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2,792,519

RIBBON HELIX TRAVELING WAVE TUBE

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8 Claims. (Cl. 315—3.5)

This invention relates to high frequency electronic devices of the kind in which the electric field of a high frequency electromagnetic wave that is propagated along a suitable transmission path interacts cumulatively with an electron stream over a distance of many wavelengths.

This application is a division of application Serial No. 640,597, filed January 11, 1946 and issued as Patent 2,636,948 on April 28, 1953.

One example of a device of the kind to which the invention relates comprises, as illustrated in Fig. 1 of the parent application, an elongated helix of fine wire that is supported throughout its length in accurate concentric relation with a rectilinear electron stream directed along its axis. The stream velocity is such that there is cumulative interaction between the stream and the electric field of signals transmitted through the slow wave transmission path provided by the helix. More specifically, the signals are applied to the end of the helix where the unmodulated electron stream enters, and they are propagated along the helix to a signal output connection at the downstream end with a velocity substantially equal to that of the stream. The signal effects an initial velocity modulation of the stream with resultant bunching, and there is further cumulative interaction including a progressive transfer of power from stream to signal.

One object of the present invention is to provide a high frequency amplifying device of the kind described that is structurally simple and capable of sustained stable operation despite severe mechanical shock.

A second object is to provide an improved coupling between a slow wave transmission path and an associated wave guide.

Still another object of the invention is to provide an improved slow wave transmission path for traveling wave tubes or the like which has a broader frequency band width and higher heat dissipation capacity than the wire helix, and which may also provide electrostatic shielding for the electron stream.

In accordance with a salient feature of the invention, the transmission path comprises a relatively wide flat conductor, or ribbon, arranged as a helix.

More specifically, and in accordance with another feature of the invention, a relatively heavy conducting ribbon helix is disposed edgewise and in contact with a concentric cylindrical conductor. This conducting cylinder lends strength and stability to the ribbon conductor, and together they form a continuous helical channel open along one side to permit interaction with the electron stream.

From another aspect, an important feature of the invention resides in a smooth transition between an input wave guide of elongated rectangular cross section and the ribbon helix transmission line, with the wider side walls of the wave guide merging into respective successive turns of the helix.

Other objects, advantages, and features of the invention will become apparent from the following detailed

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description of the embodiment illustrated in the accompanying drawings.

In the drawings:

Fig. 1 is a longitudinal section of a traveling wave tube illustrating the principles of the invention; and

Fig. 2 is a detailed view of the coupling between a rectangular wave guide and the flat ribbon helix slow wave transmission path.

Fig. 1 illustrates an electronic device constructed in accordance with the principles of the invention to obtain cumulative interaction between a stream of electrons and a signal impressed on a transmission channel. Proceeding to a detailed consideration of the transmission path, the input and output wave guides 3, 4 are continued within the evacuated envelope 5 by means of the slow wave transmission structure formed by the conducting cylinder 6 and the closely spaced turns of the conducting ribbon 7. The helical transmission channel within the tube corresponds to the rectangular external wave guide in dimensions, with the exception that one of the shorter side walls is effectively removed. As may be more clearly seen in Fig. 2, this permits transition from the external wave guide to internal slow wave transmission circuit with little discontinuity, and still provides excellent coupling between the transmission circuit and electron stream within the tube. This coupling arrangement, with one of the wider sides of the wave guide merging with the first turn 7' of the flat ribbon conductor, and the opposite wave guide wall merging with the second turn 7'', has the advantage of structural simplicity in addition to its good electric properties.

Returning to the over-all view shown in Fig. 1, the electron stream forming electrodes includes the cathode 8, the electron focusing electrode 9, accelerating electrodes 10 and 11, and the collector 12. The cathode heater current and the bias for the focusing electrode 9 are supplied from the voltage sources 13 and 14, respectively. Suitable accelerating and anode voltages are provided by the high voltage source 15. The foregoing electrode arrangement serves to provide a high velocity electron stream paralleling the slow wave transmission structure 6, 7, for amplifying interaction with the high frequency energy propagated therein.

In order to suppress undesired oscillations, suitable high frequency loss material 18 may be placed between adjacent turns of the wave-guiding ribbon 7. This material may be a mixture of ceramic and conducting material or other substance capable of absorbing energy from a high frequency field, and may extend along the wave-guiding channels between the turns of the copper ribbon 7 to distribute the loss as desired. As an alternative, portions of the ribbon 7 may be plated with high loss material such as iron, or the attenuation may be obtained in any other desired manner.

Under adverse operating conditions traveling wave tubes can be somewhat sensitive, and mechanical shock as well as undesired stray electrostatic or magnetic fields may disturb their stable operation. In the device according to the present invention, however, the ribbon helix construction has substantially greater structural rigidity than the conventional wire wound helix. Furthermore, the conducting cylinder 6, in addition to forming the outer wall of each wave-guiding channel, also acts as a protective shield against stray electrostatic fields which might otherwise deflect the electron stream. In addition, the slow wave transmission circuit disclosed herein has the ancillary advantage of high heat dissipation which becomes important at high power level operation.

In order to shield the tube from magnetic fields, the ferromagnetic shield 19 is provided. In place of this shield, a coaxial coil may be employed to provide a

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strong axial magnetic field to prevent deviation of the electron beam.

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

What is claimed is:

1. In a high frequency electron tube, an evacuated envelope, electrode means within said envelope forming a stream of electrons, a cylindrical conductor paralleling said electron stream, and a ribbon conductor in helix form having one edge contacting said cylindrical conductor, with the conducting ribbon helix extending from said cylindrical conductor toward said electron stream.

2. An electron tube as set forth in claim 1, wherein input and output wave guides are coupled to said ribbon helix adjacent the two ends thereof.

3. In combination, an evacuated envelope, electrode means within said envelope providing a stream of charged particles, a slow wave transmission path in coupling proximity thereto, said slow wave transmission path comprising a substantially cylindrical elongated conducting body having a partially open conducting helical transmission channel on a curved surface thereof, with the open side of said transmission channel facing said stream.

4. In combination, an evacuated envelope, means providing a stream of charged particles within said envelope, a rectangular U-shaped helical channel of conducting material forming a slow wave transmission circuit adjacent said stream, and input and output wave guides of substantially the same cross-section as said channel coupled to said slow wave transmission circuit.

5. The combination as set forth in claim 4 in which the distance across the mouth of said U-shaped channel is less than the depth of said channel, whereby a smooth transition may be effected between the input and output wave guides and said slow wave transmission circuit.

6. In combination, an evacuated envelope, electrode means within said envelope providing a stream of charged particles, and a slow wave transmission path comprising a flat wound conducting ribbon in coupling proximity thereto, with the width of said ribbon being greater than the space between adjacent turns of said ribbon.

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7. A wave amplifying device comprising a transmission path capable of guiding high frequency electrical waves, said transmission path comprising a hollow wave transmission channel of conducting material with a substantially continuous side aperture along at least a portion of its length and which is formed into a helix with the said aperture facing the axis of the helix, and with the turns of said helix being closely spaced so that a single conducting partition separates adjacent turns of the interior of the transmission channel, means to impress waves to be amplified upon an input end of said transmission path to permit travel of the waves along said path, an evacuated envelope and electrode means for producing an electron stream along said path in a traveling electric field associated with the said traveling waves and in the direction of travel of that field, said field being located along the axis of said helix, said stream entering said field as a substantially unmodulated stream, the said transmission path being characterized in that the propagation velocity of the said electric field is of the same order of magnitude as the velocity of the electron stream passing therethrough whereby energy is transferred from the electron stream to the said waves along the length of the said path traversed by the electron stream, and an output circuit connected to the end of the said transmission path opposite the said input end.

8. In combination, an evacuated envelope, electrode means within said envelope providing a stream of charged particles, a slow wave transmission path in coupling proximity thereto, said slow wave transmission path comprising a continuous helical wave transmission channel of conducting material and having only conducting material separating successive turns of the transmission channel, with said channel being open toward said electron stream.

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