Nov. 1, 1949 E. C. EWING 2,486,829

SUPPORTING MEANS FOR VACUUM TUBE ELECTRODES

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Fig. 1

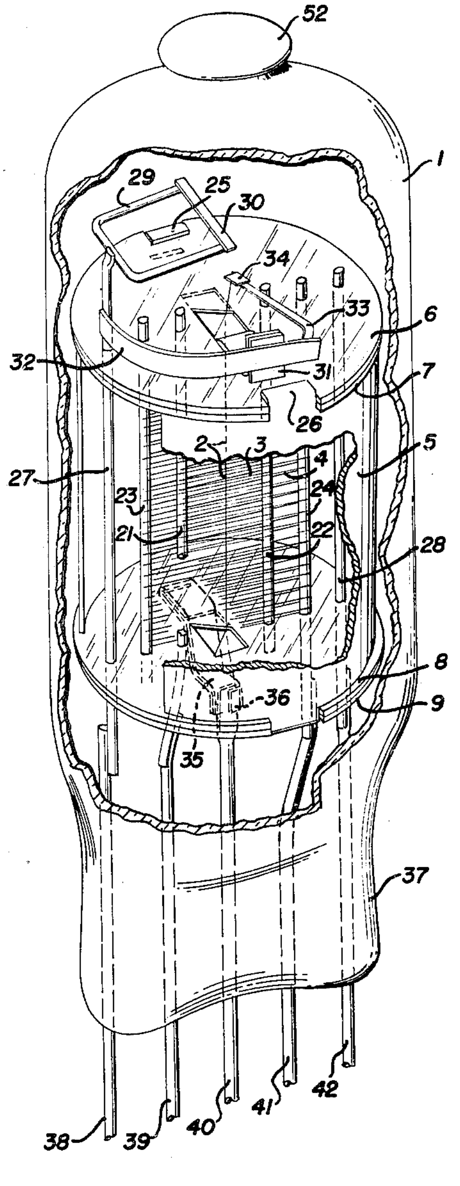


Fig. 2

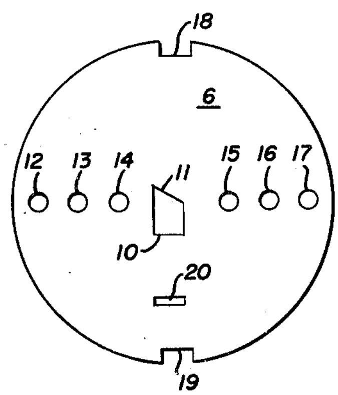
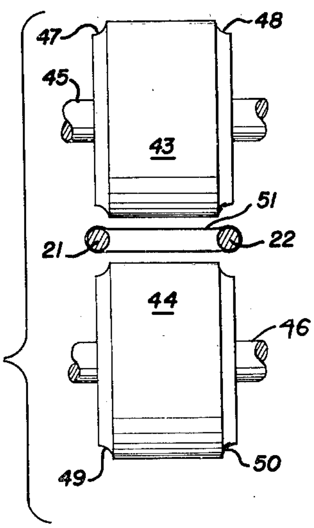


Fig. 3



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SUPPORTING MEANS FOR VACUUM TUBE ELECTRODES

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6 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge amplifier devices, and particularly to such devices which are of small size and are arranged for operation at small voltages and currents.

It is usually most convenient to construct electron discharge devices for operation at small voltages and currents with a filamentary cathode, and much difficulty has been encountered in the mounting of very small filamentary cathodes when the discharge device is required to provide high gain with minimum susceptibility to vibration. It is an object of this invention to provide an improved arrangement for supporting a small filamentary cathode in such a manner that the electron discharge device in which such a cathode is mounted is easily and accurately assembled in such away that the device has high gain and substantial freedom from microphonics due to vibration from mechanical shock or sound.

It is a more specific object of the invention to provide a filamentary cathode supporting arrangement for such a device in which the electrode supports are very readily assembled and in which those supports provide extremely accurate alignment of the filamentary cathode and control electrodes without the necessity of extremely accurate formation for the supports.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with accompanying drawing in which:

Figure 1 is a perspective view, partly broken away, of a discharge device incorporating various features of the invention;

Figure 2 is a plan view of an electrode support used in the device of Figure 1; and

Figure 3 is an end view of a control electrode as illustrated in Figure 1, shown during one step of its manufacture.

In Figure 1 a cylindrical envelope 1 encloses a filamentary cathode 2, a first control electrode 3, a second control electrode 4, and an anode 5, all supported in proper spaced relation to one another by a pair of insulating discs 6 and 7 at their upper extremities and a second pair of insulating discs 8 and 9 at their lower extremities.

The insulating discs 6, 7, 8 and 9 may be conveniently formed of mica, and are all identical in configuration. That is, the disc 6 is exactly like the disc 7, except that it is turned over

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vertically so that its opposite side faces upwardly.

In Figure 2 the insulating disc 6 is illustrated in detail. A trapezoidal aperture 10 is cut through the middle of the disc enclosing its center. The center of the disc 6, when projected in a direction perpendicular to the parallel sides of the trapezoid 10, lies along one of the non-parallel sides of the trapezoid 10. Preferably that non-parallel side 11 on to which the center of the disc 6 is so projected forms an angle of about 60° with one of the parallel sides of the trapezoid 10.

Along a line through the center of the disc 6 and perpendicular to the parallel sides of the trapezoid 10 a plurality of circular apertures 12, 13, 14, 15, 16 and 17 are cut. Along a line through the center of the disc 6 parallel with the parallel sides of the trapezoid 10 rectangular notches 18 and 19 are cut in the edges of the disc 6, and along that same line a narrow rectangular aperture 20 is cut beween the trapezoid 10 and one of the notches 18 and 19.

The first control electrode 3 includes two cylindrical side posts 21 and 22 around which fine wire is wound helically to form interstices through which electrons from the filament 2 pass outwardly. The upper ends of the side posts 21 and 22 extend through the circular apertures 14 and 15 in the mica disc 6 and 7, while the lower ends of those side posts 21 and 22 extend through the corresponding circular apertures in the mica discs 8 and 9. The second control electrode 4 is similarly provided with parallel side posts 23 and 24 around which fine wire is wound helically to form interstices through which electrons from the filament 2 after passage through the control electrode 3 may pass outwardly. The upper ends of the side posts 23 and 24 extend through the circular apertures 13 and 16 in the mica discs 6 and 7, and the lower ends of those side posts extend through corresponding apertures in the mica discs 8 and 9.

The anode 5 is formed of sheet metal, preferably pure iron or nickel plated iron, and is rolled into cylindrical form leaving a gap between the opposed edges. The internal diameter of the cylindrical anode 5 is equal to the distance between the bases of the notches 18 and 19 in the mica disc 6 so that the anode 5 may be fitted snugly between the mica discs 7 and 8 because the side posts 21, 22, 23 and 24 extend through the respective mica discs just enough to support the control electrodes properly. Integral tabs 25 and 26 are formed on diametrically opposed sides of the upper perimeter of the anode sides, and in assembly the tabs 25 and 26 are bent over the mica disc 6 to hold the assembly solidly together. Corresponding tabs, not shown, are formed on opposite sides of the lower perimeter of the anode 5 and are bent over the lower mica disc 9 to hold the discs 8 and 9 solidly in place, thereby forming the control electrodes 3 and 4 and the anode 5 into a solid integral structure.

A side-post 27 extends through the aperture 12 of the mica disc 6 and through the corresponding apertures in the other discs 7, 8 and 9, so that it lies between the opposed edges of the cylindrical anode 5.

A fixed side-post 28 extends through the aperture 17 of the disc 6 and through the corresponding apertures of the other discs 7, 8 and 9, and that portion of the post 28 between the discs 7 and 8 is welded or otherwise suitably fastened to the adjacent portion of the anode 5 to provide electrical connection thereto.

The upper end of the side-post 27 is fastened, as by welding, to a U-shaped electricity conducting wire 29, between the free ends of which is electrically connected a metal strip 30 which carries active getter material to be used in completing the exhaust of the envelope 1. A rectangular strip 32 of metal is fastened at one end to a portion of the supporting post 27 above the mica disc 6 and is fastened near its other end to a bracket formed by a strip 31 extending between insulating sheets 6 and 7 and through slot 20 and having its ends maintained in contiguous relation to each other to furnish a support for ductile member 32. The free end of the member 32 extending beyond bracket 31 is welded or otherwise fastened to form an electrical connection to a springy strip or wire 33 which extends above the trapezoid 10 in the mica discs 6 and 7. The upper end of the filamentary cathode 2 is fastened, as by welding, to a small tab 34 of metal which is electrically connected, as by welding, to the free end of the spring 33.

A somewhat similar bracket is supported from the lower mica disc 9, being formed from a strip 35 of metal whose opposite ends are threaded through the trapezoid 10 and rectangular opening 20 in the lower mica disc 9. those opposite ends being then pinched together to form a bracket extending below the two trapezoids 10 in the mica discs 8 and 9. A tab 36 of metal is fastened to this bracket and to the other end of the filament wire 2.

Lead-in connections to the various electrodes are made through a press 37 formed at one end of the evacuated envelope 1, lead-in conductors 38 and 39, 40, 41 and 42 extending in substantially parallel relation through the press 37 to the inside of the envelope 1. Conductor 38 within the envelope 1 is connected electrically to the side-post 27 and conductor 40 is connected within the envelope 1 to the bracket 35 and to the tab 36 at one end of the filamentary cathode 2, thereby forming a circuit from conductor 38 through side-post 27, strip 32, spring 33, tab 34, cathode 2, tab 36, conductor 40, and whatever external source of current may be connected between conductors 38 and 40. Conductor 39 within the envelope 1 is connected to the lower end of side post 21 below the mica disc 9 to form an electrical connection for the first control electrode 3. Conductor 41 is connected within the envelope 1 to the lower end of the side post 24 to form an electrical connection for the second control electrode 4. Conductor 42 within the envelope 1 is connected to the lower end of the side-post 28 to form an electrical connection for the anode 5.

By this particular configuration of the trapezoidal aperture 10 in the mica disc, the two discs 6 and 7, when placed together in reverse face to face relation, form a triangular aperture through the two discs. The triangle so formed is bounded on one side by a portion of a side 11 of the disc 6 and is bounded on the second side by a part of the side 11 of the mica disc 7, while the third side of the triangular aperture is bounded by two of the parallel sides of the trapezoids 10 in the two discs 6 and 7.

Because the two discs 6 and 7 are placed in reverse face to face relation, the apex of this triangular aperture, between the two sides 11, one formed by the apertured disc 6 and the other formed by the apertured disc 7, is located precisely centrally between the bases of the notches 18 and 19. The central location of this apex is not at all affected by irregularities in the shaping of the apertures 10 in the discs 6 and 7, so long as the two apertures in the discs 6 and 7 are exactly alike.

Similarly, two trapezoidal apertures of the discs 8 and 9, which are placed in reverse face to face relation, also form a triangular aperture through the two discs.

The spring 33 and the ductile strip 32 are so shaped as to hold the tab 34 at one end of the filament 2 a little to one side of the accurately centered apex of the triangular aperture in the direction of the circular aperture 15. Similarly, fastening of the tab 36 on the conductor 40 supported by the bracket 35 is at a position a little to one side of the apex of the triangular aperture through discs 8 and 9 in the direction of the cylindrical aperture 15 in those discs. Because those supporting points for the two opposite ends of the filament 2 are thus located a little to one side of the two apices of the triangular apertures in the upper and lower pairs of mica discs, tension placed on the filament 2 draws it taut in a precisely straight line between those two apices and therefore centers it precisely between the bases of the notches 18 and 19. Thereby, the filamentary cathode 2 is also precisely centered with respect to the circular apertures 14 and 15.

A permanent twist is imparted with tweezers to that end of the ductile strip 32 to which the flat spring 33 is attached, in such a direction as to tension the spring 33 an amount more than sufficient to provide the required tautness of the filamentary cathode 2. The resilience of the spring 33 is a protection against breaking the filament 2, which, while cold, has appreciable tensile strength.

The spring 33 is formed of a tungsten-molybdenum alloy and when the anode 5 and getter strip 30 are heated, the flat spring 33 being in the bombarder, or induction heating field is also heated. The alloy of which it is formed takes a "set" at a relatively low temperature so that it is caused partially to lose the tension which was imparted by twisting strip 32, and this partial loss of tension leaves the filament 2 tensioned properly when it is heated and has less tensile strength.

In Figure 3 there is illustrated a special mechanism for performing one step in the construction of one of the control electrodes 3 or 4. The control electrode 3 is illustrated in a section perpendicular to its side-posts 21 and 22, and, as shown, lies between a pair of specially shaped rolls 43 and 44 arranged respectively for rotation on shafts 45 and 46. The central portion of each of the rolls 43 and 44 is substantially cylindrical, and each end of each of the rolls is of smaller diameter and of such shape as to fit snugly around a portion of the periphery of the side-posts 21 and 22 when the rolls 43 and 44 are moved against the control electrode 3. Shoulders 47 and 48 lie between the substantially cylindrical portion of roll 43 and its end portions of smaller diameter, and similarly shoulders 49 and 50 lie between the substantially cylindrical portion of roll 44 and its end portions of smaller diameter. The shoulders 47 and 48, and similarly the shoulders 49 and 50, are spaced axially a distance just sufficient that, when the rolls 43 and 44 are pressed tightly against the side posts 21 and 22 and rolled therealong, the side-posts 21 and 22 are stretched apart just enough to tension the wire 51 of the control electrode 3 between the side posts 21 and 22 and to cause it to lie flatly against the substantially cylindrical portions of the rolls 43 and 44.

After the control electrode 3 has been rolled between the rolls 43 and 44, and pressed together with some force, the wire 51 lies in a substantially flat surface between the side posts 21 and 22, and those portions of the wire 51 on opposite sides of the control electrode are spaced apart a distance substantially less than the diameter of the side-posts 21 and 22. That distance between the portions of the wire 51 on opposite sides of the control electrode 3 is highly uniform throughout all portions of the control electrode, and is very accurately the same in all control electrodes so constructed, because the smaller end portions of the rolls 43 and 44 roll tightly along the side-posts 21 and 22 so that the cylindrical portions of the rolls 43 and 44 are spaced apart at a very accurately determined distance, the diameter of the side-posts 21 and 22 being maintained constant in all electrodes.

A control electrode so formed, with the portions of the wire 51 on its opposite sides being spaced apart an extremely accurate distance, when assembled together with the filamentary cathode 2 between the discs 6, 7, 8 and 9 is spaced with extreme accuracy from the filamentary cathodes 2 by reason of the very accurately determined distance between the side wires of the control electrode 3 and by reason of the reverse face to face position of the discs 6, 7, 8 and 9 which are provided with the trapezoidal apertures 10. By reason of such very accurate spacing between the cathode 2 and the sides of the control electrode 3, the gain of all such discharge devices so formed is uniform to an extremely high degree. By utilizing the proper spring material for the spring 33, it is easy to bend the free end of the strip 32 an amount just sufficient to put the proper amount of tension on the filamentary cathode 2 so that it maintains such highly accurate spacing from the control electrode 3 without such tension as to cause shortened life of the cathode 2 by reason of breakage.

After all of the previously described elements of the discharge device are assembled and sealed within the envelope 1 through the press 37, evacuation of the envelope 1 is carried out through a tubulation leading from the envelope 1 at the end opposite the press 37. After evacuation the tubulation is sealed off and lapped over to form the flat tube tip 52.

During such evacuation, and before sealing, the high frequency induction coil not shown is placed

circumferentially around the envelope 1 outside of the anode 5, and, by reason of the opening around the periphery of the anode 5, the control electrodes 3 and 4 are inductively heated to a red heat so that gas occluded therein is evaporated and carried away by the exhaust operation. It is preferred to make the anode 5 of ferrous material, preferably nickel plated iron, so that the induction heating coil placed around the envelope 1 adjacent the anode 5, simultaneously heats the anode 5 to a red heat, and so evaporates occluded gas from the anode 5 as well as electrodes 3 and 4, all in one operation. It is preferred to repeat this induction heating of the control electrodes 3 and 4 and the anode 5 at least twice during the exhausting operation, and it is also preferred to pass current through the filamentary cathode 2 to heat it to a red heat during this exhaust operation.

After the exhaust and sealing, high frequency induction heating is utilized to induce current in the U-shaped wire 29 and the strip 30 to boil the getter material in the strip 30 so that the release of the active getter material completes the exhausting operation.

The highly uniform gain in discharge devices so constructed is achieved not only by reason of the highly accurate spacing maintained between the opposite sides of the control electrode 3 and the filamentary cathode 2, but also by the highly accurate spacing between the control electrode 4 and control electrode 3, and also by reason of an electron beam effect produced in the electron discharge stream through the registering openings of the control electrodes 3 and 4. It is desirable that the major portion of electrons passing from the cathode 2 to the anode 5 shall move in directions substantially perpendicular to the planes of the sides of the control electrodes 3 and 4. This is accomplished by the effect of the side-posts 21 and 22 of the control electrode 3, which are maintained at a substantially negative potential with respect to the cathode 2, and the effect is aided as the electrons move through the control electrode 4 to the anode 5 by reason of the registry in the lattices formed by the two control electrodes 3 and 4. That is, a bundle of electrons passing between two of the grid wires of control electrode 3 also passes between two adjacent wires of control electrode 4 in a well defined beam. That electron beam effect together with the special control electrode structure tends to highly uniform gain in a series of electron discharge devices constructed according to the invention.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. An electron discharge device comprising, a filamentary cathode, a flat sided control electrode surrounding said cathode and including a pair of side-posts substantially parallel with said cathode and a wire wrapped helically around said side-posts, the portions of said wire lying between said side-posts being substantially flat and spaced apart with high accuracy and lying in substantially parallel surfaces closer together than the thickness of said side-posts, and means for maintaining said filamentary cathode spaced with

high accuracy between the substantially flat sides of said control electrode, said means comprising two insulating discs adjacent each of the ends of said cathode and control electrode, each of said discs having a trapezoidal opening centrally thereof with one of the non-parallel sides of said trapezoidal opening crossing a line through said cathode perpendicular to the parallel sides of said trapezoidal opening, one of the discs in each pair of discs lying reversely face to face with the other disc in each pair thereof and with the parallel sides of the trapezoidal opening in all discs substantially parallel.

2. An insulating device for use in supporting and spacing electrodes within an electron discharge device, comprising a pair of insulating sheets each sheet having accurately spaced opposite edge portions and a trapezoidal aperture centrally thereof, one of the non-parallel sides of said trapezoidal aperture lying across a line midway between said accurately spaced edge portions, said line being substantially parallel with said edge portions, said sheets being fixed together in a reverse back to back relationship to thereby produce a triangularly shaped opening having its apex on said line.

3. An electron discharge device having a filamentary cathode, and means for accurately positioning a portion of said cathode, said means comprising a pair of insulating sheets each having substantially opposite accurately spaced edge portions and each having a trapezoidal aperture substantially midway between said edge portions, said sheets being placed reversely face to face with said edge portions in accurate alignment, and means for holding said filamentary cathode in the apex of the aperture formed by the two trapezoidal apertures in said two sheets.

4. An electron discharge device having a filamentary cathode, a spring supporting one end of said cathode, and an elongated ductile member supporting a part of said spring spaced from said cathode, said ductile member being resiliently deformed readily in a direction to increase the tension of said spring on said cathode.

5. An electron discharge device comprising, an elongated ductile member, a flat spring supported on said member, a filamentary cathode fastened to a part of said spring and spaced from said member, said member being readily resiliently deformed in a direction to increase the tension of said spring on said cathode, whereby heating of said spring reduces the tension thereof to make the tension on said cathode a predetermined amount.

6. An electron discharge device comprising, in combination, an insulating support for supporting and spacing electrodes composed of two sheets of insulating material each sheet having accurately spaced opposite edge portions and a trapezoidal aperture centrally thereof, said sheets being placed in a reverse back to back relationship to produce a triangular opening having its apex on a diameter of the sheets, a slot through one of said insulating sheets, a flat bracket supported on said sheets, said bracket extending between said two sheets and through said slot and having its ends adjacently supported, an elongated ductile member supported on said bracket, a flat spring supported on said member, and a filamentary cathode fastened to a part of said spring and spaced from said member, said member being readily resiliently deformed in a direction to increase the tension of said spring on said cathode, whereby heating the said spring reduces the tension thereof to make the tension on said cathode a predetermined amount.

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