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2,967,259

RESISTANCE-STRAPPED HELIX FOR A TRAVELING WAVE TUBE

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Filed July 23, 1959, Ser. No. 829,169

5 Claims. (Cl. 315—3.6)

This invention relates to a slow-wave structure for traveling-wave amplifier tubes and more particularly to a resistance-strapped helix.

An object of the invention is to provide a traveling-wave amplifier tube which has a large 3-db bandwidth and which is very nearly free from self-oscillation caused by beam interaction with a backward space harmonic of the structure having a velocity very nearly synchronous with the electron beam. By the aforementioned description of bandwidth is meant to those skilled in the art that the ratio of the frequencies at the 3-db down points on the response curve is of the order of 1.5:1 or 2:1.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a more or less schematic representation of a traveling-wave tube showing a preferred embodiment of the helix of this invention;

Fig. 2 is an enlarged axonometric view of a portion of the helix removed from the tube of Fig. 1; and

Fig. 3 is a cross-section taken along the line 3—3 in Fig. 1.

Reference is now made to the drawing. The illustrated embodiment is a bifilar helix although the invention comprehends the use of multifilar helices made of more than two helices. The bifilar helix comprises two separate helices 2 and 4 of uniform conducting tapes of width W and thickness T . Each has the form of a helix of constant pitch p (the axial distance in which the conductor makes one complete rotation about the axis) constant pitch angle ψ (the angle between a line tangent to an edge of one of the tapes and a plane perpendicular to the cylindrical axis of the helix), and constant mean radius a .

The helices are spaced equally from each other a distance d .

The helices are connected across the center of the structure every distance d by means of resistance straps generally indicated at 6. In the preferred illustrated embodiment the portions 8 of each strap are shown as being conducting bars and the central portion 10 is a resistance. The resistance can be all concentrated in a very small region on the axis of the helix extending, for example, a distance not greater than $\frac{1}{2}$ of the strap. On the other hand, another embodiment envisions a resistance strap or lossy strap which is uniformly lossy through its length. The resistance straps can be fabricated in any one of a number of ways which would be apparent to those skilled in the art. For example, in the case of the concentrated resistance located on the axis, the conducting sections 8 can be simply solid conductors forming good electrical contact with the helix conductors and the resistor 10 can be a very thin micro-wave resistor known in the art or any other suitable resistor. Another way of fabricating lossy straps, adaptable either to the concentrated resistance form or the

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distributed resistance form, would be by using a dielectric rod as a core, plating its ends for good electrical contact with the helix conductors and plating its length either thinly or thickly to provide resistance at the center or uniformly along its length as desired.

The helix of the illustrated embodiment is shown in a conventional traveling-wave tube generally indicated at 12 which includes an electron gun 14 and a collector 16 as well as input terminals 18 and output terminals 20. The helix is supported by dielectric rods passing through its interior but omitted from the drawing for the sake of clarity.

Operation

An understanding of the operation of the present invention can perhaps best be achieved by considering first an unstrapped bifilar as a slow-wave structure. The unstrapped bifilar helix has an infinity of possible modes of propagation, two of which are important here. The "symmetric mode" is characterized by having the same RF voltage on both helix conductors at any given cross-section. The symmetric mode has a forward-traveling space harmonic which is useful for wideband forward-wave amplification. The "antisymmetric" mode is characterized by having opposite voltages on the two helix conductors at any given cross-section. The antisymmetric mode has a very strong backward space harmonic that will generally cause oscillations under the operating conditions necessary for forward amplification. It can be reasoned qualitatively that a short wire or strap connecting opposite sides of the bifilar helix will be a strong perturbation to the antisymmetric mode since it connects two points of opposite voltage, but will be only a minor perturbation to the symmetric mode since the two points connected carry the same voltage. The great advantage of the strapped bifilar helix as a slow-wave structure for traveling-wave amplifier tubes lies in the mode-selective properties of the straps. In particular, the exact center of each strap has a maximum of electric field and a zero of current in the symmetric mode, while it has a maximum of current and a zero of axial field (or voltage) in the antisymmetric mode.

Two things can be done to exploit this mode-selective current pattern. A periodicity can be introduced in one mode which does not affect the other, with the result that a mode-selective stop band is created. Or, as accomplished with this invention, the circuit can be made lossy in one mode, with negligible loss in the other. Since excess loss is wanted in the antisymmetric mode, to prevent oscillations occasioned by the strong backward space harmonic, the invention involves the insertion of series resistance which absorbs energy from the conduction current in the strap. With an ideal infinitesimal resistor at the center of each strap, the attenuation is zero in the symmetric mode because of the null in current flow at the position of the resistor. The amount of attenuation and the size of the resistor in a practical case required to suppress backward wave oscillations depend on the details of a particular tube design. The calculation of the particular resistor size can be performed using, for example, the analysis set forth in the article entitled "Strapped Bifilar Helices for High-Peak-Power Traveling-Wave Tubes" by Watkins and Dow, IRE Transactions on Electron Devices, January 1959, page 106, et seq.

As previously explained, one practical form of lossy strap can be represented by a strap which is uniformly lossy along its length instead of having its resistance concentrated on the axis of the helix. This form has a large amount of mode-selective loss, but is not completely selective.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within

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the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A slow-wave structure for use in traveling-wave tubes comprising a multifilar helix including a plurality of separate helices, each separate helix having the same constant pitch; the same constant pitch angle, and the same mean radius; said helices being spaced equally from each other along a common axis; and a plurality of straps spaced periodically from each other along the direction of the axis of the helix, each strap electrically connecting the separate helices together along a diameter of the helix, and each strap comprising lossy material.

2. The slow-wave structure of claim 1 wherein the multifilar helix is a bifilar helix.

3. The slow-wave structure of claim 1 wherein the

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lossy material is concentrated in the region of the axis of the helix.

4. The slow-wave structure of claim 3 wherein the straps are spaced from each other a distance equal to half the pitch distance of each separate helix.

5. In a traveling-wave tube, an electron gun, a collector for electrons, and a slow-wave structure; said slow-wave structure being structure of claim 1.

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**UNITED STATES PATENT OFFICE
CERTIFICATION OF CORRECTION**

Patent No. 2,967,259

January 3, 1961

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It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 16, after "bifilar" insert -- helix --.

Signed and sealed this 6th day of June 1961.

(SEAL)

Attest:

ERNEST W. SWIDER

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Commissioner of Patents