

March 17, 1953

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2,632,129

FILAMENT SUPPORT STRUCTURE FOR ELECTRON DISCHARGE DEVICES

Filed July 9, 1951

4 Sheets-Sheet 1

Fig. 1.

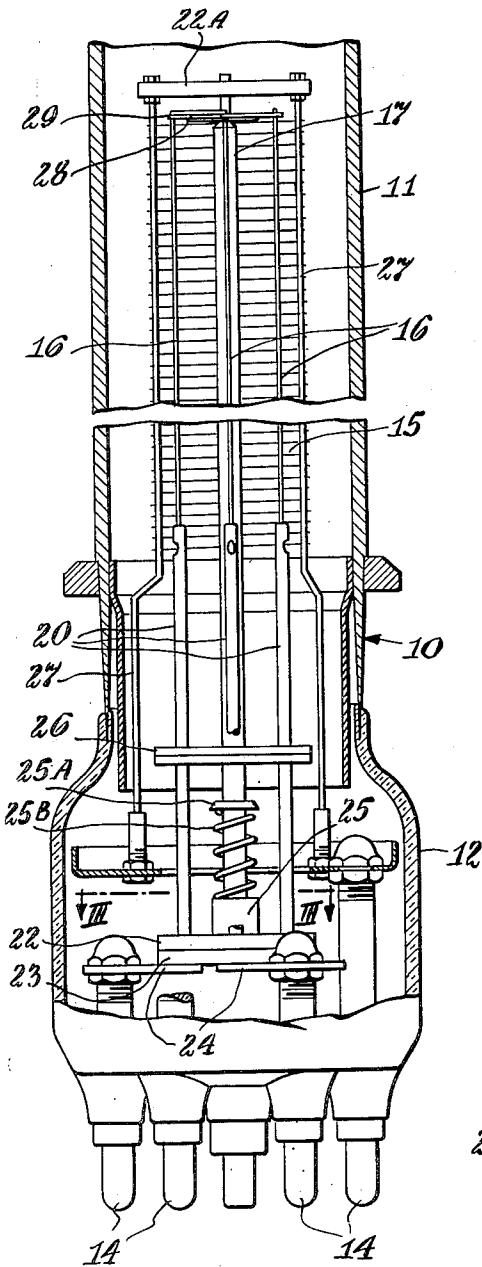


Fig. 2.

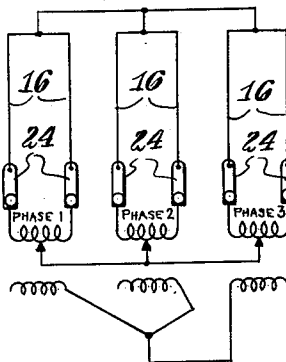


Fig. 3.

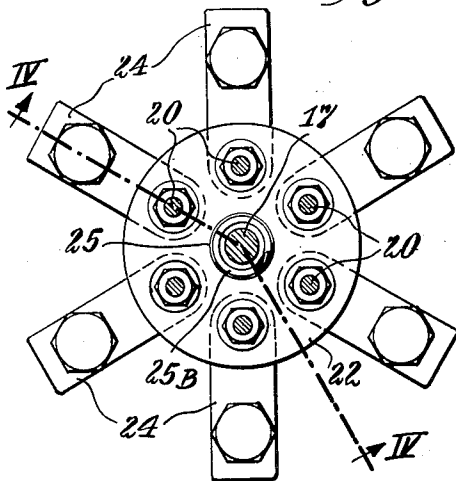
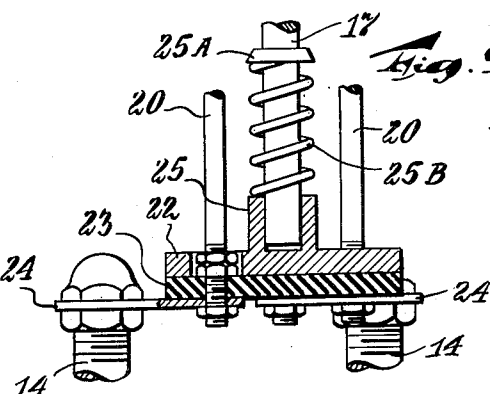


Fig. 4.



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Fig. 5.

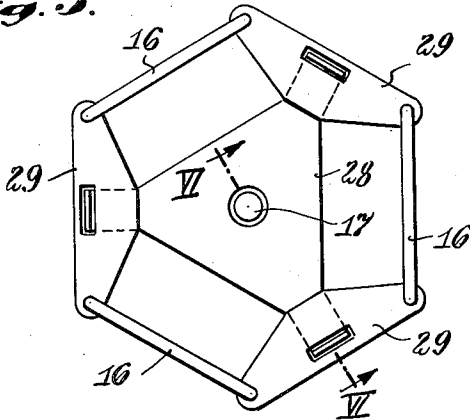


Fig. 6

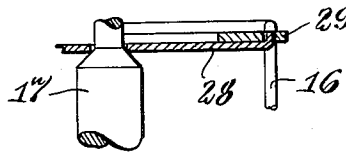


Fig. 7.

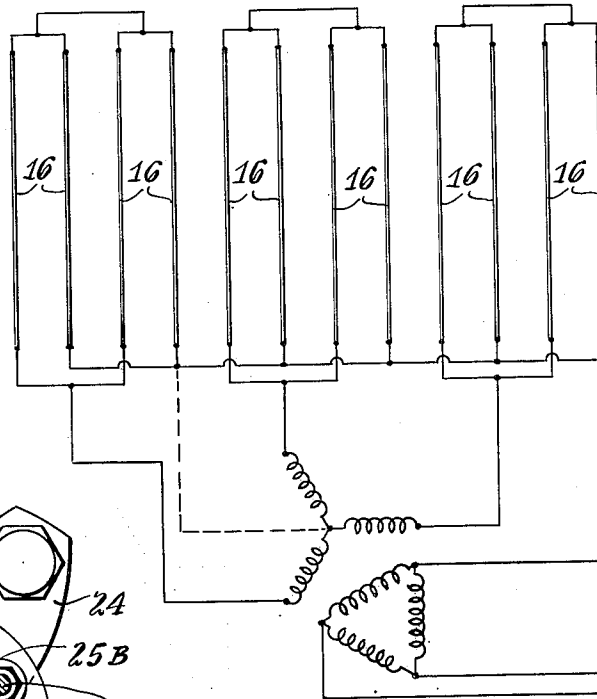
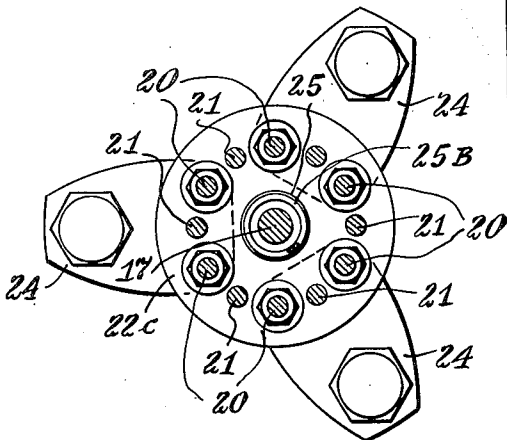


Fig. 8.



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Fig. 9.

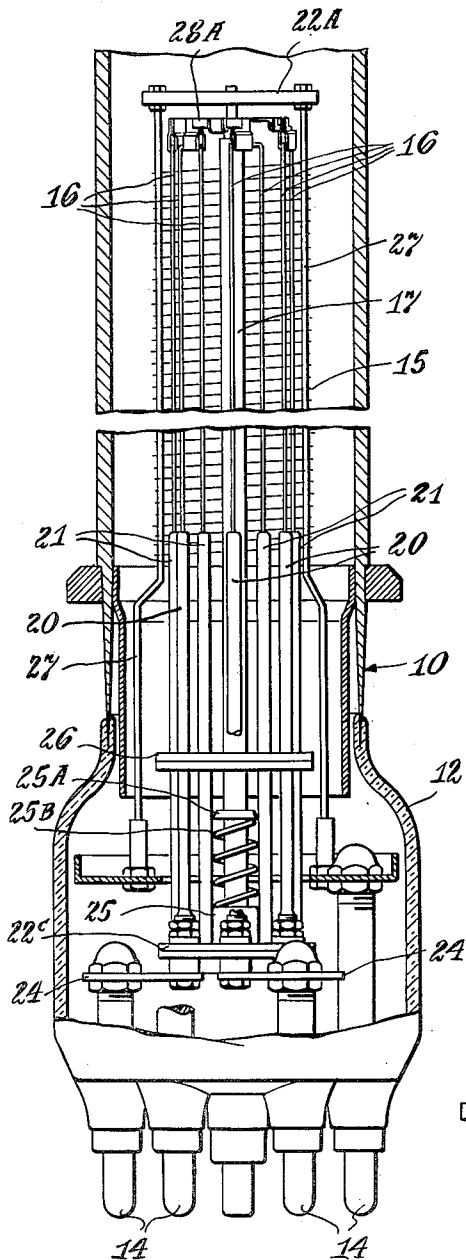
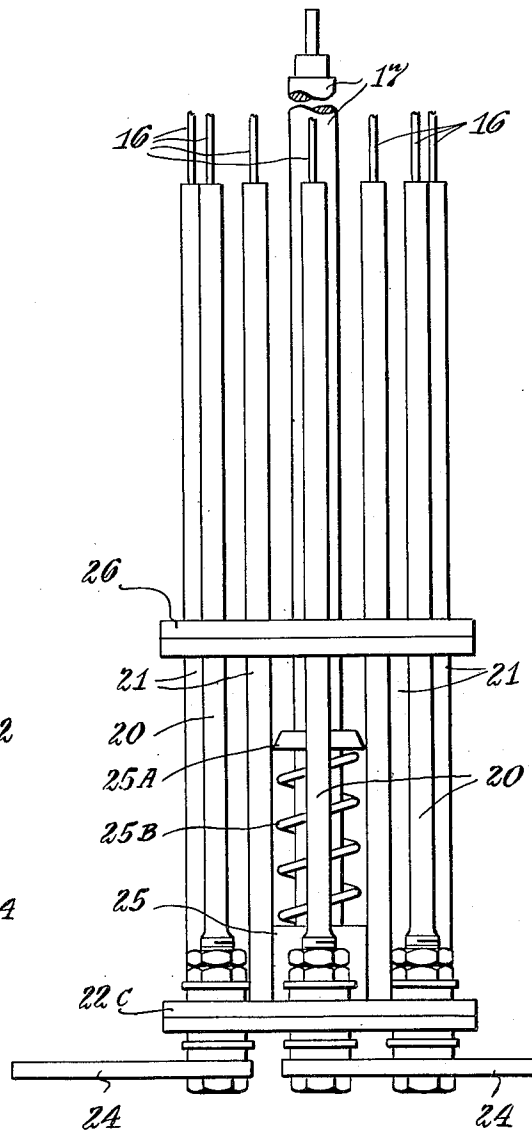


Fig. 10.



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Fig. 11.

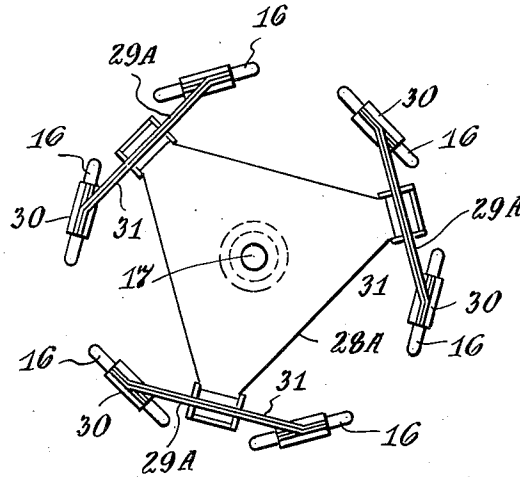


Fig. 12.

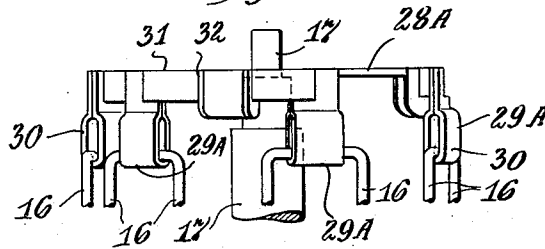


Fig. 13.

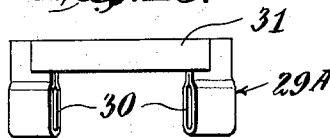


Fig. 14.



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UNITED STATES PATENT OFFICE

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burgh, Pa., a corporation of Pennsylvania

Application July 9, 1951, Serial No. 235,756

7 Claims. (Cl. 313—272)

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This invention relates to electron discharge devices, and in particular relates to an arrangement for mounting heated cathode filaments having a multiplicity of strands in a way which insures that the respective strands are maintained under substantially equal tension at all times regardless of unbalance in the electric circuits supplying them with heating current and of causes of minor displacement of the members which support them. This invention is particularly valuable in the case of power-tube cathodes having sections respectively heated from the phases of a polyphase voltage supply which is liable to voltage unbalance.

Large high-frequency power tubes usually have cathodes comprising a plurality of parallel strands of tungsten wire operated at elevated temperatures of 1700° C. and above 2000° C. A common cathode structure comprises a plurality of "hairpins" positioned with their legs parallel to and equidistant from a vertical central axis, and supplied with heating-current which flows into the ends of the "hairpins." Fig. 2 below diagrams such a circuit. A cylindrical grid concentrically surrounds this cathode-assembly, and very close and uniform spacing must be maintained at all times between the individual cathode strand and this grid. It is accordingly necessary to maintain a regulated tension on each cathode filament to keep it straight in spite of the increase in its length as it heats up. Such a tension also insures against de-alignment and sagging if its terminal supports sag in the course of its active life.

The amount of heating energy required by the cathodes of the larger power tubes is so great that it is desirable to supply it from a three-phase supply-line, and in such a case the cathodes comprise three symmetrical groups of "hairpins." To illustrate the invention one example is here given showing one "hairpin" per phase, and a second example having two hairpins per phase is also given. However, its general principles are applicable, in ways that will be apparent to those skilled in the art, to other polyphase energy sources.

In accordance with the general principles of the invention, the ends of the hairpins are anchored to a rigid base in the base-end of the tube, while the bights of the hairpins are engaged by a pivotally-mounted support carried by a center-rod which is spring-mounted on the same base.

In its general aspects, the present invention has, therefore, the object of overcoming the difficulties and defects of prior art cathodes such, for example, as those mentioned above.

Another general object is to provide an improved form of cathode for electron tubes of the high-power type.

Another object is to provide a support for cathodes of the multi-strand type which shall insure a substantially even tension in the individual strands at all times.

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Another object is to provide a support for cathodes which are divided into an uneven number of sections supplied respectively from separate terminals of a power-source, and which is so arranged as to maintain substantially even tension among these sections.

A more specific object is to provide an improved support for multi-strand cathode supplied with heating current from a three-phase power-source.

Still another object is to provide a support for maintaining even tension among the strands of a three-phase cathode while employing only a single tensioning-spring, and one which is located remote from the heated regions of the cathode.

A further object is to provide a cathode structure for hot-cathode tubes supplied with three-phase heating current which is simple and economical to manufacture and in which a single spring maintains substantially even tension on all sections of the cathode notwithstanding the unbalancing of voltage between phases which is usual in commercial power supplies.

Other objects of the invention will appear to those skilled in the art to which it appertains as the description proceeds.

Referring to the attached drawings in which like numerals of reference indicate similar parts throughout the several views:

Fig. 1 is a view in elevation, and partly in section, of an electron discharge tube embodying the invention in a cathode comprising one hairpin filament per phase of a three-phase heating supply.

Fig. 2 is a schematic diagram of the cathode-heating circuit for Fig. 1.

Fig. 3 is a top view to enlarged scale along line III—III of Fig. 1.

Fig. 4 is a section along the line IV—IV of Fig. 3.

Fig. 5 is a top view to enlarged scale of the cathode-filament support structure of Fig. 1.

Fig. 6 is a detail along the line VI—VI of Fig. 5.

Fig. 7 is a schematic diagram of the cathode-heating circuit for a modification of my invention in which the cathode for an electron tube consists of six "hairpin" filaments supplied with heating current from a three-phase source.

Fig. 8 is a sectional plan similar to Fig. 3 but showing the modified construction referred to above.

Fig. 9 is an elevational view, partly in section, of the tube referred to in connection with Figs. 7 and 8.

Fig. 10 is an elevational view to enlarged scale showing the supports and anchors to the tube base for the ends of the cathode-filaments of Fig. 8.

Fig. 11 is a top view to enlarged scale of the supports at the upper end of the cathode filaments of Fig. 8.

Fig. 12 is a side view of the support assembly of Fig. 10.

Fig. 13 is a detail view in elevation of a filament saddle which is employed in supports of Fig. 10, and

Fig. 14 is a detail sectional view showing a portion of the support for the saddle shown in Fig. 12.

Referring in detail to Figs. 1 through 6, an electron discharge tube to which the invention may be applied comprises a vacuum-tight container 10 having a major portion of its wall formed by a copper anode 11 of a type well known in the art which is sealed at its lower end to a glass bowl or base 12.

From the bottom of the bowl, at the exterior thereof, project the usual prongs 14 for making connection with the internal electrodes.

Coaxially within the anode is a grid 15, and inside the grid is a cathode 16 formed as a plurality of hairpin sections each with parallel wires or legs and all said legs symmetrically disposed in cylindrical arrangement in relatively close proximity to the grid. On the axis of the coaxial arrangement of electrodes is a metallic post 17 which constitutes a center support for the upper end of the cathode. Each leg of each filament section is secured at its lower end to a post 20, of which there is one for each filament leg, the several posts extending downwardly into the bowl 12.

Each of the three hairpin filaments has its lower ends connected to one pair of phase terminals of one of the phases of a three-phase alternating current power source in accordance with the diagram Fig. 2. The posts 20 which extend downward into bowl 12 are secured in equal spacing to a circular insulating plate or disc 23 concentric with the center-post 17. Consecutive posts are respectively connected to brackets 24 which are respectively fixed to the tops of an equal number of terminal prongs 14 of the tube base, thus fixedly supporting the plate 23 and the filament-posts 20.

Fixed to the top of plate 23 is a metal plate 22 having clearance-holes insulating it from each post 20. The plate 22 has at its center a sleeve 25 which the lower end of post 17 engages with a sliding fit. The post 17 is provided with a collar 25A against which a spring 25B presses to bias post 17 in an upward direction for reasons which will be more fully explained below. A spacer 26 of the type described in Dailey et al. U. S. Patent No. 2,404,042 may provide added rigidity for posts 20. The post 17 may be additionally supported, if desired, by having its upper end in sliding engagement with an insulating plate 22A supported on the upper ends of the grid support legs 27.

The maintenance of even tension on the three hairpin filaments 16 is effected by a plate 28 of the form shown in greater detail in Figs. 5 and 6 which is loosely supported on a tapered shoulder near the upper end of post 17. The reduced end of post 17 passes through a central hole in plate 28, thus permitting the latter to tilt through a substantial angle in any azimuth about the axis of post 17. The outer end of each of the three arms of plate 28 is turned up so as to pass through a hole in a filament saddle 29, thereby non-rigidly supporting the latter. Each filament-saddle 29 has at its ends a pair of holes through which the legs of the hairpin filaments 16 are threaded. The several saddles 29 and plate 28 are preferably metallic thereby electrically connecting the several filaments at the mid-part or bights thereof.

When the cathode-structure comprising filaments 16, end posts 20, support plates 22, 23, post 17, spring 25B, plate 28 and saddle 29 are assembled as shown in Fig. 1, it will be seen that plate 28 will be urged upward by post 17 and will pivot about its central hole until the three hairpin filaments 16 are each put in tension such as to exert forces of substantially equal moment about that center. The non-rigid engagement of plate 28 with each saddle 29 permits the latter to tilt lengthwise until the two legs of the hairpin it engages are likewise equally tensioned. Thus, regardless of any inequality of heating in the respective filament-legs due to unbalance of the three-phase system supplying them with current, and regardless of any distortions of the rigid portions of the supporting frame, the system adjusts itself until all filament-legs are in substantially equal tension.

It will be noted that the central hole of plate 28 is laterally displaced from the line connecting the support point of any one saddle with that of another, and that this insures the tilting of the plate 28 until equalization of tension takes place. Such lateral displacement of the central hole will exist in a filament support designed for any three-phase heating supply. The principles of this support system are accordingly particularly suited to three-phase heater-supplies; and it will be noted that the plate 28 would have no one stable position were there less than three downward forces acting at points on its periphery; and could not so more as to equally tension all forces if more than three downward forces acted at its periphery. In short, my arrangement is particularly adapted to the support of filaments heated from a three-phase source.

However, similar arrangements employing tension plates having central elastic supports are useful, though with less perfect effectiveness, for heating supplies in general which have an odd number of phases, since it is characteristic of odd phase numbers that, when the cathode-sections which they respectively supply are distributed with symmetry about a central axis, no two cathode-sections can be connected by a straight line which passes through that axis. The invention is equally applicable for obtaining substantially equal tension in filament strands connected in series or parallel on a single phase power supply thereto. This utility is consequential upon the fact that it is not always possible in fabrication of filaments to have the leg or strands thereof exactly even in length from the point of attachment to the lead-in post and the bight of the filament.

Turning now to the modification of my invention shown in Figs. 7 through 14, the cathode comprises three groups of "hairpin" filaments 16, each group consisting in effect of a pair of hairpins connected in multiple. Thus, as shown in Figs. 7 and 8, each phase-terminal of a three-phase supply is connected to one end of each of two hairpin filaments while the remaining ends of all of the hairpins are connected together by plate 22C.

The general arrangement in applying the invention to a six-hairpin cathode is sufficiently similar to that for the three-hairpin system of Fig. 1, so that it is believed to be sufficient to describe the structural features which are different in the six-hairpin system.

While the entire cathode-structure is again supported by brackets 24 from the three heater circuit prongs 14, there are now six filament posts

20 connected in pairs to the brackets 24 and six filament posts 21 which are fixed in the metal plate 22C. While not required for operation, a lead may be connected from the plate 22C to a terminal prong 14, if it is desired to furnish a channel to the neutral of the three phase heater supply for any reason. The filament-posts 21 are positioned on the circumference of the same circle about the axes of post 17 as are the posts 20, and spaced at equal distances apart. Figs. 8 and 9 show the support-posts in more detail. The posts 20 pass with insulating spacing and insulator intervention through the metal plate 22C and rigidly support the latter from the underlying insulating plate and the three brackets 24, two posts 20 being affixed to each bracket. The center-post 17 is journaled with sliding fit in the central sleeve 25 on plate 22A and is urged upward by spring 25B as in the Fig. 1 arrangement.

Each hairpin filament has one end connected to a post 20 and the other end to an adjacent post 21, with the result that each filament is bridged between one of the phase terminals 24 and the plate 22C which thus forms a neutral terminal for the entire filament heating system.

The upper ends of the hairpins are again supported from a tension-plate 28A by means of filament saddles 29A, these being formed as indicated in more detail in Figs. 11 to 14. As in Fig. 1, the tension plate 28A has a central hole through which the end of center post 17 protrudes and on which it is free to pivot. The bights of the cathode filaments 16 are however threaded through loops 30, one at each end, of the filament-saddles 29A. Fig. 13 shows such a filament-saddle in more detail. The middle yoke 31 connecting the two loops 30 of each saddle is insulatedly cradled in the trough-shaped terminus of one of the three arms forming the apexes of triangular tension plate 28A. Insulators 32 fixed in the trough-shaped termini and having slots 33 in which the paddles 29A can fulcrum and rock slightly, thus hold these saddles. To insure stability of the fulcrum the yokes 31 are provided with a notch to engage a projection on insulator 32.

The upper end of center post 17 is guided by the grid post spacer 22A. The upward pressure of center-post 17 against the center of tension-plate 28A causes the latter, and the saddles 29A, to tilt and pivot until restrained by substantially balanced equal tensions on all the legs of the hairpin filaments.

I claim:

1. An electron-emissive cathode comprising three groups of conductors symmetrically positioned about a central axis, a base member rigidly connected to the lower ends of said conductors, an upwardly biased member universally pivoted relative to said base member at a point on said axis, and three insulated filament supports pivotally connected to said upwardly-biased member at points equidistant from said axis and from each other.

2. An electron-emissive cathode comprising three groups of hairpin filaments having their lower ends rigidly connected in symmetrical spaced relation on the circumference of a circle to a base member, all the hairpin filaments in any one group having their upper ends connected to a filament saddle individual to that group, a support member having a universal pivot support to said base member at a point on the central axis of said circle, pivotal supports for said filament saddles at three points on said sup-

port member which are equi-distant from said axis and from each other, and means for electrically insulating said filaments from said support member.

3. An electrode assembly comprising a central standard, three hairpin filament groups symmetrically spaced about said standard and having their lower ends fixed to a base member, a rigid member having universal freedom of movement on said standard and pivotally connected at three points equidistant from said standard and from each other to the upper ends of said filaments, insulation between the upper ends of said filaments and said rigid member, and means biasing said rigid member upward relative to said base member.

4. In an electrical discharge tube, three heating-current input terminals, three pairs of hairpin filaments, each of the two filaments constituting a pair, having one end connected to one of said three input terminals, said conductors being parallel to a common axis and having their outer ends connected together, an upwardly-biased member supported on a universal pivot which is centrally positioned relative to said conductors, and insulating pivoted supports for the upper portions of said conductors positioned on said upwardly-biased member at points substantially equidistant from said universal pivot.

5. In an electrical discharge tube, a heated cathode comprising three groups of conductors having their lower ends connected to be heated from a three-phase source, said conductors being parallel to a common axis, an upwardly-biased member supported on a universal pivot which is centrally positioned relative to said conductors, and insulating pivot supports for the upper portions of said conductors positioned on said biased member at points substantially equidistant from said universal pivot.

6. In an electrical discharge tube, three heating-current input terminals each having one end of a hairpin filament connected to it, an upwardly-biased member supported on a universal pivot which is centrally positioned relative to said hairpin conductors, and insulating pivot supports for the upper portion of said conductors on said upwardly biased member at points substantially equidistant from said universal pivot.

7. In an electrical discharge tube, three heating-current input terminals each having one end of a hairpin filament connected to it, the other ends of said hairpin filaments being connected together and said hairpin filaments having their legs positioned parallel to a central axis, an upwardly-biased member supported on a universal pivot which is positioned on said axis, and insulating pivoted supports for the upper ends of said hairpin filaments positioned on said upwardly biased member at points substantially equidistant from said universal pivot.

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