

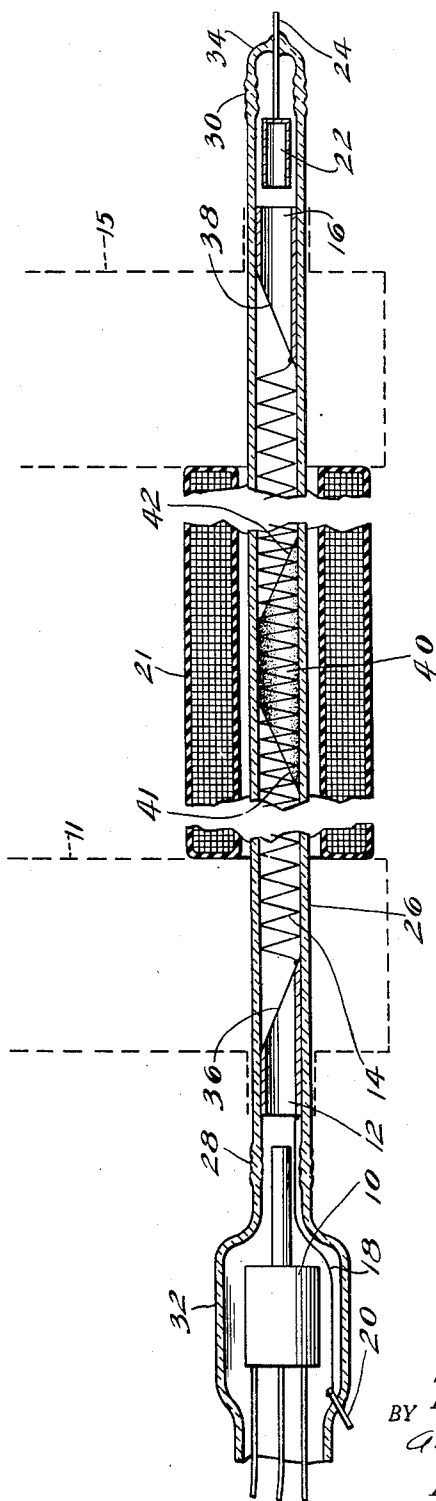
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F. C. BREEDEN ET AL

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TRAVELING WAVE TUBE

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INVENTOR.
Francis C. Breeden
BY Leo C. Eisaman
Attorney

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TRAVELING WAVE TUBE

Francis C. Breeden and Leo C. Eisaman, Flushing,
N. Y., assignors to Sylvania Electric Products
Inc., a corporation of Massachusetts

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The present invention relates to high-frequency amplifier tubes of the traveling-wave type, and has as its purpose the improvement of such tubes.

It is known that when one end of a properly proportioned helix in such tube is excited by a high-frequency wave, the wave travels along the helical conductor about an electron beam that is directed centrally along the helix. There is a mutual interaction between the electron beam and the high-frequency field of the helix. At the output end of the traveling-wave tube, the signal level is far greater than at the input end. A small part of this signal is reflected that would cause self-oscillation. To overcome this tendency it is usual to incorporate an attenuator midway along the helix, to damp out the reflections. The wave traveling forward along the helix is also attenuated, but since at this stage there is already considerable modulation on the beam itself, which modulation is again induced in the remaining portion of the helix, the attenuator serves a net useful purpose.

A type of traveling wave tube commonly used heretofore includes a length of glass tubing with electrodes to direct an electron beam axially, an input probe, an output probe, and a metal helix connected between these two probes. Three or more ceramic rods space the helix away from walls of the glass tubing and support it centrally about the path of the electron beam; and the probes are separately supported. The attenuator in such traveling-wave tubes is in the form of graphite coating about these ceramic rods, extending a short distance lengthwise of the rods midway along the helix.

The present invention improves upon that type of traveling-wave tube in several respects. This invention provides a traveling-wave tube having a helix that occupies substantially the full diameter of the enclosing tubing, yielding several important advantages. Coupling of signal energy to and from the amplifier is facilitated. The tubing encasing the helix should be of highly refractory material such as fused quartz to resist cracking due to heating of the helix in manufacture and operation of the tube, and should have a low electrical loss so that the traveling wave is not unintentionally damped.

In place of the graphite coating on the ceramic rods, the attenuator here provided desirably is a film of refractory metal having relatively high resistivity, on the inside wall of the tubing in extensive peripheral contact with the helix, not at isolated points as in the case of the graphite-coated rods. Nichrome is particularly well suited to this purpose. It is advantageously vapor-deposited over an area sharply defined by a mask.

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The thickness of the film is carefully controlled so that near its extremities it is thinner than at the middle for non-reflective attenuation.

The zone of coating of the attenuator material and its thickness are both controlled and these two factors promote establishment of the desired character and degree of attenuation. Certain of the turns in the helix are entirely encircled by attenuator material, whereas the turns opposite the extremities of the attenuator zone have progressively diminished arcs of attenuator coating. The tapered attenuator pattern provides effective attenuation over a broad band of frequencies, and minimizes reflections.

An illustrative traveling wave tube in accordance with the present invention is shown in the accompanying drawing to which reference is made in the following detailed disclosure. An electron beam is produced by gun 10, containing the usual filamentary heater, electron-emitting cathode and a beam-forming sleeve. An input probe 12 is positioned beyond this cathode assembly in the direction of beam travel, and is joined to helix 14 which in turn is connected to output probe 16 at the far end of the tube. A lead 18 is joined to electrode 12 and is energized through terminal 20 for establishing the proper helix potential. A magnetic field established by a coil 21 about the tube maintains focus of the electron beam. Beyond output probe 16 is a collector 22 for the electron beam, with its external terminal 24.

The signal input is normally applied by a waveguide surrounding the tube at probe 12 as indicated by the dashed lines 11. The waveguide is properly positioned in relation to this probe so that a wave is propagated along helix 14. An output waveguide, also penetrated by the traveling-wave tube, is normally positioned as shown by the dashed lines 15 in the region of probe 16, which probe transmits the amplified wave into the output waveguide.

Probes 12 and 16 and helix 14 are snugly encased in vitreous tubing 26 which advantageously is fused quartz or some other non-porous low-loss material of comparable refractory merit. The temperature to be resisted depends on the degree of heating considered necessary for satisfactory exhaust of gases occluded in the metal of the helix. The tubing is joined through graduated seals of successively different types of glass at regions 28 and 30 to envelope portions 32 and 34 of suitable glass sealed to the necessary terminals for gun 10, lead 20 and terminal 24. The small outer diameter of the tubing requires a small size of hole in the waveguide walls, thus minimizing losses and radiation problems.

The input probe 12 and the helix as well as

the output probe 16 are as large as the diameter of the enclosing tubing permits. The large size of the probes facilitates coupling from the traveling-wave tube to the input and output waveguides, by reducing the inductance of the probes. In order to further improve this coupling, electrodes 12 and 16 are formed with edges 36 and 38 tapered at about 20° to the axis of the tube. The snug fit of the helix in the tubing also promotes the success of the attenuator. This attenuator in the present instance is of nichrome, vapor-deposited on the inside wall of the tubing before insertion of the helix. The quantity of the metallic deposit and the pattern of the deposit are both controlled in the present instance so that attenuator 40 will be effective and reliable in its operation. This form of construction permits a large degree of amplification without reaching self-oscillation. The tapered peripheral extent of the attenuator toward its extremities 41, 42 greatly enhances the broad band characteristics of the tube, and absorbs the otherwise troublesome reflections.

The bore of the quartz tubing will be somewhat larger than the outer diameter of the helix to allow for differences in thermal expansion and contraction. There is nevertheless a good degree of coupling between the helix and the attenuator film. If slight motion of the helix within the tubing is possible, slight variations in degree of attenuation will result. For best results such a tube should be used in the horizontal position shown with the maximum length of attenuator film lowermost.

It will be apparent that while the novel features in the illustrative tube mutually contribute toward an improved unit, certain of the features will be useful severally as improvements in traveling-wave tubes. Furthermore modification of details and substitution of equivalents will occur to those skilled in the art. Therefore the appended claims should be broadly interpreted, consistent with the spirit and scope of the invention.

What is claimed is:

1. A traveling wave tube comprising a wire helix, means to direct an electron beam axially along the helix, electromagnetic coupling means coupled to at least one end of said helix, a low-loss envelope of substantially circular cross-section having a bore diameter approximately equal to the external diameter of said helix, and an attenuating coating on the interior wall of the envelope substantially encircling the helix over a definitely restricted zone along the helix, said coating being progressively reduced in peripheral extent toward the ends of the attenuating zone.

2. A traveling-wave tube having a wire helix, means including an axial magnetic beam focusing device to direct an electron beam axially along the helix, electromagnetic coupling means coupled to at least one end of said helix and a refractory low-loss evacuated envelope snugly fitting and encasing the helix substantially continuously along the length thereof.

3. A traveling wave tube comprising a conductive helix, means to direct an electron beam axially along the helix, input and output probes coaxial with and joined to said helix, said probes being tubular and each having an end face sloping toward its connection with the helix.

4. A traveling-wave tube comprising a wire helix, means including an axial magnetic focusing device to direct an electron beam axially

along the helix, electromagnetic coupling means coupled to at least one end of said helix, an evacuated length of highly refractory low-loss non-porous tubing of essentially circular cross-section closely encasing said helix and in engagement therewith substantially continuously along the length thereof, and a film of refractory metal on the inner wall of the tubing within a restricted zone between the ends of the helix.

5. A traveling-wave tube comprising a conductive helix, means for projecting an electron beam centrally along the helix, tubular input and output probes having slanting ends joined to the extremities of the helix, a length of refractory non-conductive tubing snugly encasing said probes and substantially continuously snugly encasing said helix, and a pattern of resistive metallic film having tapered extremities on the inside wall of the tubing in a restricted zone between the ends of the helix.

6. A traveling-wave tube including a wire helix, means including an axial magnetic focusing device for directing an electron beam along the axis of said helix, electromagnetic coupling means coupled to at least one end of said helix and an evacuated low-loss refractory insulating tube snugly fitting and encasing said helix continuously along the length thereof, said casing having an attenuating film encircling said helix in a restricted zone along the length thereof.

7. A traveling-wave tube having a wire helix, means including an axial magnetic focusing device for directing an electron beam along the axis of said helix, electromagnetic coupling means coupled to at least one end of said helix, and an evacuated refractory low-loss tubular insulating support fitted around said helix, the internal diameter of said tubular support being approximately equal to the outer diameter of the helix.

8. A traveling-wave tube having a wire helix, means including an axial magnetic focusing device for directing an electron beam along the axis of said helix, electromagnetic coupling means coupled to at least one end of said helix, an evacuated refractory low-loss tubular insulating support fitted around said helix, the internal diameter of said tubular support being approximately equal to the outer diameter of the helix, and an energy absorbing film on the inside wall of said tubular support in a restricted zone encircling said helix at an intermediate portion of the length thereof.

FRANCIS C. BREEDEN.
LEO C. EISAMAN.

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