Feb. 7, 1961 D. G. DOW 2,971,114

HELICALLY-STRAPPED MULTIFILAR HELICES

Filed July 23, 1959

FIG_1

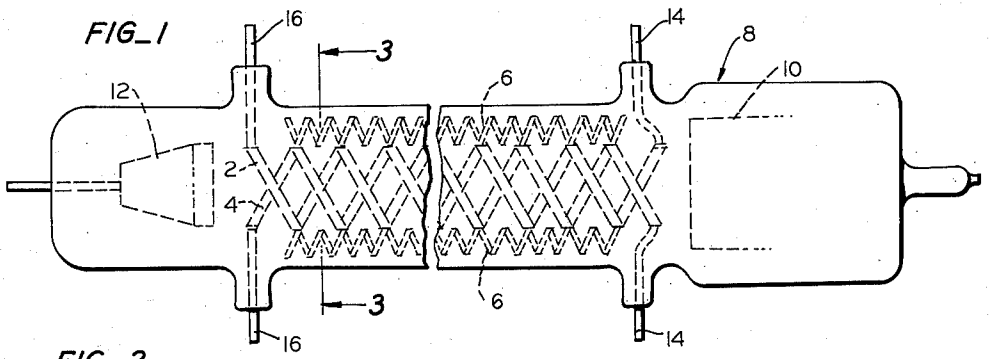


FIG_2

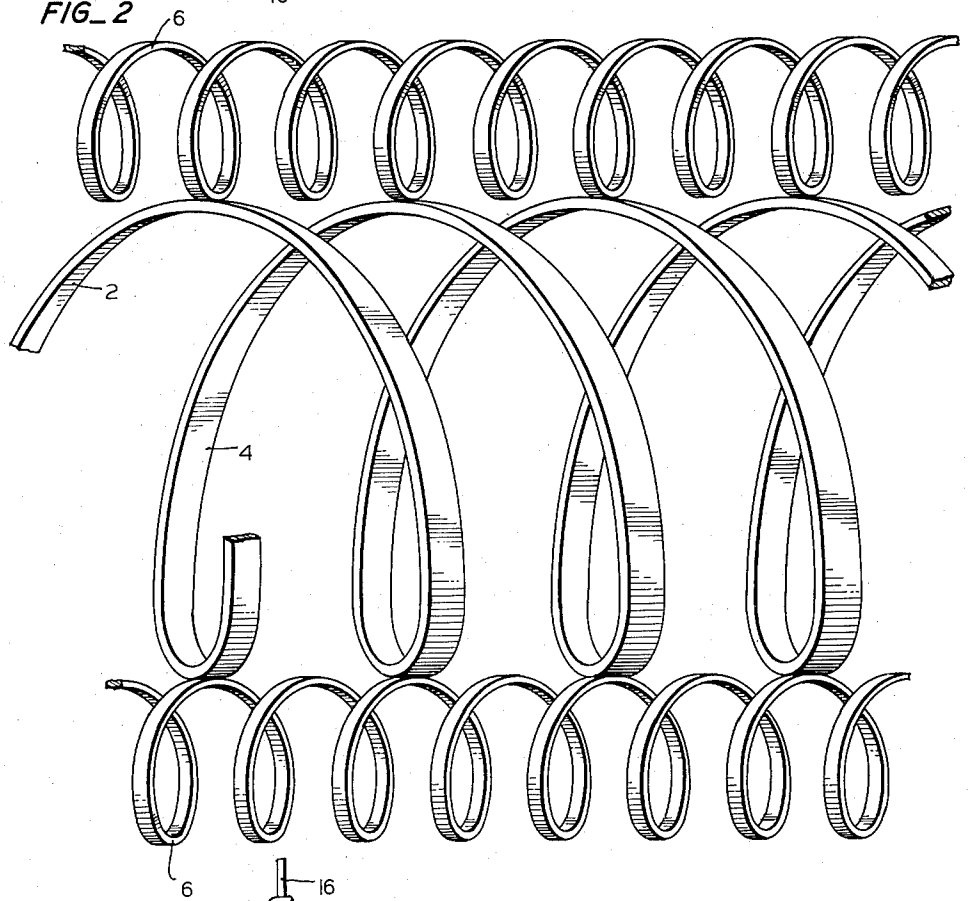
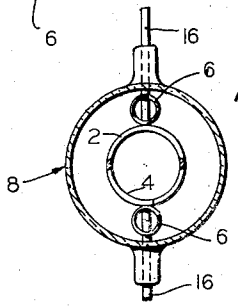


FIG_3



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HELICALLY-STRAPPED MULTIFILAR HELICES

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4 Claims. (Cl. 315—3.6)

This invention relates to a slow-wave structure for traveling-wave amplifier tubes, and more particularly to helically-strapped multifilar helices.

An object of the invention is to provide a traveling-wave tube which will have a large 3-db bandwidth and which will be 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 ratio of the frequencies at the 3-db down points on the response curve ranges from 1.5:1 to 2:1 or more.

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 constituting one preferred embodiment of the invention;

Fig. 2 is an enlarged axonometric view of a portion of the slow-wave structure removed from Fig. 1; and

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

Reference is made to the drawing. The preferred illustrated embodiment of the slow-wave structure of this invention is a multifilar helix shown as a bifilar helix comprised of two separate helices **2** and **4**. These two separate helices constitute the main helix, of radius *a*, being formed of two identical helices spaced equally along a common axis. Although the drawing shows, as noted, a bifilar helix (two helix array) the invention comprehends the use of more than two identical helices to constitute the main helix. Auxiliary helices **6** provide a firm electrically conducting contact with the main helices wherever they meet and serve to electrically join the separate helices of the main helix in conducting relation. The auxiliary helices can also be multiple-wire helices, but it is satisfactory to make them as illustrated, in the form of simple, single or monofilar helices. The auxiliary helices are constructed in such a way that the average phase velocity of an electromagnetic wave in the fundamental helix mode, along either one of them by itself, is approximately the same as the velocity of the similar mode along the separate helices constituting the main helix, when considered by themselves.

The illustrated helix is shown in Fig. 1 embodied in a conventional traveling-wave tube, generally indicated at **8** which includes an electron gun **10**, a collector **12**, input terminals **14**, and output terminals **16**. The electron beam travels generally along the axis of the main helix. The helically-strapped multifilar helix slow-wave structure can be supported by simply resting against the glass envelope of the tube, if desired.

This type of support offers an advantage over certain other slow-wave structures in that it requires no obstructing interior supports within the main helix and hence can

be conveniently used with a single electron beam inside the structure, thus simplifying a number of constructional problems.

Although there can be any number of auxiliary helices, the most useful situation occurs when the number of auxiliary helices is the same as the number of helices in the central portion or main helix of the structure. These auxiliary helices are spaced evenly around the circumference of the main array.

The cross-sectional form of the conductors constituting the various helices can be that of a tape, as in the illustrated embodiment, or can be of any other convenient shape.

The relative diameters of the main helices and the auxiliary helices may vary. The larger the auxiliary helices, relative to the main helices, the less chance there will be of backward-wave oscillation, but there will be some simultaneous lowering of interaction efficiency.

The individual phase velocities of the various helices can be modified, depending on various non-ideal properties of a particular system, such as dielectric loading, and electronic loading, which may be frequency dependent.

Operation

An understanding of the operation of the helically-strapped helix of this invention can perhaps best be achieved by considering an unstrapped multifilar helix in the form of a bifilar helix.

The unstrapped bifilar helix has an infinity of possible modes of propagation, two of which are important here. The so-called "even" mode is characterized by fields at the two helices being in phase with each other. It has a forward-traveling space harmonic which is useful for wide band forward-wave amplification and a moderately strong —2 backward space harmonic which may cause oscillations at extremely high currents. An "odd" order or "push-pull" mode also exists for which the fields at the two helices are out of phase at any cross-section. This mode has a very strong backward space harmonic that will generally cause undesired oscillations necessary for forward amplification.

The present invention utilizes the very strong coupling between the inner and outer helices to distort or suppress completely the odd mode. Since the even mode synchronizes approximately with the auxiliary helices, there will be negligible effect on the propagation velocity of this mode (which is the one desired for forward-wave amplification). The odd mode, however, has no counterpart on the auxiliary helices, since they have a tighter spacing, in general, and thus a different set of space harmonics, including none which are close to those of the odd mode of the multifilar main helix. Thus the odd mode will be severely distorted by the auxiliary helices.

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 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 parallel intertwined helices, each separate helix having the same constant pitch, the same constant pitch angle, and same constant mean radius, and lying along a common axis; said separate helices being spaced from each other in such a manner that the distance measured in a direction parallel to the axis of the multifilar helix between a point on one turn of the multifilar helix and the corresponding point on the next adjacent turn of the multifilar helix is the same for every such pair of turns of the multifilar helix; and a plurality of auxiliary conducting helices, spaced evenly around the circumference of said multifilar

helix and in firm electrically-conducting contact with the said separate helices wherever they meet, the auxiliary helices being tangent to the said separate helices and having their axes parallel to the axis of the multifilar helix.

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 number of auxiliary helices equals the number of separate helices constituting the multifilar helix.

4. In a traveling-wave tube, an electron gun and a collector for electrons spaced apart in said tube for forming an electron beam, and a slow-wave structure; said slow-wave structure comprising a multifilar helix positioned to surround said electron beam and including a plurality of separate parallel intertwined helices, each separate helix having the same constant pitch, the same constant pitch angle, and same constant mean radius, and lying along a common axis; said separate helices being spaced from each other in such a manner that the distance measured in a direction parallel to the axis of the multifilar helix between a point on one turn of the multifilar helix and the corresponding point on the next adjacent turn of the multifilar helix is the same for every such pair of turns of the multifilar helix; and a plurality of auxiliary conducting helices, spaced evenly around the circumference of said multifilar helix and in firm electrically-conducting contact with the said separate helices wherever they meet, the auxiliary helices being tangent to the said separate helices and having their axes parallel to the axis of the multifilar helix.

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