Feb. 18, 1964 R. W. WILMARTH 3,121,819

ARRANGEMENT FOR REDUCING HIGH VOLTAGE BREAKDOWN BETWEEN HELICAL WINDINGS IN TRAVELING WAVE TUBES

Filed Dec. 30, 1959 2 Sheets-Sheet 1

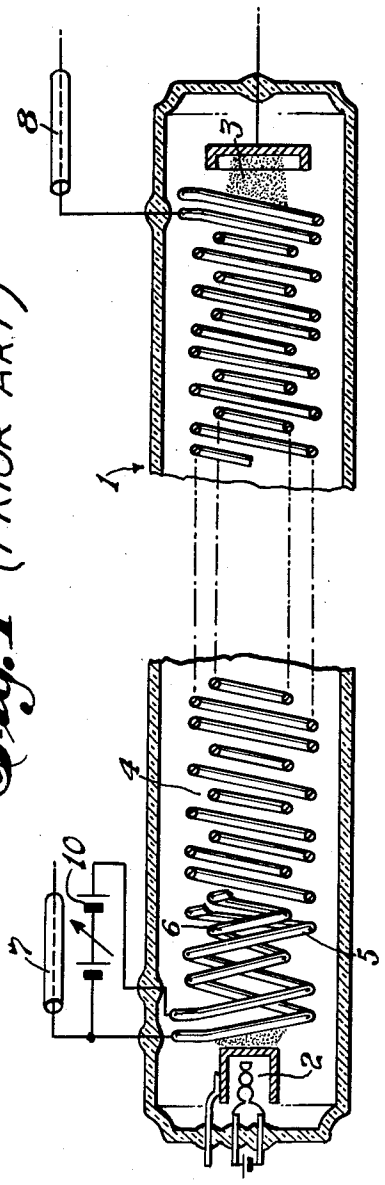


Fig. 1 (PRIOR ART)

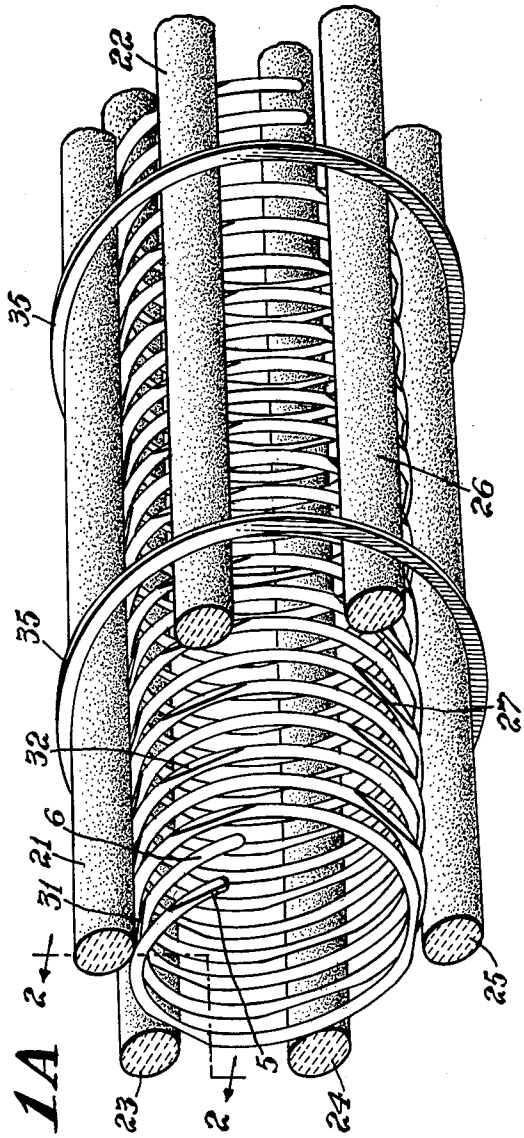


Fig. 1A

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Fig. 3A

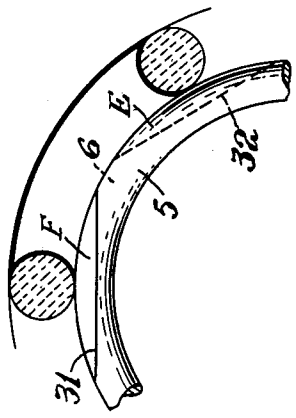


Fig. 6

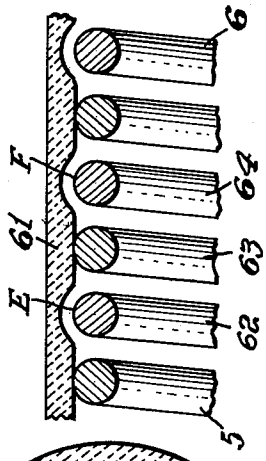


Fig. 3

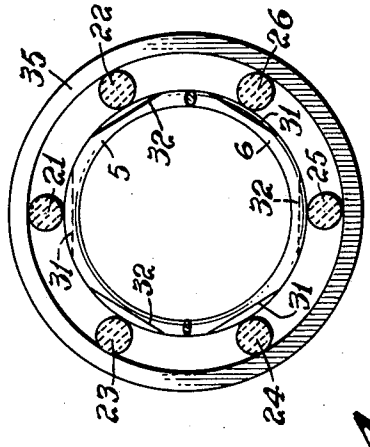


Fig. 5

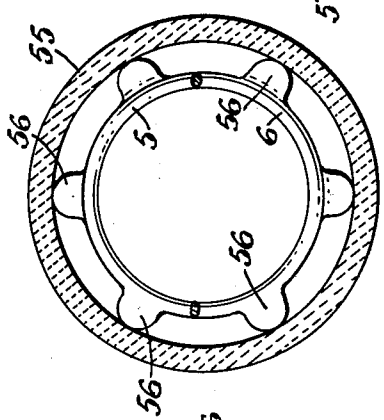


Fig. 4

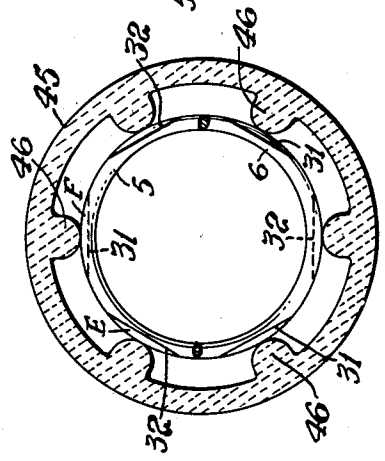
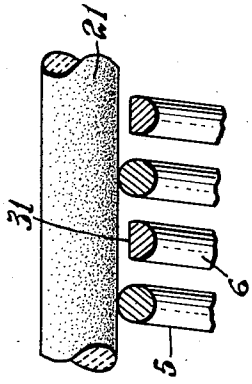


Fig. 2



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ARRANGEMENT FOR REDUCING HIGH VOLTAGE BREAKDOWN BETWEEN HELICAL WINDINGS IN TRAVELING WAVE TUBES

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9 Claims. (Cl. 315—3.6)

This invention relates to electron discharge devices and more particularly to traveling wave tubes.

Traveling wave tubes are known, which utilize a bifilar helix, for electrostatic strong focussing of the electron beam or to provide an R.F. interaction circuit with the beam or both, for example, as disclosed in U.S. Patent No. 2,834,908 issued to R. Kompfner, May 13, 1958. High frequency electromagnetic waves traveling down a bifilar helix can be made to interact continuously with an electron stream. Such a traveling tube circuit is also well suited for spatial harmonic operation in which the electromagnetic wave interacts periodically with the electrons. This mode of operation is suited to operation of a traveling wave tube at higher frequencies.

Traveling wave tubes, which provide electrostatic focussing of the electron beam, generally utilize as the slow wave structure, two helices wound in bifilar fashion. When bifilar helices are used, there are three conditions to be satisfied:

(1) Good R.F. performance i.e. wide bandwidth with a flat gain characteristic;

(2) Good focussing of the beam;

(3) Precluding voltage breakdown between helices.

In many traveling wave tubes of the bifilar helix type, the helices have small pitches so that a considerable voltage gradient exists between the helices, resulting in electrical breakdown, which is generally found to invariably occur along the insulating rod supports for the helices and between adjacent turns.

Accordingly, an object of the invention is to prevent electrical breakdown along the supporting rods and/or between the adjacent turns of the helices in high frequency tubes.

A feature of the invention are helices for electrostatically focussed tubes, wherein a lengthened support spacing is provided between adjacent turns of the two helices to prevent sparking and electrical breakdown.

Another feature of the invention are helices for traveling wave tubes and the like, with flattened areas providing alternate gaps along the insulating supports of the helix, whereby high voltage breakdown is minimized between turns and over the insulating support.

The invention will be better understood from the following more detailed description provided in connection with the accompanying drawings, in which:

FIG. 1 is a longitudinal section of a traveling wave tube having a bifilar helix construction in accordance with the prior art;

FIG. 1A is an elevational view of a bifilar helix and its support rods in accordance with the invention;

FIG. 2 is a longitudinal section of a supporting rod and the bifilar helices of FIG. 1A taken along line 2—2;

FIG. 3 is a cross-sectional view of the helix of FIG. 1A showing the support rods and the flattened bifilar helix;

FIG. 3A is an explanatory diagram showing the leakage and/or arcing paths involved in FIGS. 1A and 3;

FIG. 4 is a modification of the helix and support of FIG. 3;

FIG. 5 is another modification of the helix and support shown in FIG. 3; and

FIG. 6 shows a further modification of the helix and support structure in accordance with the invention.

Referring to FIG. 1, which shows a prior art type traveling wave tube utilizing a bifilar helix 4 formed on a mandrel in a manner known to the art as exemplified by U.S. Patent No. 2,834,908 aforementioned. An electron gun 2 and collector 3 are positioned at opposite ends of the traveling wave tube 1 so that the electron stream flows along the axis of the helix 4, consisting of windings 5 and 6 rotated with respect to each other.

A wave transmission coaxial line 7, can be connected to winding 5 at one end of the tube as an input and a similar coaxial transmission line 8 can be connected to the other end of helical winding 5, providing an output when conventional, or non-spatial harmonic operation of the traveling wave tube 1 is desired. When it is desired to excite the bifilar helix 4 to provide strong spatial harmonic field components, an input signal may be applied to helical winding 5 out of phase by 180° with the input to winding 6.

When the traveling wave tube 1 operates as a conventional amplifier, a signal wave of high frequency applied to helical winding 5 travels down the tube 1 with an axial phase velocity that is substantially the same as that of the electron stream. As the signal which may be of short wave length, i.e. for example, in the microwave range, travels along the helix, it interacts with the focussed electron stream in a well-known manner, so that upon reaching the output, its amplitude has increased.

The electron stream is confined within the bifilar helix 4 by the focussing action of the static electric field supplied by battery 10, whose voltage may be adjusted to provide optimum focussing. The D.C. voltage may be applied between windings 5 and 6 as illustrated in FIG. 1.

Referring to FIG. 1A, which represents a preferred embodiment of the invention, six supporting rods 21–26 of insulating material are shown for supporting a bifilar helix 27 consisting of a pair of windings 5 and 6 wound on a mandrel and displaced angularly (60°) with respect to each other. The helical windings 5 and 6 serve as a focussing system for the electron beam in the manner described for FIG. 1, or as an R.F. circuit or both. In many cases, where the helical windings have small pitches, there is a considerable voltage gradient present between the helices, which operate at different potentials. Often when sparking and voltage breakdown occur on the helical structure, it has invariably been found to occur along insulating support rods 21–26 and between adjacent turns of the windings 5, 6.

In order to minimize and preclude sparking and voltage breakdown, the helical windings 5, 6 are flattened by machining or grinding along their length, as illustrated in FIG. 1A. Each of the helical windings 5, 6 has three flats, equally spaced around the periphery. When the two helices are disposed as shown in FIGS. 1A and 3, the flats 31 on the inner helix 6 are spaced between the flats 32 of the outer helix 5. The helices 5 and 6 are held by the six insulating support rods 21–26, disposed at equal angular spacings peripherally. Metallic fastening rings 35 are disposed axially along the rods to provide a unitary assembly of support rods and helices.

Referring to FIGS. 2 and 3, the flats 31, 32 on the windings 5 and 6 are effective in minimizing and eliminating breakdown due to the high voltage difference existing between these helical windings. Due to the presence of the flats 31, 32 a vacuum gap between a round turn and a flattened turn is created in the breakdown path along the support rod 22. Auxiliary vacuum gaps between the rods 21–26 and the adjacent flattened portions of windings 5, 6 are similarly created. In the case of flattened helices, the breakdown voltage would be more

than 10 times greater for the construction shown in FIG. 3 than for a round helix construction of the prior art without flats. In the prior art rounded windings, breakdown occurs in the insulator support rod at less than 1/10 of the breakdown voltage required for the flattened helical windings and the analogous expedients disclosed in accordance with the invention.

Referring to FIGS. 3 and 3A, the supporting rods **21–26** alternately contact helical windings **5**, **6** whereby gaps in vacuo are provided by the three flats **31** and three flats **32**, on these windings. The longitudinal support rods **21–26** are held by clamp rings **35** encircling the rods along their length whereby a unitary assemblage of rods and helices is maintained.

FIG. 3A shows a voltage breakdown path for the bifilar helix in accordance with the invention, as including a pair of vacuum gaps E, F created between the flats and adjacent turns of helical windings **5** and **6** respectively. Due to the presence of the discharge gaps E, F in vacuo, a much higher voltage is required to produce breakdown than for helical windings with round turns and no flats.

FIG. 4 shows a modification of the helical construction of FIG. 1A, wherein an insulating fluted clamping tube **45** with interiorly arranged projections or flutes **46** are equispaced peripherally around the bifilar helix having flats **31**, **32**. The flutes **46** and the opposing flats **31**, **32** provide discharge gaps in vacuo to reduce any tendency to breakdown in a peripheral path including sections of the fluted tube **45**, analogous to the arrangement described for FIG. 3A. The fluted tube **45** may be glass, ceramic, or other suitable insulator.

FIG. 5 shows a modification of the helix and support system of FIG. 4 wherein the clamping ring **55** has a smooth bore. In this construction, the smooth clamp rings **55** encircle the helical windings **5** and **6**, which have been machined on the outside thereof, to provide knobs or projections **56** thereon located at equal angular spacings around the turns. The helical windings **5**, **6** are staggered to realize a long breakdown path between knobs.

Referring to FIG. 6, which shows another modification of the helix and support system, a long breakdown path can be also achieved with insulating rods **61**, which are alternately notched to provide discharge gaps E, F with respect to adjacent turns **62**, **63**, **64** of the helices **5**, **6**. Discharge gaps E, F in vacuo provide a breakdown path requiring higher breakdown voltages than that required for the insulation medium of the round support rods **61** per se.

It should be understood that more or less than six support rods may be used, although as more rods are provided, the breakdown path is decreased. Likewise, multifilar helical windings may be utilized in lieu of bifilar windings **5**, **6**.

While the invention has been described to illustrate the general principles thereof, it should be obvious to those skilled in the art to which the invention pertains, that changes or modifications may be made therein without departing from the spirit or scope of the invention.

I claim:

1. A traveling wave tube comprising a bifilar wound helix, whereby a stream of electrons may be projected along and within said helix, a plurality of parallel, insulating support rods longitudinally spaced about the outer periphery of said helix and means providing peripheral spark discharge gaps in vacuo between said helix and supports to minimize electrical breakdown between adjacent turns of said bifilar helix and said supports.

2. A traveling wave tube as in claim 1, wherein said bifilar helix comprises two windings, one interwound alternately with the other, each alternate helix being flattened longitudinally at peripheral areas adjacent each support rod respectively.

3. A traveling wave tube as in claim 1, wherein the bifilar helices operate at different focussing potentials, each helix having flattened portions opposite certain of the supporting rods to provide alternate gaps in vacuo for minimizing high voltage breakdown between the helical windings and the supporting rods.

4. A traveling wave tube as in claim 1, further including clamping metallic rings mounted at points longitudinally of said support rods, and wherein said means comprises a lengthened breakdown path including said ring, and at least a pair of discharge gaps provided between certain turns of the helix and certain of said rods.

5. In an electron beam device, a wave propagating circuit extending along the beam, comprising a multifilar helix having flattened portions longitudinally of the coils, support rods for said helix, and means providing paths of electrical breakdown between said rods and helix longer than the intervening rod section between adjacent turns.

6. A beam tube having a longitudinal helix, a plurality of longitudinal support means positioned around said helix, alternate turns of the helix along the length of each adjacent support means being peripherally spaced therefrom to provide spark discharge gaps between adjacent helix turns and support means to increase the breakdown voltage therebetween.

7. The beam tube of claim 6, wherein said support means are notched to provide alternate spark gaps with adjacent turns of said helix whereby the breakdown path along the support is increased.

8. The beam tube of claim 6 including a bifilar helix, alternate turns of the helix being flattened to provide discharge gaps to increase the breakdown voltage, and insulating support rings having projections contacting said bifilar helix around and along the length thereof.

9. In combination, an electron beam vacuum tube, first and second interwound multifilar helices surrounding said electron beam, said windings being at different direct current potentials, insulation supports for said helices, and means for increasing the breakdown voltage between said supports and adjacent turns of said helices including flattened longitudinal portions on each helix equispaced angularly to form discharge gaps with said supports, said helices being spaced 60° angularly with respect to each other.

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