May 29, 1956 G. J. AGULE 2,748,310

FILAMENT STRUCTURE

Filed Sept. 16, 1952

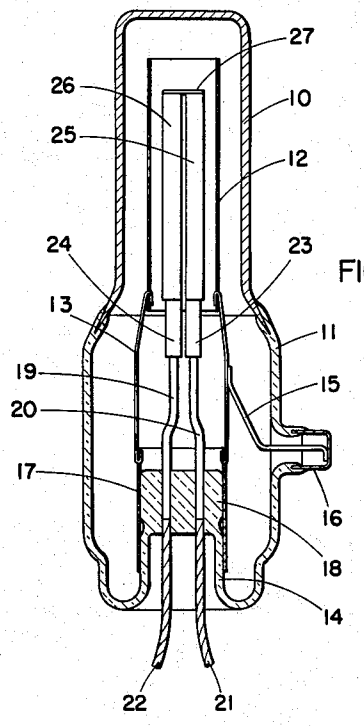


FIG. 1

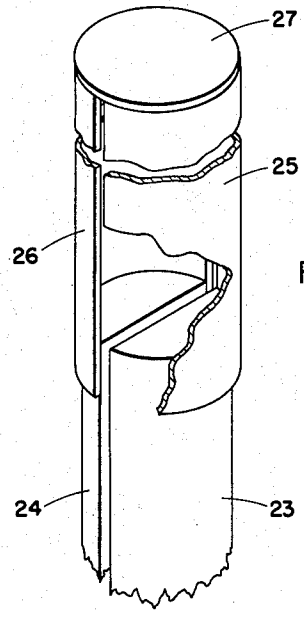


FIG. 2

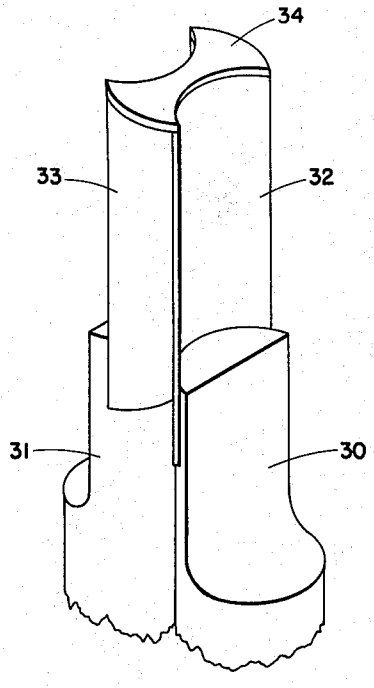


FIG. 3

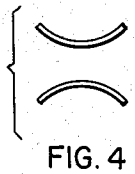


FIG. 4

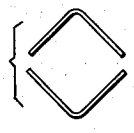


FIG. 5

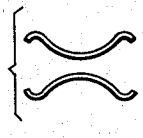


FIG. 6

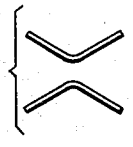


FIG. 7

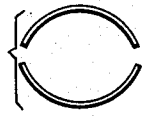


FIG. 8

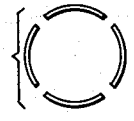


FIG. 9

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United States Patent Office 2,748,310 Patented May 29, 1956

2,748,310

FILAMENT STRUCTURE

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Application September 16, 1952, Serial No. 309,855

5 Claims. (Cl. 313—247)

This invention relates to a filament structure for use in electron tubes. More specifically, this invention concerns a rigid, self-supporting, directly heated type of cathode which is easily fabricated to precise dimensions.

Self-supported filament structures, particularly those of the so-called free hung or squirrel cage type, are considered desirable in the electronic art because their simplicity in structure results in ease of fabrication and reduction in capacitive coupling with other elements due to elimination of complicated support structures. However, self-supported cathodes have, in general, proved less rigid than cathode structures which are supported at both ends. The lack of rigidity has permitted lateral movement of the filament due to mechanical shock or vibration of the tube. When lateral movement causes the filament to short to its adjacent electrode, the electrical characteristics and opertaion of the tube are upset and the fragile filament strands may be broken. Breakage is particularly common where the filament structure is long, brittle material is employed in the filament wires, and/or the filament wires are of small diameter. Breakage of filament strands has become a particularly serious problem during the shipping of tubes.

My invention provides a self-supporting cathode structure which is unusually sturdy and rigid. The relative rigidity of my structure is due to its shape and arrangement of parts, and particularly to the shape and arrangement of the several active portions of the cathode. These active cathode portions are composed of sheets of emissive material or emitter base material instead of relatively fragile filamentary wires. The sheet material portions forming the active cathode elements are shaped into various non-planar forms. In so shaping these sheets, care is taken to form them in such a way that parallel elements running in one direction in the sheet will remain parallel. Usually the elements which are to remain parallel are selected such that they are also lengthwise elements of the sheet. Thus shaped, the sheets have a considerable amount of rigidity and resistance to bending across the parallel elements of these sheets. Further rigidity is obtained by arranging the sheets in a configuration such that lateral movement tending to bend the filament toward its adjacent electrode will necessitate bending all of the strips across these parallel elements. Likewise, any outward bowing of portions of the active filament due to magnetic effects produced by heater current will also be resisted because such bowing necessitates bending the sheets across their parallel elements.

In the preferred form of my invention a plurality of non-planar active cathode sheets of refractory metal are arranged in an axially symmetrical configuration such that the sheets extend in the same general direction and such that the parallel elements of each of these sheets are parallel to the parallel elements of the other sheets. In order to permit the flow of current through these sheets, one edge of each of the sheets is conductively connected to an edge of each of the other sheets and preferably the corresponding edges of said sheets. These mutually connected edges are otherwise mechanically unsupported. The opposite edge of each sheet is mechanically supported on means ultimately supported on the vacuum envelope. This supported edge of each sheet is also electrically connected to a conductor means which provides a conductive path to the outside of the vacuum envelope. The support and conductor means are frequently the same members.

In order to increase the rigidity of my filament structure and to maintain the proper non-planar shape of the emissive portions of the filament, the sheets may be fixed to rigid members which conform to the non-planar shape of the sheets. These rigid shape preserving members may either have an edge or a surface which conforms to the shape of the filament sheet, which edge or surface is advantageously fixed to the sheet by a joint which is generally perpendicular to the parallel elements of that emissive member. Such rigidizing members may be placed at any axial level, and it is possible for either the conductor at the unsupported end of the filament or the support members at the supported end of the filament, or both, to serve as the sole aid to rigidizing the sheets. Thus, the conductor joining the otherwise unsupported end of the filament is advantageously composed of a planar member having edges affixed to the edges of the sheets by welding or other appropriate means. Similarly, the members which support the filament structure may be shaped to conform to the shape of the sheet members. The use of shape conforming members at the opposite edges of the sheets usually provides sufficient rigidity, but, if the sheets are unusually long, intermediate non-conducting members conforming to the shape of the non-planar sheets may also be employed. An additional means of adding to the rigidity of the filament structure will be described hereinafter.

My filament structure has many advantages. For instance, the sheet members forming the active portions of the cathode may be formed to very precise dimensions. Other members of the cathode structure may also be made to precise dimensions. In addition, the relatively few pieces necessary to fabricate my cathode minimize the danger of cumulative error in overall cathode dimensions. These several provisions permit of making a self-supported cathode structure of much more accurate dimensions than those heretofore employed. The relatively few pieces involved and the ease of fabrication of these pieces make manufacture of my cathode relatively simple. Furthermore, the structures of my invention lend themselves to fabrication using well known and inexpensive methods and processes of manufacture.

Emission of my novel cathode represents improvement both quantitatively and qualitatively over the prior art. Because of the relatively large surface area of the active cathode, more emission is possible from my structure than from a prior art structure of the same overall dimensions. Thus, it is possible to reduce cathode size and yet have increased emission using my cathode structure. Qualititatively, structures of my invention permit more efficient use of their emission through electron beaming. Since the shape of the emitting surface may be made to vary considerably, the type of beaming obtainable may vary through wide ranges. On the other hand, emission without beaming is also possible.

For a better understanding of my invention reference is made to the following drawings:

Fig. 1 illustrates in section an electron tube triode in which my novel structure is employed.

Fig. 2 illustrates an enlarged, foreshortened view of the cathode illustrated in Fig. 1 in perspective and in partial section.

Fig. 3 illustrates in perspective a modified form of my cathode structure.

Fig. 4 is a schematic view taken perpendicular to the parallel elements in the sheet members and showing the arrangement and shape of the sheet members in a filament configuration similar to that of Fig. 3.

Fig. 5 is a schematic view of the same general type as that of Fig. 4 showing an alternative filament sheet arrangement.

Fig. 6 is a schematic view of the same general type and arrangement as Fig. 4 with an added structural feature providing greater overall rigidity.

Fig. 7 is a schematic view similar in type to Fig. 4 showing another filament configuration.

Fig. 8 in a view similar to that of Fig. 4 shows a modification of the Fig. 2 structure.

Fig. 9 in a view similar to that of Fig. 4 illustrates an alternative arrangement to produce emission essentially in the pattern of that produced by the filament of Fig. 2.

Referring to Fig. 1, and electron tube triode is illustrated in section. The vacuum envelope of this electron tube is composed of a cup shaped external anode **10** of copper or other suitable conductive material and glass bulb **11** which is sealed to the lip of cup **10**. Within the vacuum envelope, located coaxially within cup shaped anode **10**, is grid structure **12**. Grid structure **12** is supported upon supporting structure **13** which in turn is affixed to a reentrant portion of the vacuum envelope **14**. An electrical connection **15** from the grid supporting structure is connected within cup shaped terminal **16** which is sealed to the side wall of the vacuum envelope **11**.

Reentrant envelope portion **14** terminates in stem press **18** through which are sealed cathode lead-in wires **19** and **20**. Lead-in wires **19** and **20** are terminated outside the vacuum envelope in leads **21** and **22** and inside the vacuum envelope in support-conductor members **23** and **24**, which may advantageously be composed of molybdenum. Support-conductor members **23** and **24** are each affixed respectively to active cathode members **25** and **26**. Active cathode members **25** and **26** are sheets of non-planar shape. In this case they are of semi-circular section and arranged in a circular cylindrical configuration. The sheets may be composed of pure or thoriated tungsten, or they may be composed of a suitable base metal, oxide or thoria coated. In order to minimize heater currents required, the cathode sheets are made quite thin, advantageously in the order of .0005 inch thick. In forming the active portions of the cathodes **24** and **25** to a non-planar shape, the lengthwise elements of the members are maintained parallel. The contour of the surface of support members **23** and **24** is advantageously made to conform to the desired shape of the active cathode sheets and the sheets are advantageously affixed against the support members in such a manner, as by welding, that the support members will help the active portion retain its particular non-planar shape. Similarly the conductive member **27** which joins the edges of the sheet member **25** and **26** at the otherwise unsupported end of the filament may be made of disc shape in order to conform to the contour of active cathode members **25** and **26**. Thus, the disc conductor **27** may be affixed to the corresponding edges of sheets **25** and **26** along the full length of said edges, thereby substantially adding to the rigidity of the cathode structure. This type of cathode structure may be substituted for filamentary cathodes of cylindrical geometry. It has the advantages of relatively great rigidity, high emission, and precision fabrication.

Fig. 2 shows in perspective the cathode structure of Fig. 1 enlarged and foreshortened. It has been partially cut away in order to show the details of construction more clearly.

A modified version of the cylindrical cathode structure of Figs. 1 and 2, having support portions shortened so that the path length between the active filament and a cathode terminal outside the tube envelope is minimized, provides an ideal high emission density cathode for use at high frequencies. The precise dimensions to which my cathode can be made enable the manufacture of tubes with smaller interelectrode spacing between the cathode and its adjacent electrode, thereby reducing electron transit time. The rigidity of my cathode structure prevents the filament from shorting to the grid despite their close spacing. Then, too, the uniformity of the spacing between almost all the points on the cathode surface and the adjacent electrode insures uniform transit time for practically all electrons emitted. Finally, the high emission density of my structure's active portion makes possible a comparatively short cathode, even for high power applications, so that my structure is useful up to microwave frequencies until the overall length of the active filament exceeds one-sixteenth of the wavelength.

Fig. 3 illustrates a modified cathode structure of my invention wherein the active cathode sheet members are made concave. The support-conductors **30** and **31** are each affixed to active cathode sheet members **32** and **33** by welding or other appropriate means. Sheet members **32** and **33** are in turn connected together at the edge opposite the supported edges by conductive member **34**, which also supplies rigidity to the structure and helps maintain the shape of the structure by means of a continuous joint between an edge of each sheet and the edge of the conductive member **34** which edges correspond in shape. This structure has the advantage of producing beamed emission. The electrons emitted from the active surfaces of this structure will tend to converge somewhere in front of the active surface. If the emission from the back surface of members **32** and **33** is also employed, a beamed type of focusing of that emission will also result.

The arrangement of active filament portions shown in Fig. 4 is essentially the same as the arrangement in Fig. 3. This arrangement produces beamed emission.

Fig. 5 illustrates in section, an electrode arrangement wherein emission would occur in four distinct directions. Use of grid and anode structures parallel to each of the planar surfaces of this structure yields the advantage of panar electrode arrangement of a multiple basis.

Fig. 6 illustrates an arrangement similar to that of Fig. 4 except that the edges of the concavity are rolled back in an arc of small curvature. The emission of this arrangement is like that of Fig. 4 arrangement, beamed and convergent, but some of the emission will not tend to focus as in the case of the structure of Figs. 3 and 4 because of the rolled back edges. Rolling the edges back adds rigidity to the cathode structure and is valuable when the active cathode sheets are long. Rolling or bending the edges back to obtain added rigidity is a useful expedient for any shape of active cathode sheet.

Another type of beamed emission is possible with the structure of Fig. 7. It should be noted that this arrangement permits the use of both the front and back of the active cathode surfaces. Thus unlike cathodes of the prior art, essentially the whole emission of this cathods arrangement may be utilized, thereby effectively providing four V-shaped emitting areas. The emission of each of the four emitting areas is beamed. Careful selection of combinations of spacings and angular shape of the active cathode will yield four emission patterns which are essentially identical at the anode surfaces.

The structure of Fig. 8 is useful in a geometry wherein divergent emission in two approximately opposed directions would be desirable.

The structure of Fig. 9 is suitable for use in a tube of conventional cylindrical geometry and is a satisfactory substitute in most instances for the structure of Fig. 2. It is perhaps a more convenient structure to fabricate for use in tubes of large dimensions where active segments providing 180° of a cylindrical surface might be cumbersome to handle.

Many variations on the shape and arrangement of the structures shown may be conceived, each of which is within the scope and spirit of this invention. Likewise,

arrangement of the active portions in helical or other more complex shapes is also within the scope of my invention. In addition, changes in the support members or the conductor member at the unsupported end of the structure are within the scope of the claims and are contemplated by my invention.

I claim:

1. A filament structure comprising a plurality of refractory metal strips of arcuate cross-sectional shapes symmetrically arranged about an axis to form a substantially cylindrical emission surface, all of which strips extend generally in the same direction, are the same length and terminate at the same level, means symmetrical to the said axis conductively connecting together adjacent ends at one end of the strips and support conductor means having cylindrical segment mounting surfaces conforming to the shapes of and connecting the opposed ends of the strips.

2. In an electron tube embodying an envelope including an anode of cup-shaped form, a cathode structure within the envelope comprising a plurality of elongated strips of metal sheet material of substantially arcuate cross-sectional shapes arranged within the anode and symmetrically encircling the axis thereof with the convex surfaces of the strips forming a substantially cylindrical emission surface, supporting means for the strips comprising a support member for each individual strip having a supporting surface rigidly secured to a surface of the strip adjacent one end thereof and shaped to conform to the shape of the surface to which it is secured, and conducting means connecting together the unsupported ends of the strips.

3. In an electron tube embodying an envelope including an anode of cup-shaped form, a cathode structure within the envelope comprising a plurality of elongated strips of metal sheet material of substantially arcuate cross-sectional shapes arranged within the anode and symmetrically encircling the axis thereof with the convex surfaces of the strips forming a substantially cylindrical emission surface, supporting means for the strips comprising a support member for each individual strip having a supporting surface rigidly secured to a surface of the strip adjacent one end thereof and shaped to conform to the shape of the surface to which it is secured, and conducting means connecting together the unsupported ends of the strips comprising a planar conductor of sheet metal material mounted on and rigidly secured in bridging relation to the ends of the strips.

4. In an electron tube embodying an envelope including an anode of cup-shaped form, a cathode structure within the envelope comprising a plurality of elongated strips of metal sheet material of substantially arcuate cross-sectional shapes arranged within the anode and symmetrically encircling the axis thereof with the convex surfaces of the strips forming a substantially cylindrical emission surface, supporting means for the strips comprising a support member for each individual strip having a supporting surface rigidly secured to a surface of the strip adjacent one end thereof and shaped to conform to the shape of the surface to which it is secured, and conducting means connecting together the unsupported ends of the strips comprising a planar conductor of sheet metal material mounted on and rigidly secured in bridging relation to the ends of the strips and having a substantially circular peripheral shape conforming substantially to the configuration of said emission surface.

5. An electron tube comprising an evacuated envelope having a reentrant end portion at one end and a cup-shaped anode at its other end, a grid structure of cylindrical shape located coaxially within the anode and supported upon said reentrant end portion, a cathode structure within the grid structure comprising a plurality of elongated strips of metal sheet material of substantially arcuate cross-sectional shapes symmetrically encircling the axis of the grid structure with the convex surfaces of the strips forming a substantially cylindrical emission surface for emission of electrons in all directions onto the anode, supporting means for the strips comprising a support member for each individual strip mounted on said reentrant end portion and having a supporting surface rigidly secured to a surface of the strip adjacent the end thereof nearest the reentrant end portion, the supporting surface of each support member being shaped to conform to the shape of the surface to which it is secured, and conducting means connecting together the unsupported ends of the strips, and conductors connected with the grid and cathode structures respectively and extending through the envelope.

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