April 30, 1957 J. W. SKEHAN 2,790,924

FILAMENT STRUCTURE

Filed July 28, 1953

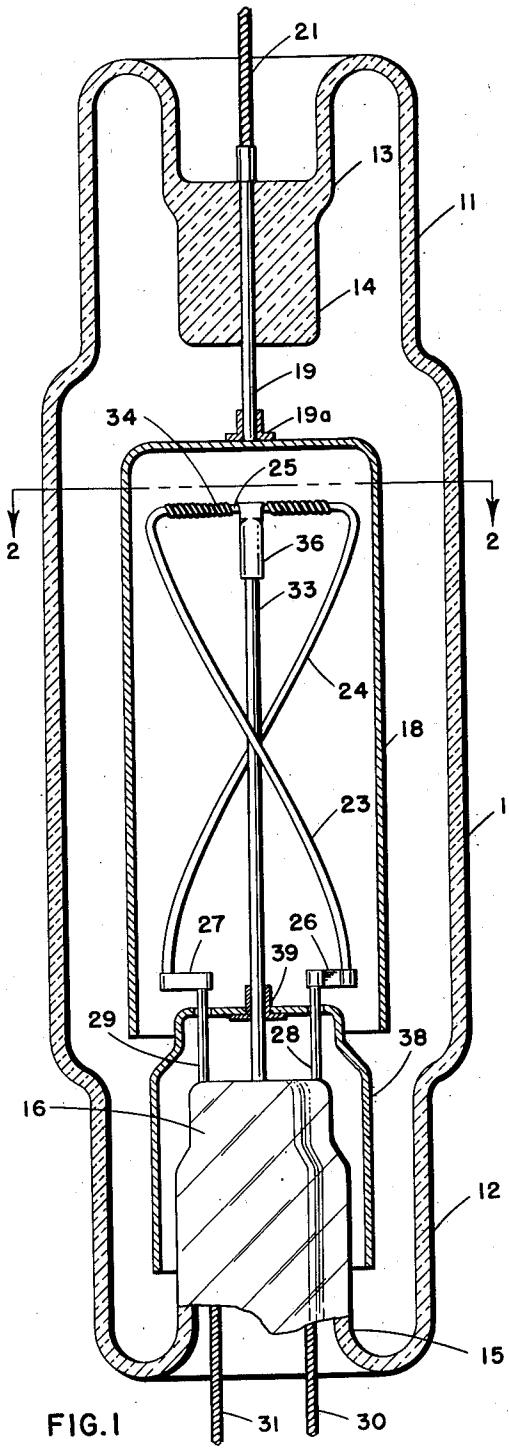


FIG. 1

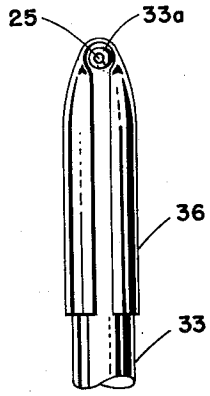


FIG. 3

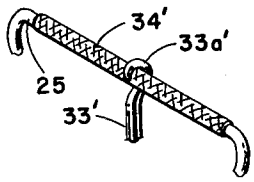


FIG. 4

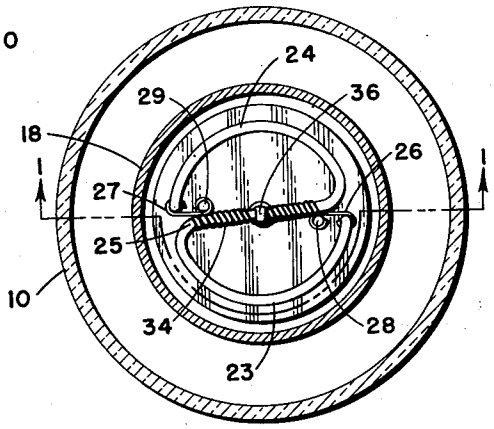


FIG. 2

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FILAMENT STRUCTURE

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6 Claims. (Cl. 313—273)

This invention relates to filament structures for use in electron tubes, particularly in high power electron tubes. In particular, this application relates to a simple, sturdy, filament structure which employs a simple support structure.

In modern tube applications it is desirable to provide filament structures which will provide maximum efficiency with minimum power loss. It is particularly desirable to obtain a high power output without having to dispose of a great deal of heat generated by lost power. To this end, filaments have been constructed of various high emission materials, such as thoriated tungsten, which require relatively low currents to attain a desired amount of emission. Unfortunately, such high emission materials are usually quite brittle or fragile. As a result of this brittleness and fragility, the rate of filament breakage has been extremely high in tubes employing these high emission materials for filaments.

Particularly in shipping, and to some extent in other handling, electron tubes are subjected to mechanical shock. When a strand of fragile or brittle material is mounted between a pair of relatively solid support members, it is unable to yield in such a manner as to absorb the shock, and the brittle strand will break.

The present invention provides a novel filament structure which is capable of absorbing mechanical shock without breakage. A structure having unlimited freedom to absorb shock would be undesirable because it would probably also have the ability to change shape and possibly to short to the adjacent electrode. This novel structure, while capable of considerable flexibility under shock, will retain its specific shape under all the shock conditions that are usually encountered. This shape is such as to permit accuracy in interelectrode spacing over the length of the active filament portions. The present structure involves solid mounting for the filament strand at one end and resilient mounting at the opposite end of the active filament portion. While the structure is quite rugged and able to absorb shock normally encountered in shipping and handling, it is also extremely simple and highly efficient.

The emissive portions of the filament are helical in shape and are coaxially arranged to conform to the contour of the adjacent cylindrical electrode. Across a diameter at one end of the cylindrical surface defined by these helical emissive filament portions extends a connecting or intermediate portion of the filament. This connecting portion is rigidized in such a manner that it will normally remain essentially straight and extend across the diameter of the cylinder but so that it will readily yield under shock. Usually this rigidization will cause an increase in the effective diameter of the non-emissive filament portion. Accordingly, this connecting portion may be considered essentially non-emissive because of its greater effective diameter, hence lower resistance and less tendency to become heated, than the emissive portions. It is important that this non-emissive portion be maintained in its position as a diameter of the cylinder so

that the helical portions will remain in their proper orientation. Rigidization of this non-emissive portion by reinforcing means causes it to maintain its diametric position and remain essentially straight except under conditions of shock. The means of the reinforcement may vary, but it is usually most convenient to wrap the proposed non-emissive portion of the filament with heavy wire, thereby forming a helical covering or sheath over the filament in the region which is to be non-emissive. Because of the resulting relative rigidity of this non-emissive portion, one solid support member then becomes sufficient to hold the whole non-emissive filament portion. This solid support is preferably furnished by an axial rod which is affixed to the reinforced non-emissive filament portion. The ends of the filament strand are terminated at the opposite ends of the cylinder defined by the filament portion. Each of these ends of the filament may be mounted on a solid support. These support members for the ends of the filament may be of any conventional type which permits the active filament strand to remain in position on the cylindrical surface which it defines.

For a better understanding of this invention reference is made to the accompanying drawings which may be generally described as follows:

Fig. 1 illustrates, in partial section taken along line 1—1 in Fig. 2, an electron tube diode employing my novel filament, which filament is shown in elevation;

Fig. 2 is a cross-sectional view of the tube shown in Fig. 1 taken along the line 2—2 in Fig. 1;

Fig. 3 is a detailed view of the supporting member for the non-emissive portion of my novel filament;

Fig. 4 illustrates modified means supporting and rigidizing the filament's essentially non-emissive portion.

Referring to the drawings, it may be seen that the present invention may be employed in an electron tube structure having a generally cylindrical vacuum envelope **10** advantageously composed of glass. At its opposite ends the diameter of the cylindrical envelope may be reduced to form neck portions **11** and **12**, respectively. The end of the envelope at neck portion **11** is terminated in a reentrant envelope portion **13** which itself is terminated in stem press **14**. Similarly, neck portion **12** is closed by reentrant envelope portion **15** which terminates in stem press **16**.

A generally cup-shaped anode **18** providing a cylindrical active surface internal of the cup is supported on the stem press **14**. Actual support is furnished by rod-like member **19** which is embedded in stem press **14** and connected by annular flange member **19***a*, or similar means, to the bottom of anode cup **18**. Supporting rod **19** penetrates the vacuum envelope through press **14** and is affixed externally of the vacuum envelope to a flexible lead **21**.

The filament structure consists of strand portions, which are preferably a single strand, as illustrated, apportioned into emissive and non-emissive portions of the filament. The emissive portions **23** and **24** are helical in form and preferably extend over 180°. They may extend over any selected angle, however. These helical portions are arranged coaxially in the tube to define a cylindrical surface which is coaxial with anode **18**. The non-emissive filament portion **25** extends generally diametrically across one end of the cylinder and joins the two helical portions **23** and **24**. Solid mounting is provided for the ends of the filament strand by tabs **26** and **27** which are connected respectively to rods **28** and **29**. As illustrated, rods **28** and **29** penetrate the vacuum envelope through press **16** and may be terminated respectively in flexible leads **30** and **31**. Solid support for the other position of the filament

is supplied by axial rod 33 which is embedded in stem press 16.

Use of this center mast support eliminates tabs similar to tabs 26 and 27 which have heretofore been widely employed at both ends of filament strands, i. e., as illustrated in my Patent Number 2,422,141. Such tabs are undesirable because they add to the overall filament resistance and because as the filament strand shifts within such tabs during use, the overall resistance of the filament structure is changed. Accordingly, elimination of two such tabs both reduces filament resistance and makes said resistance more stable. At the same time elimination of some of the tabs simplifies the filament structure and makes it less costly to manufacture.

Axial rod 33 is advantageously terminated in an eye 33a through which passes filament portion 25, as may be seen in greater detail in Fig. 3. A rigidizing covering 34 extends over much of the non-emissive portion 25 of the filament. This rigiziding covering advantageously consists of a helical winding of refractory metal wire of sufficient wire diameter and sufficient helical pitch to normally insure relatively fixed position of this non-emissive portion of the filament. This rigidizing means must, however, even at high temperatures, permit a minimum of flexibility which is sufficient to absorb shocks to which the filament is subjected, and at the same time a maximum of rigidity which will serve to prevent changes in shape of the supported emissive portions of the filament. A clip-like shield 36 is placed over the end of rod 33 to reinforce its relatively fragile eye portion 33a.

It is advantageous to employ shielding means at the filament end of the tube. Shielding means 38 is mounted upon axial rod 33 in some conventional manner, as by annular bracket 39, and arranged about stem press 16 to protect said press from high voltage effects, particularly from random particles. Care must be taken to prevent shield 38 from making contact with rod connections 28 and 29, and, accordingly, the holes in shield 38, through which said rods pass, are considerably enlarged.

As has been previously mentioned, this filament structure is particularly valuable for use with thoriated tungsten filaments. When thoriated tungsten filaments are employed, the high degree of vacuum required to prevent the poisoning of the thoriated filament may necessitate the use of getters within the tube envelope to clean up residual gases and to maintain a high degree of vacuum at all times. Any of the well known getter substances and gettering structures which are satisfactory for use with thoriated tungsten filaments may be employed with this novel filament structure.

When a thoriated tungsten filament is employed, high emission density is obtained because of the action of a tungsten carbide sheath forming the outer layer of the filament. In order to provide this carbide sheath, the thoriated tungsten filament is heated to a prescribed temperature for a prescribed period in a carbonaceous atmosphere. In the manufacture of the filament of the present invention, the thoriated tungsten filament is not placed in a carbonaceous atmosphere for activation until it is fully assembled. Preferably it is not carburized until it is mounted on one end of the tube envelope structure which is ready to be sealed to the rest of the tube envelope structure which mounts the other tube electrode. As the filament is heated in a carbonaceous atmosphere, the diametric portion of the filament does not readily heat because of its effective larger diameter and heavier mass than the rest of the filament due to the rigidizing covering employed therewith. As a result, only the helical portions of the filament are activated by the absorption of carbon, and the diametric portion of the filament, which must sustain most of the burden under conditions of vibration, is tougher, less brittle and less emissive than the activated portions of the filament.

Fig. 4 illustrates another type of termination for the supporting center mast and another type of rigidizing means for the non-emissive portion of the filament. In this instance, the casing 34' is engaged by hook member 33a' which terminates rod member 33'.

Many other modifications of the support and rigidizing means for the filament are possible. For instance, a tubular metallic member might be employed in place of the helical winding or braided covering. Many other means of rigidizing and supporting the non-emissive portion of the filament will occur to one skilled in the art and are capable of being substituted for the structures illustrated.

Although this invention is particularly valuable for use with thoriated tungsten filaments because of its ability to absorb shock and yet retain its shape and position, the present invention is valuable for use with other filament materials, too. Other variations in the structure shown and described are possible. For example, the filament strand may be composed of two strands in series rather than one, and more than one filament structure may be employed in a tube. Various other modifications in the structures shown and described will occur to those skilled in the art and are intended to be within the scope and spirit of this invention.

I claim:

1. A filament structure for use in electron tubes having a cylindrical electrode geometry, said filament structure comprising a filamentary strand having two emissive portions and an intermediate portion which is essentially non-emissive, said emissive portions being essentially helical in form and defining a cylindrical surface and said relatively non-emissive portion being of predetermined shape and diametrically crossing one end of the cylinder defined by the emissive portions, shape maintaining means secured to the non-emissive portion of said filament in order to maintain it in substantially its initial shape, support means affixed to the non-emissive reinforced portion, and separate support means at the ends of the filament strand at the opposite end of the cylinder from the reinforced filament portion and on the same general axial level with one another.

2. A filament structure for use within an electron tube having a cylindrical electrode geometry, said structure comprising stranded filament means which is apportioned into two emissive portions of essentially helical form defining a cylindrical surface and a non-emissive portion intermediate said emissive portions and generally diametrically mounted across one end of the cylinder defined by the emissive filament portions, means maintaining the diametrically mounted portion in substantially its initial shape, rod-like support means affixed to the non-emissive filament portion and support means at the ends of the stranded means at the opposite end of the cylinder defined by said filament from the non-emissive filament portion.

3. A rectifier tube having within a vacuum envelope a cylindrical anode and a filament structure having active emissive portions defining a cylinder coaxially mounted within said anode, said filament structure comprising a single filament strand having three portions, the two portions adjacent the end of said strand being essentially helical and being the emissive filament portions defining the cylinder and the intermediate non-emissive portion of the filament generally defining a diameter of the cylinder at one end thereof, a rigidizing wrapping consisting of wire helically wound around the non-emissive portion of the filament, an axial support rod affixed to the non-emissive portion, and a pair of support members at the respective ends of the filament strand at the opposite end of the cylinder from the non-emissive portion.

4. A filament structure for use within an electron tube having a cylindrical electrode geometry, said structure comprising stranded filament means which is apportioned into two emissive portions of essentially helical

form defining a cylindrical surface and a non-emissive portion intermediate said portions and generally diametrically mounted across one end of the cylinder defined by the emissive filament portions, a winding of wire arranged helically around said non-emissive portion for reinforcement, rod-like support means affixed to this non-emissive filament portion and support means at the ends of these stranded means at the opposite end of the cylinder defined by said filament from the non-emissive filament portion.

5. A filament structure for use within an electron tube having a cylindrical electrode geometry, said structure comprising stranded filament means which is apportioned into two emissive portions of essentially helical form defining a cylindrical surface and a non-emissive portion intermediate said emissive portions and generally diametrically mounted across one end of the cylinder defined by the emissive filament portion, a winding of wire arranged helically around said non-emissive portion for reinforcing this diametrically mounted portion, an axial rod support engaging the non-emissive filament portion at one end and support means at the ends of the stranded means at the opposite end of the

cylinder defined by said filament from the non-emissive filament portion, said support means and axial rod support being supported on the vacuum envelope.

6. A filament structure comprising a filament strand having two opposed emissive helical portions joined at one end by an integral non-emissive interconnecting portion, said helical portions having been carburized and said integral non-emissive interconnecting portion remaining uncarburized, and means making electrical connection to the emissive helical portions at the ends thereof opposite those joined by said integral interconnecting portion.

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