Oct. 22, 1968 J. W. KENDALL, JR 3,407,328

DIRECTLY HEATED CATHODE SUPPORTING STRUCTURE

Filed March 10, 1966 2 Sheets-Sheet 1

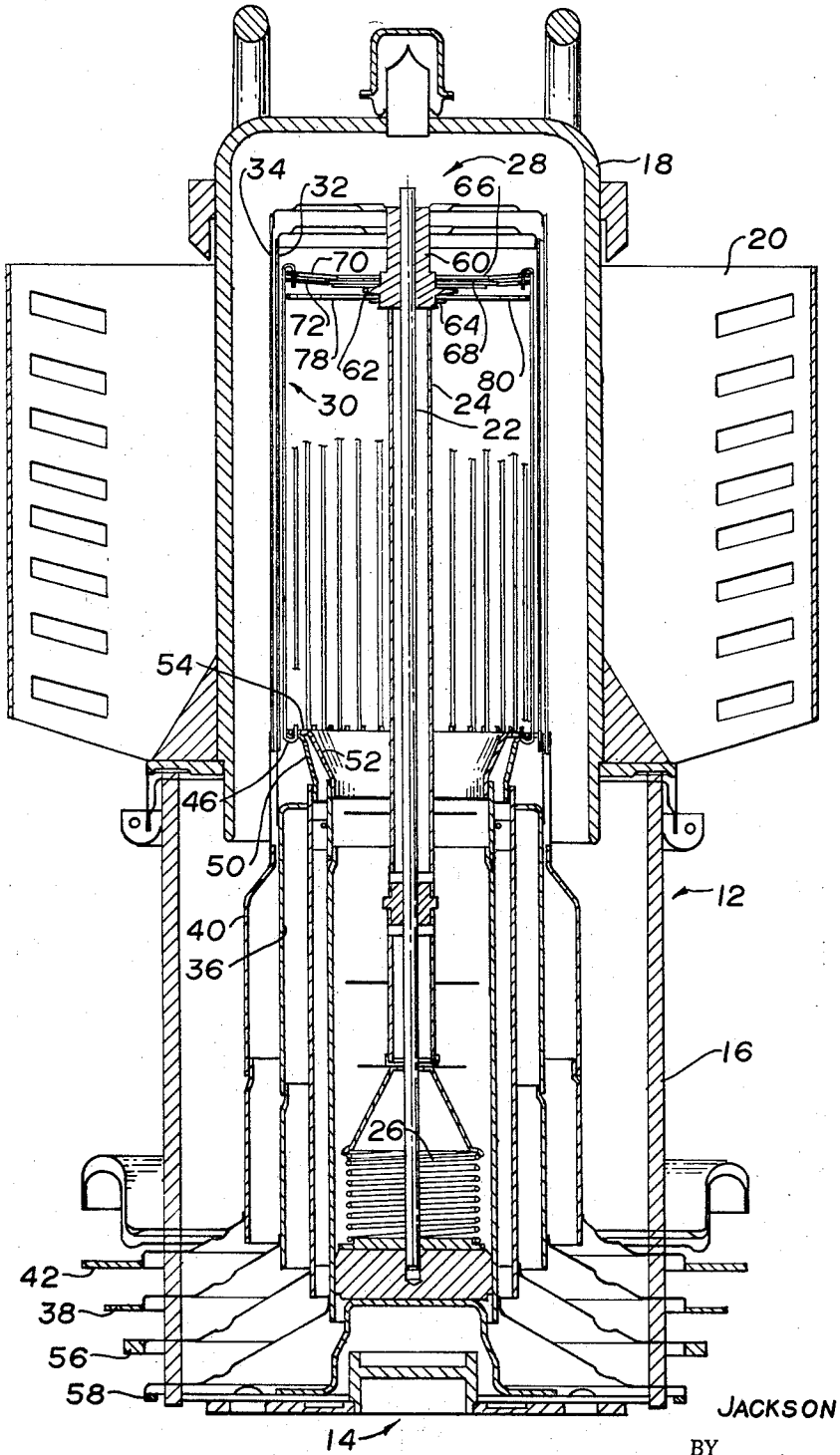


FIG. 1

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DIRECTLY HEATED CATHODE SUPPORTING STRUCTURE

Filed March 10, 1966 2 Sheets-Sheet 2

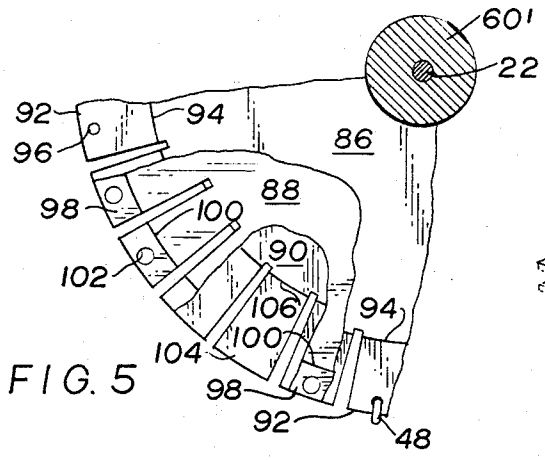


FIG. 5

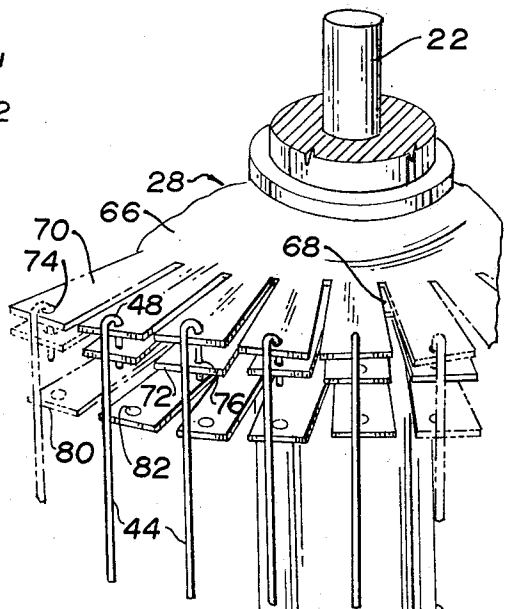


FIG. 2

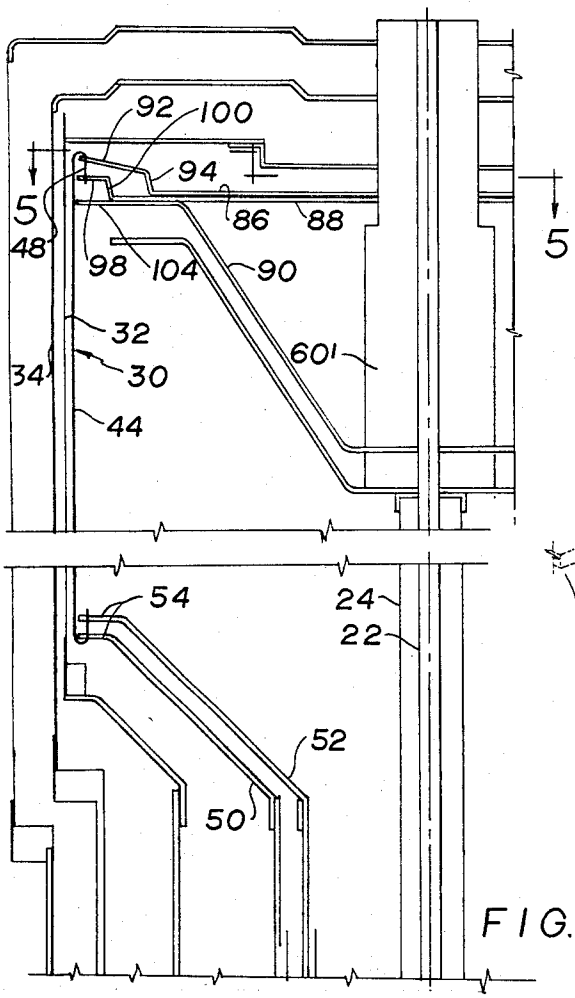


FIG. 4

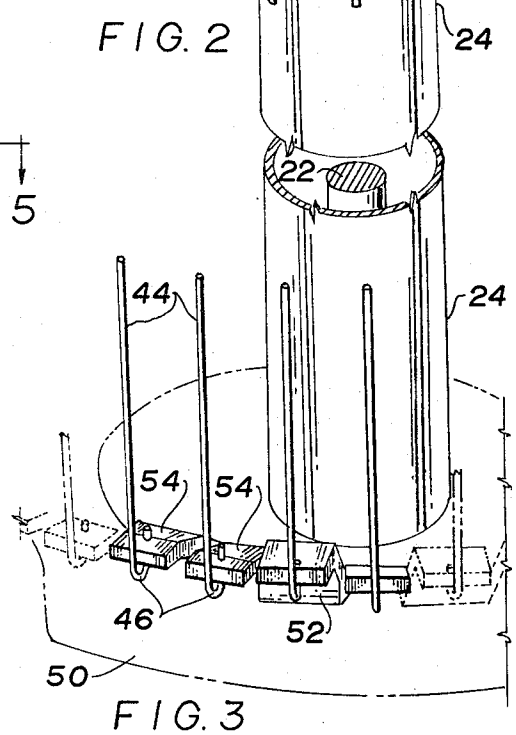


FIG. 3

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DIRECTLY HEATED CATHODE SUPPORTING STRUCTURE

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ABSTRACT OF THE DISCLOSURE

Structure for supporting a hooked end of a tensed filament in a vacuum tube. The structure comprises upper, middle and lower tabs disposed one above the other. The filament passes through an aperture in the upper tab which has weak resilience to compensate for deviation in the length of the tensed filament from its predesigned norm and from the length of other filaments in the tube. The filament also passes through an aperture in the middle tab which has greater resilience to limit movement of the upper tab. The filament further abuts the lower tab which serves to prevent inward lateral movement of the filament.

This invention relates to the filament structure of a power grid type vacuum tube.

In electron tubes, directly heated cathodes require maintenance of dimensional stability during the various operating phases of tube use. This, naturally, includes wide variation of temperature changes ranging from ambient to many hundred degrees. The cathode structures conventionally are formed of filaments or wires of thoriated tungsten or other suitable thermionic materials, all of which have the inherent thermal physical properties of expansion under increased temperatures and contraction under conditions of lowering temperatures.

In electron tubes of the type with which this invention is concerned, the filament wires are arranged in horizontally spaced, vertically extending orientation to form a cylindrical or caged pattern. As is conventional practice, a stem is incorporated in the central portion of the cylinder or cage with a spring biased piston or rod arranged at the top and/or at the bottom in direct contact with the filament support at the top and the bottom to maintain the filaments under tension during the various phases of operation. This structure has been satisfactory in generally compensating for the overall expansion and contraction of the filament wires. Quite frequently, however, individual filament wires, either because of varying physical geometry or slight changes in temperature, exhibit different rates of expansion or contraction which causes an individual wire to behave differently from the remainder of wires. Unless this factor is accounted for, the filament is liable to bow or distort, thereby changing the electrical characteristic of the tube by varying the cathode to grid spacing or, in extreme cases, actually shorting with the grid or with an adjacent filament strand.

The principal object of this invention is to provide a support for the aforesaid type of filament structure which incorporates independent resilient tensioning for each individual filament strand together with an independent spacer which inhibits lateral bowing action of the filament.

The cathode support structure of the present invention includes a filament support having three arm-like elements associated with each filament strand or wire. The first or upper element affords a relatively weak resilient tensioning arm or tab and a conductive contact to the filament strand for the establishment of appropriate electrical contact to the filament wires. The second or middle arm provides a somewhat stronger spring action and functions to limit the movement of the upper or the first spring. The third or lower arm forms a radial spacer engaged with the inside face of the filament strand to prevent inward lateral movement of the filament.

A feature and advantage of this invention is that the spring tensioning elements or arms are mounted in radially spaced relation from a central point of the structure to afford arcuate vertical movement by means of a mechanically simple springed disc structure. Such a structure normally has the disadvantage of changing the radial spacing during vertical movement. In the present invention, the third or lower element remains in a relatively fixed position to maintain the filament spacing, thus allowing the combination of simple filament tensioning with fixed spatial relation being maintained.

A further object of this invention is the provision of bottom and top filament mounting plates in which the plates are formed with apertures to receive the folded over or hooked ends of the filament wires. A feature and advantage of the aforesaid filament mount is that the connection between the filament and the mounting plates is basically mechanical and need not rely on soldered or welded connections, thus allowing the structure to be composed of refractory metals which improve the structural characteristics under conditions of elevated temperatures. Accordingly, fabrication of the cathode structure is materially expedited by the present invention.

Other objects, features and advantages will be more apparent after referring to the following specification and accompanying drawings in which:

FIG. 1 is a side elevation view in partial cross-section of a vacuum tube employing the cathode structure of the present invention;

FIG. 2 is a partial perspective view at enlarged scale of the upper cathode support structure of the FIG. 1;

FIG. 3 is a partial perspective view at enlarged scale of the lower cathode support structure of FIG. 1;

FIG. 4 is a partial elevation view of a modified form of the filament structure of FIG. 1; and

FIG. 5 is a partial cross-sectional view taken along line 5—5 of FIG. 4, portions being broken away to reveal internal details.

Referring more particularly to the drawing, a typical high-power vacuum tube **12** is shown as including a base **14** which carries a generally cylindric envelope **16** on top of which is mounted in hermetically sealed relation an external anode **18**. Anode **18** is typically provided on the exterior surface thereof with a plurality of radially extending cooling fins **20**. Supported in upstanding relation to base **14** is a central rod **22** disposed coaxially with anode **18**. Rod **22** supports a sleeve **24** in sliding relation thereof. Sleeve **24** is resiliently biased upwardly of base **14** by interposition of a spring structure **26** mounted in circumscribing relation of rod **22**. At the end of sleeve **24** remote from spring **26** is mounted an upper electrode support structure **28** which through the action of spring **26** is biased upwardly to tension the electrodes in a more or less conventional fashion.

Anode **18** is of generally cylindric form, and the electrodes supported on electrode support **28** are arranged in generally cylindrical form concentric with the anode. The electrodes include a directly heating cathode indicated at **30**, a control grid **32**, and a screen grid **34**. Grids **32** and **34** are each formed of a plurality of thin wire members, control grid **32** being electrically terminated at its lower end in a sleeve **36** which is connected in a conventional way to a terminal flange **38** mounted on base **14**, and screen grid **34** is terminated at its lower end in a sleeve **40** which is connected in a conventional way to a terminal flange **42** also mounted on base **14**. The individual wires constituting grids **32** and **34** are maintained in tension by spring **26** acting through sleeve **24**

and upper electrode support **28**. The wires forming the grids are of substantially thin gage and operate at substantially low temperatures so that maintenance of such grid wires in a uniformly tensioned condition is effected by the force of spring **26**. Cathode **30**, however, is formed of a plurality of thick, high temperature wires which require special attention for maintenance of uniform tension.

Cathode **30** is formed of a plurality of filament strands **44** of thoriated tungsten or like thermionic material. Each of the strands has at the ends thereof reversely bent portions that form hooks **46** and **48**. The lower hook **46** of each strand is attached to one of two lower cathode supports **50** and **52**, each of which is provided with a plurality of apertured fingers **54** that extend upwardly therefrom in alternation around the circumference of the supports. Accordingly, adjacent filament strands **44** are electrically connected to different terminals constituted by respective lower cathode supports **50** and **52**, the filament supports being electrically connected in a conventional way to terminal flanges **56** and **58**, respectively, carried by base **14**.

The upper cathode support constructed according to the present invention includes a collar **60** that constitutes an element of upper electrode support **28**, and that is biased upwardly through the action of spring **26** and sleeve **24**. Collar **60** has extending radially therefrom an upper circular flange **62** and a lower circular flange **64** for supporting the upper cathode support. Overlying flange **62** and supported thereby are stacked saddles **66** and **68**, which are formed of refractory material having resilient and electrically conductive properties. Each saddle **66**, **68** has radiating therefrom an equal plurality of tabs or fingers **70** and **72**, respectively. The tabs are formed by radially extending excised portions intermediate the tabs, the excised portions defining tabs **70** extending farther inwardly of saddle **66** than the excised portions defining tabs **72** on saddle **68**. Consequently, tabs **70** have a greater radial extent as a consequence of which they will have a lesser degree of resilience or a greater degree of flexibility or bendability. Each tab **70** is formed adjacent the radial extremity thereof with a hole **74** for receiving hook **48** of filament strand **44**. Tabs **72** are each formed with a hole **76** in alignment with respective holes **74** in tabs **70**. Holes **76** each have a diameter substantially greater than the diameter of the extremity of hook **48** so that tab **70** can move relative tab **72** without interference. Spaced below saddles **66** and **68** and supported on flange **64** is a lower or third saddle **78** generally similar to the upper saddles and having a plurality of tabs **80** extending radially therefrom. Tabs **80** are formed by inwardly, radially extending excised portions between adjacent tabs, the excised portions extending inwardly of saddle **78** somewhat less than in the case of saddle **68** so that tabs **80** are somewhat less flexible or more rigid than tabs **72**. Each tab **80** is formed with a hole **82** therein in alignment with holes **74** and **76** of tabs **70** and **72** respectively so as to afford unhibited clearance to the extremities of hooks **48** on the filament strands. The radial extremities of tabs **80** bear against the inner face of associated strands **44** to radially space the strands outwardly.

In operation, the cathode supporting structure of the present invention is assembled by engaging hooks **46** in tabs **54** and engaging hooks **48** in tabs **70** prior to full application of the upward resilient force of spring **26**. In initially forming the hooks on the ends of strands **44**, only moderate attention to precise uniformity of the distance between the hooks need be accomplished. On application of the force of spring **26**, saddles **66**, **68**, and **78** are biased upwardly through collar **60** and sleeve **24**. As a consequence, each individual strand **44** is tensioned, and the resilience or flexibility existing in tab **70** of saddle **66** compensates for any variation in lengths between individual filament strands. Ideally, the length of strands **44** is established so that tabs **70** assume an upwardly sloping position when the filaments are first installed. In order to compensate for filament strands shorter than the ideal, tabs **72** act to backup or reinforce the flexure of tabs **70** and limit the downward movement of the upper tabs because tabs **72** have somewhat greater resilience or less flexibility. Because holes **76** have a diameter substantially greater than the diameter of the filament hooks, tab **70** and filaments can move relative tab **72** without interference. The radial extremities of tabs **80** afford radial spacing of the filament strands so that the very small amount of radial movement permitted by movement of tabs **70** is compensated for by the relatively rigid or fixed spacer tabs **80**. Hole **82** in each tab **80** assures movement of tab **70** and hook **48** without interference from tab **80**.

When power is applied to the filament by appropriate electrical connections to terminal flanges **56** and **58**, a current flow is established through lower cathode support **50** and its associated tab **54**, up a filament strand **44**, through saddle **70**, down the adjacent strand **44** to an associated tab **54** of lower cathode support **52**, and thence to the terminal flange. As the filaments heat up and tend to lengthen through thermal expansion, the resilience of tab **70** compensates for such expansion and prevents the strands **40** from becoming bowed. Should the individual strands be subjected to different degrees of temperature rise, and therefore different degrees of thermal expansion, each individual tab **70** compensates for such differences. Because each tab **70**, **72**, and **80** is resilient, any fusion between the filament and any of the tabs will not interfere with the proper individual tensioning of the respective strands. On cooling, the above described phenomenon is reversed so that, as the filament strands contract, tabs **70** are flexed or tensioned downwardly to a somewhat greater degree. The downward movement is in no wise inhibited by the lower tabs because they are resilient and because holes **76** and **82** are substantially greater than the diameter of filament wires **44**.

Referring now to FIGS. 4 and 5 there is shown a modification of the present invention wherein the lower cathode structure is substantially identical to that described in connection with FIGS. 1 and 3, and wherein a collar **60'** forms an element of upper electrode support structure **28**. The collar is carried on sleeve **24** which is biased upwardly by spring **26**, the spring not being specifically shown in FIG. 4. Suitably affixed to collar **60'** is an upper saddle **86**, an intermediate or middle saddle **88**, and a lower saddle **90**. Saddle **86** is formed with a plurality of radially extending tabs **82** which are bent upwardly at **94** and which are formed with apertures **96** adjacent the radial extremity thereof for receiving hook **48** therein. Saddle **88** is formed with a plurality of tabs **98** bent up at **100** to underlie the outer radial portion of tabs **92**. Because tabs **98** have a shorter radial extent than tabs **92** they are somewhat less flexible or more resilient than tabs **92** and therefore function to backup or limit the downward movement of tabs **92**. Saddle **90** is formed with an upwardly sloping main body and has horizontal tabs **104** on the periphery thereof which tabs are bent into a generally horizontal position at **106**.

The operation of this embodiment of the present invention is generally similar to that described hereinabove in that relatively flexible tabs **92** engage hooks **48** of the filament strands to afford electrical connection between the filament strands and to tension the strands initially. Tabs **98** underlie tabs **92** and limit the downward movement thereof. Because hole **102** in tab **98** is substantially larger than hole **96** in tab **92**, the extremity of hook **48** is free to move relative to tab **98** without interference. Tabs **104** on saddle **90** further limit the downward movement of tabs **98** and support the same in position to properly engage hook **48**. Lower tabs **104** also support at their radial extremities the individual filament wires **44** so as to establish the filament wires in a fixed radial position irrespective of the movement of tab **92**. As in-

dividual filament wires expand due to increasing temperature the resilience of tab **92** maintains the filament strand in a straight unbowed condition, and the contact between tab **104** and the filament maintains fixed radial spacing of the filament wires. As the filament strands tighten on lowering temperature, tab **92** bends downwardly and its downward movement is limited by tab **98**. Because tab **98** possesses some degree of resilience or flexibility it does not rigidly fix the downward extent of tab **92**. Tab **104** on saddle **90** is similarly moderately flexible so that should the filament strand become fused to the tab, the spring action of tab **92** is still effective in maintaining the proper tensioned unbowed condition in the filament strand.

It will thus be seen that the present invention in both embodiments particularly illustrated above provides a cathode mounting structure which compensates both for minor variations of filament strand length that may exist during initial fabrication of the structure and also compensates for varying degrees of contraction and expansion in response to thermal variations arising during tube operation. Because the present invention affords a filament structure in which the individual wires are always in a straight unbowed condition, the control grid can be spaced more closely to the filament without liability to creating a grid-cathode short, thereby improving the amplification characteristics of the tube.

While several embodiments of this invention have been shown and described it will be obvious that other adaptations and modifications may be made without departing from the true spirit and scope of the invention.

What is claimed is:

1. A filament structure for a vacuum tube comprising a plurality of strands of thermionic filament wire, each said strand having a first end and a second end, means for fixedly mounting the first end of each said strand in said tube, each said strand on the second end thereof having a reversely bent portion defining a hook, a plurality of tab members each defining an aperture for engaging respective said hooks, and means establishing a first force for resiliently biasing the totality of said tab members away from said fixedly mounting means to tension said filament strands, each said tab member being resiliently movable independently of all other said members and providing a force less than said first force for affording individual tensioning of each said strand.

2. A support structure for a vacuum tube filament comprising at least one strand of thermionic wire having reversely bent portions at each end thereof to define first and second hooks, a base structure mounted in said tube having an apertured tab for engaging said first hook, and a tensioning structure for engaging the other end of said strand and being mounted in spaced apart relation to said base, said tensioning structure including a first resilient tab having an aperture therein for engaging said second hook, a second tab underlying said first tab, said second tab being less flexible than said first tab to limit the movement of said first tab and having a hole therein in registry with the aperture in said first tab for affording clearance of said second hook relative said second tab, and a third resilient tab adjacent to and spaced from said second tab for affording stability to said strand in a direction transverse of the longitudinal axis thereof.

3. The support structure according to claim **2** including means for resiliently biasing said tensioning structure away from said base structure in a direction axially of said strand.

4. A cathode structure for a vacuum tube comprising a lower filament support having a plurality of apertured tabs disposed in a generally circular configuration; and equal plurality of thermionic wire strands having reversely bent portions at each end thereof to define first and second hooks, said first hooks being engaged in respective said apertured tabs; and an upper filament support mounted in spaced relation of said lower filament support, said upper filament support including a first saddle having a plurality of first resilient tabs radiating therefrom, one of said tabs being associated with each lower tab and having a hole therein in alignment with the aperture in the associated lower tab, the second hook of each strand being engaged in the hole of a respective first tab, said first saddle being disposed from said lower filament support by an amount sufficient to flex said first tabs for tensioning each said filament strand, a second saddle underlying said first saddle and having a plurality of resilient tabs one of which is associated with each said first tabs, said second tabs acting to limit flexure of said first tabs in a direction toward said lower filament support, and a third saddle underlying said second saddle and spaced apart therefrom, said third saddle defining an equal plurality of radially extending third tabs, said third tabs having an outward radial extent sufficient to contact said strands for all positions of flexure said first tabs to radially space said strands in fixed spatial relation of said upper filament support.

5. The cathode structure according to claim **4** wherein said first and second saddles are formed of planar resilient circular plates having inwardly radially extending excisions therein to define respective said first and second resilient tabs, each said first and second tab having an upwardly bent generally vertically extending portion spaced inwardly of the periphery of said saddles and a generally horizontally extending portion outwardly of said vertically extending portion, the vertically and horizontally extending portions of said second tab being of less extent than corresponding portions of said first tab so that said second tab is more resilient than said first tab, and said third tabs extending from said third saddle substantially horizontally and in underlying contact with said second saddle, said third tabs having an inward horizontal radial extent sufficient to underlie the vertically bent portions of said first and second tabs so that the resilient movement afforded by said first and second tabs is substantially proportional to the radial extent of the horizontal portions thereof.

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