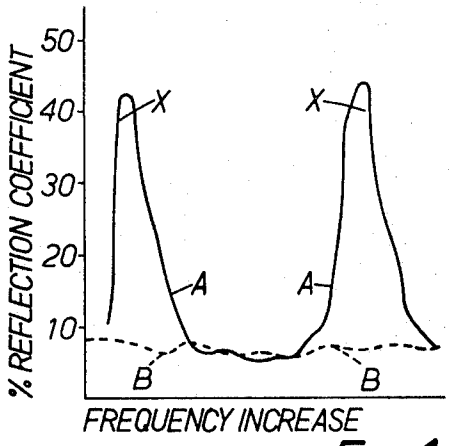

FIG. 4.

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HELIX TYPE TRAVELLING WAVE TUBES

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ABSTRACT OF THE DISCLOSURE

In a helix type travelling wave tube the delay helix is connected via an axial wire which is the antenna to a co-axial metal cylinder choke of larger diameter than the helix, which surrounds a portion of the helix near one end thereof, the antenna being re-entrantly arranged. The D.C. potential for the helix is applied to the choke through a short relatively large diameter D.C. connection helix, and a lead which is run longitudinally through the choke and between the choke and the delay helix and connected to the choke at the end remote from the D.C. connection helix.

This invention relates to travelling wave tubes and more specifically to what will herein be termed "helix type travelling wave tubes" by which is meant, in this specification, travelling wave tubes of the type in which the delay line or slow-wave structure is a helix. This is a very common type of tube.

The invention is explained in connection with and is illustrated in the accompanying drawings in which

FIGS. 1 and 2 are schematic representations, provided for purposes of explanation, showing (so far as is necessary for understanding thereof) two typical known helix type travelling wave tubes;

FIG. 3 is a view, similar to those of FIGS 1 and 2, showing an embodiment of this invention; and

FIG. 4 is a graphical figure showing the nature of the improvement achieved by this invention.

Like references denote like parts in the drawings.

In helix type travelling wave tubes radio frequency signals are coupled in to the helix at or near one end thereof from a wave guide transmission line or the like through which said signals are applied. Commonly the coupling is effected through the vacuum-retaining envelope of the tube, said envelope being electrically transparent at least in the region where the coupling is to be effected. The end of the helix proper is connected to one end of a length of axial conductor—herein called the antenna—which is suitably positioned in relation to the wave guide or other high frequency input to receive energy transferred therefrom. In order to achieve maximum energy transfer, a good impedance match is assured by connecting the end of the antenna remote from the helix proper to a so-called choke, usually in the form of a cylinder of metal co-axial with and of rather larger diameter than the helix. Necessary operating D.C. potential for the helix is applied via the choke and the antenna from a suitable source. Broadly speaking there are two ways of arranging the choke. One is what may be termed the sequential arrangement with the choke and helix spaced apart by the length of the antenna. The other is what may be termed the re-entrant arrangement in which the choke surrounds a portion of the helix near to one end thereof and the antenna is re-entrantly arranged, being brought back towards the choke axially within a few of the end turns of the helix projecting out of the choke. In both cases the D.C. potential for the helix is applied to the choke through a short, relatively

large diameter helix (which will hereinafter be termed the D.C. connection helix to distinguish it from the aforesaid helix which acts as the delay line of the tube) one end of which is connected to the nearest point on the choke and the other end of which is connected to a terminal or connection cylinder.

FIG. 1 illustrates a known helix type travelling wave tube with a sequential arrangement of the choke. Referring to FIG. 1 the vacuum-retaining glass or other suitable envelope of the tube is represented at **1** and **2** is the delay helix proper. It is supported by a plurality of quartz rods **3** of which there may be, for example, three at 120°. The end of the helix continues into an axial wire **4** which is the antenna and the other end of which is connected to a choke **5** in the form of a co-axial metal cylinder of rather larger diameter than the helix **2**. Operating D.C. potential is applied from a terminal cylinder (which does not appear in the broken away view of FIG. 1) through a large diameter D.C. connection helix **6** to the choke **5** and thence through the antenna **4** to the helix **2**. A waveguide input is shown in FIG. 1. The waveguide, which is referenced **7**, is so positioned in relation to the antenna **1** as to provide satisfactory high frequency coupling thereto and the whole arrangement is constructed and dimensioned in accordance with well known principles to provide maximum transfer of high frequency energy to the helix **2**. 7A is the usual short-circuited waveguide stub.

A known arrangement as shown in FIG. 1 is generally satisfactory apart from one defect. This defect is that there is less than maximum utilisation of the available longitudinal dimension. The longitudinal dimension, i.e. the dimension in the axial direction, occupied by the choke and the antenna is quite substantial and because, in a helix type travelling wave tube, the gain attainable is related to the length of the helix—*ceteris paribus*, the longer the helix the greater the gain—a tube as shown in FIG. 1 and of given axial length will have a helix **2** of considerably shorter length. Accordingly, for a tube of given length, the gain is less than is desirable.

The adoption of the re-entrant arrangement of choke overcomes this defect and results in a considerable improvement in gain from a tube of given length. The known re-entrant arrangement is illustrated by FIG. 2. Here the choke **5** surrounds part of the helix **2** near it and leaving a few of its end turns projecting out of it (to the left of it in FIG. 2). The antenna **4** is brought back co-axially through these turns and connected to the choke. D.C. potential is applied at the terminal cylinder (partly shown and referenced **8** in FIG. 2) which is connected to one end of the D.C. connection helix **6** the other end of which is connected to the adjacent end of the choke **5**.

The arrangement of FIG. 2 has the advantage over that of FIG. 1 that it allows a considerably longer helix **2** to be accommodated in a tube of given length and therefore results in substantially improved gain. However an arrangement as shown in FIG. 2 has the serious defect of tending to make the tube, in effect, narrow band by limiting the width of the frequency band over which satisfactorily good impedance matching is obtained. The matching obtained may be represented by a curve connecting reflection co-efficient, expressed as a percentage of input high frequency signal, with frequency. The full line curve A of FIG. 4 typifies results as commonly obtained with a known arrangement as shown in FIG. 2, and, as will be seen, it exhibits pronounced peaks X which are not greatly separated along the frequency scale. The positions of the peaks, which are caused by resonance effects due to the D.C. connection helix **6** crossing a region of high electrical field, can be moved along the frequency scale by suitable design of the connection

helix 6 but it has not been found in practice possible to eliminate them from the frequency band over which travelling wave tubes are commonly required to operate.

The present invention seeks to provide improved helix type travelling wave tubes which shall combine the advantages, as respects gain, of the known re-entrant arrangement of FIG. 2 with the advantage, as respects wide band operating characteristics, of the in-line choke arrangement of FIG. 1.

According to this invention a helix type travelling wave tube comprises a delay helix having one end connected to an antenna which is arranged to couple input high frequency into said delay helix and extends inwardly inside end turns thereof; a choke to which the other end of the antenna is connected and which is outside and embraces said helix near the antenna end thereof so that said end turns project out of said choke at its end nearer the antenna; and means for applying D.C. potential to said helix, said means including a D.C. connection helix embracing said end turns and a connection which is separate from the choke itself and extends between the end of the D.C. connection helix nearer said choke and a point on said choke at or near the end thereof remote from said D.C. connection helix.

According to a feature of the invention a helix type travelling wave tube comprises a delay helix; a cylindrical choke co-axially surrounding a portion of said delay helix adjacent one end thereof and leaving a few turns thereof projecting from said choke at that end; an antenna co-axially situated within said projecting end turns and connected between the projecting end of the delay helix and the choke at or near the adjacent end thereof; and a D.C. connection helix co-axially surrounding said projecting turns and having its end nearer said choke connected to said choke by a connection which runs longitudinally inside said choke and between said choke and said delay helix to a point at or near the end thereof remote from said D.C. connection helix.

FIG. 3 shows a preferred embodiment of the invention. Comparing FIG. 2 with FIG. 3 it will be seen that the essential difference between these two figures is that whereas, in FIG. 2, the near end of the D.C. connection helix 6 is directly connected to the adjacent end of the choke 5, in FIG. 3 it is connected to the choke through a lead 61 which is run longitudinally through the choke and between the choke and the delay helix and connected to the choke at its end remote from the D.C. connection helix 6. This difference is, from the purely mechanical point of view, very small indeed so that there is the great advantage that, practically speaking, the construction of FIG. 3 is not any more costly, or only negligibly more costly, than that of FIG. 2. Electrically, however, and from the operating point of view, the improvement achieved by this difference, mechanically simple though it is, is quite remarkable, for the result is virtually to eliminate the peaks X of the full line curve A of FIG. 4 from a wide practical range of frequencies and produce a curve as shown by the broken line B of FIG. 4.

The theoretical explanation of why the invention produces the remarkable improvement it does is obscure and not fully understood. While the invention is not dependent in any way upon the accuracy and sufficiency, or otherwise, of the reasons now to be advanced, it appears

probable that the improvement is due in part to progressive shielding of the connection 61 from the high frequency field by the choke, and in part to the fact that connection between the said lead 61 and the choke is made in a region of low high frequency field strength, so that the reactances of the D.C. connection circuit do not affect the coupling of radio frequency power between the waveguide and the delay helix.

As will be appreciated, in FIG. 3, the electric field is substantially symmetrical over the whole helix section so that cathode ray beam disturbance associated with the antenna in the known arrangement of FIG. 1 is avoided while stability of charge on the quartz support rods 3 is obtained, as is not the case with the arrangement of FIG. 1.

I claim:

1. A helix type travelling wave tube comprising a delay helix having one end connected to an antenna which is arranged to couple input high frequency into said delay helix and extends inwardly inside end turns thereof; a choke to which the other end of the antenna is connected and which is outside and embraces said helix near the antenna end thereof so that said end turns project out of said choke at its end nearer the antenna; and means for applying D.C. potential to said helix, said means including a D.C. connection helix embracing said end turns and a connection which is separate from the choke itself and extends between the end of the D.C. connection helix nearer said choke and a point on said choke substantially at the end thereof remote from said D.C. connection helix in a region of low high frequency field strength, whereby reflection coefficient peaks are substantially eliminated over a wide range of frequencies.

2. A helix type travelling wave tube comprising a delay helix; a cylindrical choke co-axially surrounding a portion of said delay helix adjacent one end thereof and leaving a few turns thereof projecting from said choke at that end; an antenna co-axially situated within said projecting end turns and connected between the projecting end of the delay helix and the choke at or near the adjacent end thereof; and a D.C. connection helix co-axially surrounding said projecting turns and having its end nearer said choke connected to said choke by a connection which runs longitudinally inside said choke and between said choke and said delay helix to a point substantially at the end thereof remote from said D.C. connection helix in a region of low high frequency field strength, whereby reflecting coefficient peaks are substantially eliminated over a wide range of frequencies.

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