Sept. 12, 1950 A. K. WING, JR 2,522,419

FILAMENT STRUCTURE

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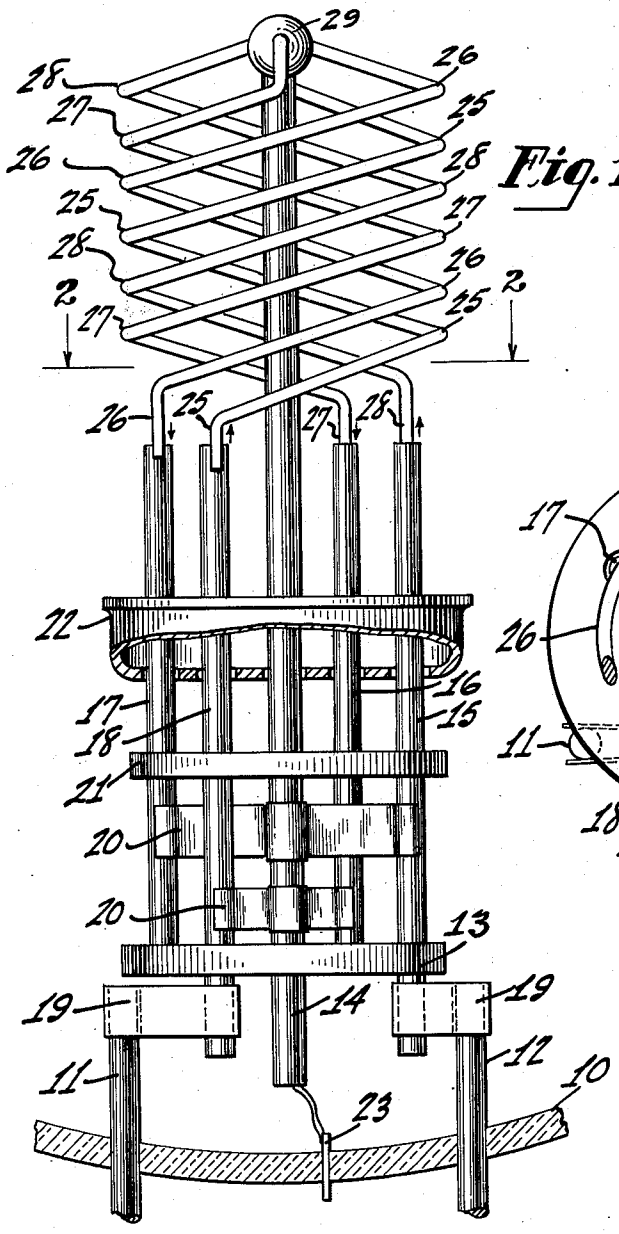


Fig. 1.

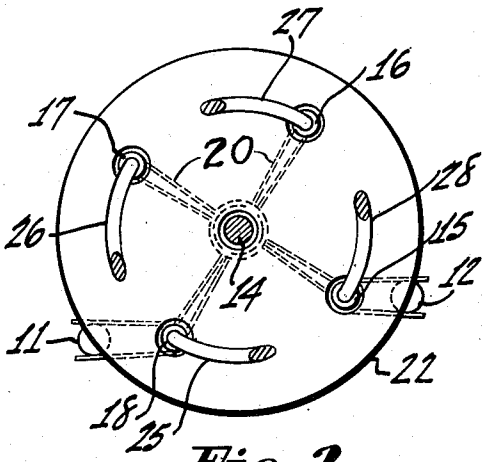


Fig. 2.

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FILAMENT STRUCTURE

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My invention relates to a filamentary structure for thermionic tubes and more particularly to a filamentary structure which is useful as a filamentary cathode, particularly in high power thermionic tubes, and as a heater for indirectly heated cathodes.

Filamentary cathodes which have adequate cathode emission for high power thermionic tubes at a filament temperature low enough to give satisfactory life must have ample filament surface area. The conventional double helical or reverse coil filament cathode such as shown in United States Patent 1,745,181, Mischler, January 28, 1930, is essentially two coaxial series-connected helices or helical coils of the same pitch with the turns of one coil interleaved with the turns of the other coil. As the adjacent turns carry current in opposite directions, the magnetic forces between the adjacent turns or strands tend to maintain the spacing between the turns, hence the structure is inherently stable. When the two helical coils are operated in parallel with the current flowing in the same direction in both coils, the structure is unstable, as any deviation in spacing between adjacent turns results in a cumulative distortion which pulls the turns together. The surface area of a double helical filamentary cathode can be increased by decreasing the pitch so that more turns are wound in the available space, but this expedient reduces the mechanical stiffness of the cathode. A double helical filament could be extended by adding more turns of the same pitch, preferably with a simultaneous increase in pitch to counteract the decrease in stiffness resulting from the longer helix with the disadvantage that the physical length of the cathode is increased with correspondingly higher interelectrode capacitances, which is objectionable in tubes intended for operation at high frequency.

The principal object of my invention is to provide a stable filamentary structure which has considerably greater stability and surface area than a conventional double helical reverse coiled filament occupying the same space, and which is suitable for high power thermionic tubes and particularly for tubes operated at high frequencies, such as 300 megacycles. Another object is to provide a filamentary structure which is useful as a heater for indirectly heated cathodes on account of its inherent stability and almost complete freedom from hum due to the magnetic fields set up when the filament is energized with alternating current.

In accordance with my invention I increase the

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emissive area of the cathode by using a plurality of pairs of helices or helical coils connected in such a way that adjacent turns carry current in opposite directions, thereby obtaining a filament surface greater than that of a conventional double helical filament and an increasing inherent stability at least equal to that of the double helical filament. The filamentary structure preferably comprises an even number of helices or helical coils threaded one within the other with each turn of each helix juxtaposed to the turns of the helix next to it, so that each turn of a helix lies alongside a neighboring turn. All of these helices are joined and electrically connected at one end of the structure at a common point which is electrically the mid-point of the filament cathode. The other or free ends of the helices are so connected to the current supply terminals that current flows in one direction through one helix and in the opposite direction through the helix next in order around the structure. In every turn of each helix the direction of current flow is opposite to that of the current flow in the next or neighboring turn of the adjacent helix. The free ends of the helices opposite to the ends which are joined at a common point are arranged in a row or array, preferably on the circumference of a circle, and in the same order in which the helices are positioned along their common longitudinal axis. By connecting one current supply terminal to the free end of every other or alternate helix in order around the array, and connecting the other current supply terminal to every other or alternate free end in the array, the current flows through the helices in such a way that all of the adjacent turns carry current in opposite directions.

My invention will best be understood in connection with the accompanying drawing in which Figure 1 is a vertical plan view of a preferred form of my invention showing the filamentary structure as a directly heated cathode, the conventional grid and anode with which it is used being omitted, and Figure 2 is a cross section of Figure 1 along the line 2—2.

In the particular form of filamentary structure which I have shown merely for illustration of one embodiment of my invention a glass stem 10, preferably of the disc or cup-type, carries a mount which has two rigid terminals 11 and 12 sealed into and extending through the stem. These terminals supply current to the filament and also support the mount on the stem.

The mount comprises an insulating disc 13 which carries a metal filament support rod 14

at its center and near its rim four inner leads, 15, 16, 17 and 18 positioned at the corners of a square of which the support rod is the center. The two inner leads 15 and 18 extend through the disc 13, and their lower ends are electrically connected to the two terminals 11 and 12 respectively by sheet metal connectors 19, which are welded to the inner ends of the terminals and to the lower ends of the leads 15 and 18 and rigidly connect the terminals to the leads and also support the disc 13. The inner lead 15 is connected to the diametrically opposite inner lead 17 by a jumper 20, which at the middle is enlarged to encircle without touching the support rod, and inner lead 16 is similarly connected to inner lead 18. The inner leads and the center support rod are preferably steadied by an insulating spacer 21. A cup-shaped metal shield 22 mounted on and electrically connected to the center support rod and having in the bottom four holes through which the inner leads extend without touching the shield surrounds the inner leads near their upper ends. Electrical connection to the midpoint of the filamentary cathode may be made by a lead-in wire 23 sealed into the stem and connected to the center support rod 14.

In accordance with my invention the filamentary structure of the mount comprises four substantially identical helices or helical coils 25, 26, 27 and 28, all of the same diameter, length and pitch mounted coaxially and threaded together screw fashion and with their upper ends remote from the stem all joined and electrically connected to one another, for example by arc welding at a common point 29 which, in the embodiment shown, is also the upper end of the filament support rod 14. The other, or free ends of the four helices are arranged in a row or array about the center support rod and each end is joined to an inner lead. The terminal 11 is connected to the free ends of helices 25 and 27 which are connected in parallel to the common point 29, and the terminal 12 is connected to the free ends of the helices 26 and 28 which are also connected in parallel to the common point 29. Assuming for convenience that terminal 11 is positive, and that current flows from the positive terminal 11 to the negative terminal 12, the current will flow through all four helices in the directions indicated by the arrows and in opposite directions in each turn of the adjacent helices. For example, the current passes through helix 25 from the inner lead 17 to the common point 29 and thence through the next helix 26 to the inner lead 15, and so on in order around the array. As the helices are substantially identical, the same amount of current flows through each helix. I have found that in a filamentary structure made as shown in the drawing with four helices and even with a pitch increased over what would ordinarily be used with the conventional double helix the filament surface available in the same overall physical space is about 60% more than with the conventional double helix. The increased pitch of each individual helix has resulted in a filament assembly having markedly better stability than a conventional double helix filament. It is obvious that more than the four strands shown in the drawing can be used, the only limitation on the number of strands being reasonable clearance between helices and the physical arrangement of the legs and the inner leads. A helical filament structure of large diameter can be designed in accordance with my invention by using a steep pitch for each of a large number of strands, thus obtaining a stability not obtainable with the conventional double helix.

What I claim as new is:

1. A filament structure for thermionic tubes comprising four substantially identical coaxial helices threaded one within the other with their turns juxtaposed and each having a turn lying substantially alongside a turn of a neighboring helix, a support rod extending through said helices, one end of said support rod being connected to adjacent ends to said helices, four inner leads of relatively large cross-section connected to the other ends of said helices for effectively supporting said helices and for providing good electrical connection thereto, alternate ones of said inner leads being connected electrically for providing current flow in the same direction in alternate ones of said helices, and two lead-ins connected to said inner leads whereby induction effects on each helix is neutralized and the current in the several helices is maintained substantially the same.

2. A filament structure for thermionic tubes comprising a plurality of pairs of coaxial coils of the same pitch and size threaded into one another with their same ends adjoining and electrically connected to a power supply of the same potential the other ends of said coils being arranged in a row in the same order as said coils are positioned along their longitudinal axis, a current supply conductor connected to said other ends of alternate coils, and a second current supply conductor connected to said other ends of the remainder of said coils.

3. A filament structure for thermionic tubes comprising four coaxial coils of the same diameter and pitch threaded into one another with their turns juxtaposed and equally spaced, the same ends of said coils being electrically connected at a common end of a centrally located post, and a pair of current supply conductors, the other ends of the first and third coils being connected to one of said conductors and of the second and fourth coils to the other conductor.

4. A filament structure for thermionic tubes comprising a plurality of pairs of parallel connected coaxial filament coils threaded into one another with juxtaposed turns equally spaced from one another, said coils electrically connected by a single centrally located support at one end and having their opposite ends arranged side-by-side in an array in the same order as said coils are distributed along their longitudinal axis, a pair of current supply terminals, and means for electrically connecting alternate filament ends of said array to one terminal and the other filament ends to the other terminal, whereby said coils of each group are connected in parallel and current flows in one direction in one coil and in the opposite direction in the next coil in order around the array.

5. A filament structure for thermionic tubes comprising a plurality of pairs of substantially identical coaxial helical coils threaded one within the other, each of said coils comprising a separate element, the ends of said coils at one end of said structure being relatively closely spaced from each other, a rod extending through said coils longitudinally thereof, one end of said rod being connected to said ends of said coils, the other ends of said coils being farther spaced from each other than the first-mentioned ends, inner leads of relatively large cross-section connected to said other ends of said coils, said inner leads being dis-

posed in a planar array wherein alternate ones of said leads are connected to alternate ones of said coils longitudinally of said structure, and two other electrical conductors of relatively large cross-section connected to said alternate leads whereby a rugged structure is provided and freedom from induction effects in the coils is assured.

6. A filament structure for thermionic tubes comprising four identical coaxial helical coils threaded into each other with each turn of the two intermediate coils between the turns of two neighboring coils and the turns of all said coils juxtaposed and equally spaced, a single conductive support joined to the same end of said coils, whereby the potential applied to said support will be the same for each of said coils, and two current supply conductors at the other ends of said coils, said other ends of alternate coils being connected to one of said conductors and said other ends of the remainder of said coils connected to the other conductor to cause the direction of current flow in each turn of each coil to be opposite to the direction of current flow in the turn next to it.

7. A filament structure for thermionic tubes having a plurality of pairs of substantially similar axially disposed but angularly displaced coils whereby the coils are threaded one within the other and having a set of adjacent ends disposed in a substantially circular array, inner leads of relatively large cross-section disposed in parallel relation and connected to said coils at their said adjacent ends, a rod support extending through said structure, the other set of adjacent ends of said coils being relatively closely spaced from each other and connected to one end of said support rod, a lead-in for said structure, said lead-in being connected to alternate ones of said inner leads, whereby alternate ones of said coils receive current in the same direction, and another lead-in connected to the other of said inner leads whereby the other of said coils receive current in a direction opposite to said first-named direction whereby induction effects in the coils are neutralized.

8. A mount for an electron discharge device including a filamentary cathode and support therefor, said cathode comprising a plurality of coaxial coils threaded into one another, said support comprising means at one end of said mount for supporting said coils comprising a conducting rod supported at the other end of said mount and extending longitudinally through said coils, one set of adjacent ends of said coils being connected to one end of said conducting rod, a plurality of additional conducting rods connected to the opposite adjacent ends of said coils, an insulating support for said conducting rod and said additional conducting rods, and two lead-ins for said cathode, said lead-ins supporting said insulating support.

ARTHUR KYLE WING, JR.

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