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J. C. IRWIN

2,352,635

ELECTRON DISCHARGE DEVICE

Filed Dec. 31, 1942

FIG. 1

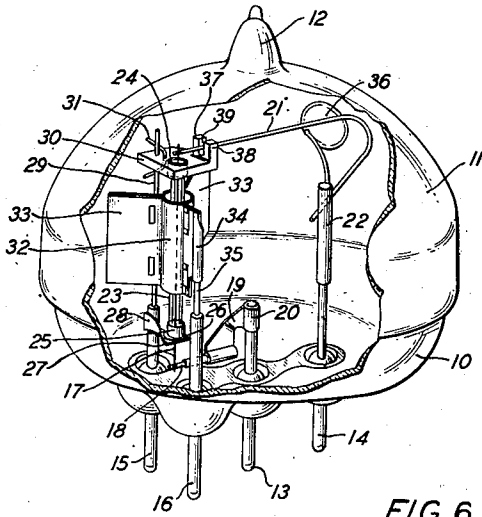


FIG. 2

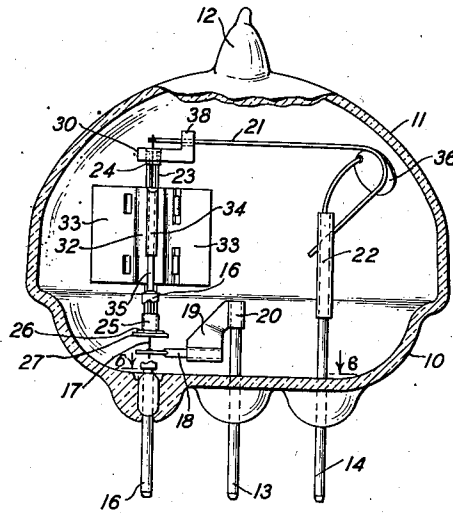


FIG. 6

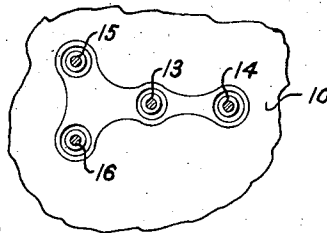


FIG. 3

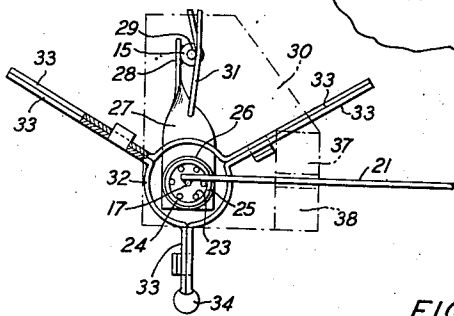


FIG. 4

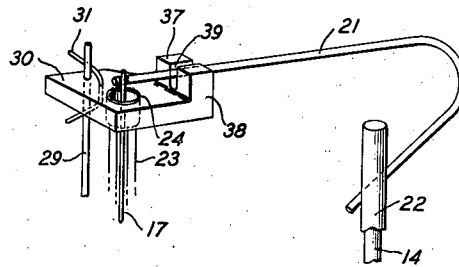
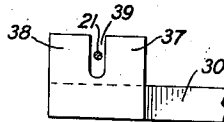


FIG. 5



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ELECTRON DISCHARGE DEVICE

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10 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices and more particularly to such devices for the generation and amplification of ultra-high frequency energy.

In ultra-high frequency transmission systems, of the order of 150 megacycles, the electrodes of the discharge device are of relatively small dimensions in order to accelerate the electron transit time between the source and the output electrode. Such minute dimensional requirements impose various construction difficulties in the assembly of the electrodes to maintain the characteristics of the device sufficiently stable to operate with high efficiency at the power output or energy level required for such devices.

When the electrodes are individually supported in coaxial relation in an evacuated containing vessel by their respective leading-in conductors, certain electrodes, particularly the cathode and control electrode, and especially the cathode, if it is in filamentary form, are easily distorted by temperature strains or mechanical stresses whereby the uniform spacial interrelation of the electrodes, which controls the stable characteristics in the operation of the device, is temporarily altered or permanently changed to such an extent that the efficiency and usefulness of the device in the designated system is materially affected.

An object of this invention is to stabilize the electrical characteristics of an electron discharge device intended for operation in the ultra-high frequency range.

Another object of the invention is to insure coaxial relation between the small dimensional electrodes of the device without reducing the output efficiency thereof.

A further object of the invention is to maintain constant linearity in the relation of the cathode or filament with respect to other cooperating electrodes.

The invention is applicable to electron discharge devices which include a plurality of small diameter electrodes in coaxial relation, the electrodes being supported from a base of an enclosing vessel by distributed conductors extending therein parallel to the electrodes. The electrodes generally comprise a central linear filamentary cathode surrounded by the cage control electrode or grid which is enclosed by an output electrode or anode, the adjacent electrodes being in close proximity in order to diminish the electron transit time and the dimensional configuration being such as to pro-

duce the desired characteristics for operation in the microwave bands of frequencies.

In accordance with this invention, the filamentary cathode is maintained in axial symmetry with respect to the control electrode and anode by an insulating member or spacer having integral upright projections which together form a guiding slot for a cantilever tension spring connected to one end of the cathode. This construction materially enhances the efficiency of the device by insuring the coaxial position of the cathode with respect to the other cooperating electrodes while permitting the spring to normally compensate for difference in temperature conditions imposed on the cathode.

A feature of the invention relates to the additional alignment of the control electrode with respect to the cathode and anode. The spacer member is provided with a guiding opening in which one end of the grid cage is situated whereby the grid is maintained in constant uniform relation to the other electrodes and the grid is free from distortion due to excessive temperature changes.

A further feature of the invention pertains to the shielding effect produced by the slot between the integral upright guides when sputtered conducting material is deposited on the spacer member. Since the spacer member is solely in contact with the control electrode any deposit formed on the surface thereof will not create a leakage path to an adjacent electrode because such other electrodes are isolated therefrom. The tension spring of the filamentary cathode is laterally free from the surfaces in the slot and since these surfaces are not exposed to the sputtered material, a leakage path cannot extend to the cathode.

Another feature of the invention relates to the offset support of the spacer member to further reduce leakage loss and thereby increase the efficiency of operation of the device. The insulating member is attached to an upright support which is connected solely to the cage grid and the point of engagement is offset from the grid opening and the guiding projections for the tension spring. This construction facilitates the location of the electrodes with respect to their supporting conductors in the device and the relation of the insulating spacer with respect to the electrodes and the filament tensioning spring without endangering the high resistance paths between the various electrodes.

These and other features of the invention will be more clearly ascertained from the following

detailed description when considered with the accompanying drawing.

Fig. 1 illustrates in perspective a device made according to this invention with the enclosing vessel broken away to show the internal assembly of the electrodes;

Fig. 2 is a view, in elevation, of the device of Fig. 1 with the vessel shown in cross section and portions of the conductors broken away to illustrate the connection of the filament to the supports at opposite ends;

Fig. 3 is a top plan view of the coaxial electrodes, on an enlarged scale, with the spacing insulator shown in phantom relation to the electrodes;

Fig. 4 shows the insulating spacer of this invention in an enlarged perspective view and the portions of the other elements in the device cooperating therewith;

Fig. 5 is a partial view of the spacer in rear elevation to illustrate the relation of the tensioned spring in the guiding slot of the spacer; and

Fig. 6 is a plan view of a portion of the inside of the base of the device of this invention taken along the line 6-6 of Fig. 2 showing the position of conductors in the base.

Referring to the drawing and particularly to Fig. 1, the ultra-high frequency discharge device of this invention comprises a hollow vitreous container of the hard glass type, such as borosilicate glass, which forms a highly evacuated receptacle for the various electrodes enclosed therein. This vessel is formed of a molded dish stem 10 sealed at the periphery to a dome or shell portion 11 which terminates in a central sealing tip 12. When the electrode assembly within the vessel is a triode employing a filamentary cathode, the stem is provided with a plurality of distributed rigid conductors sealed in protuberances of the stem, the conductors extending parallel to the axis of the vessel and being widely spaced with respect to each other to reduce leakage paths between them. As shown in Fig. 1, a conductor 13, preferably of tungsten, is sealed in an axial position of the stem, another conductor 14 is offset with respect to conductor 13 but in the same plane thereof and a pair of conductors 15 and 16 are sealed in parallel relation on the opposite side of conductor 13 and disposed in a transverse plane on opposite sides of the plane extending through conductors 13 and 14. A short filamentary cathode 17 is mounted parallel to the axis of the device and substantially coincident with the bisecting point of the planes of the conductors 13 to 15 inclusive, and is held in rigid position at the lower end by welding to the end of a radial wire arm 18, which is fixed in one end of a strap bracket 19 which has the other end 20 embracing the inner end of conductor 13. The opposite end of the filamentary cathode 17 is held under tension by a cantilever spring 21, of molybdenum wire, secured to an extension 22 projecting on the inner end of conductor 14. The cathode 17 serves as the electron source of the triode and is preferably formed of tungsten or thoriated tungsten to withstand the high temperatures incident to the operation of the device and to supply a copious flow of electrons for the discharge path to the output electrode. Furthermore, the cathode is of relatively small dimensions to decrease the spaced relation with the other cooperating electrodes of the triode and to provide a structure of minute dimensions to produce energy radiation in the microwave range.

The cathode is surrounded by a coaxial control

electrode or grid formed of a plurality of parallel molybdenum wires 23 secured in a circular boundary to the inner surfaces of a pair of end collars 24 and 25, the lower collar 25 being provided with an end flange 26. The flange of the lower collar is welded to the flat surface of a metallic connector 27 having an opening therein comparable to the diameter of the grid but having a sufficient surface around the opening for welding the flange 26 thereto. The opposite end of the connector 27 is bent at right angles and welded to the inner end of conductor 15 as shown at 28 in Fig. 3. The conductor 15 is also provided with a smaller diameter extension rod or support 29 which carries at its upper end a rectangular insulating block or spacer member 30, the block being provided with a circular opening to form a guiding sleeve or seat for the collar 24 of the grid. The block is securely held on the extension 29 by a strap wire 31 extending through the block and being welded to the extension on opposite sides of the block. The control electrode or cage grid surrounding the filamentary cathode is coaxially mounted with respect to the cathode yet is permitted to expand and contract due to temperature changes by reason of the sliding support of the grid at the top of the assembly. This construction materially improves the operation of the device since the grid, which is necessarily a frail structure, is prevented from being distorted by mechanical stresses or temperature changes.

The aforementioned coaxial electrodes are surrounded by an output electrode or anode formed of three arcuate sections 32, of sheet molybdenum, having tangential plate portions 33 extending therefrom, the plate portions being mechanically locked together on adjacent arcuate portions to form a cylindrical electron receiving surface and provide radiating fins for dissipating the heat energy generated in the device. The outer surface of the arcuate portions 32 and the fins 33 may be roughened, by sandblasting, to increase the heat radiation of the anode. A pair of the tangential plates extending from the anode in line with the conductor 16 are shortened and provided with a tubular socket 34 through which extends a rod 35 which is welded to the top of the socket and at the lower end is rigidly fixed in the inner end of conductor 16. A getter mounting 36 may be attached to the upper end of the extension 22 on conductor 14, to facilitate the maintenance of a high vacuum in the vessel after the completion of the exhaust of the vessel through the tip 12. The construction of the individually supported electrodes and the distribution of the short conductors in the stem provide high leakage resistance between the cooperating electrodes and their leading-in conductors which contribute to the trouble-free operation of the device in ultra-high frequency systems with low loss of energy output due to spurious leakage paths within the device.

In order to proportion the electrode dimensions to operate with efficiency in microwave systems and to decrease the electron transit time between the source or cathode 17 and the output electrode or anode, it is essential that the diameters of the various electrodes be as small as possible and yet be of such dimensions to satisfy the over-all electrical characteristics of the device. As a typical example, in order to operate with efficiency in the 150-megacycle range, the diameter of the anode should be of the order of $\frac{1}{8}$ inch. This requirement necessarily reduces the diameters and spacings of the other cooperating electrodes and ac-

cordingly there is great danger of the shorting of the filament against the grid. With a $\frac{1}{8}$ -inch diameter anode, as set forth in the typical example, the grid has an inside diameter of 50 mils or .050 inch and the filamentary cathode has a diameter of 8.5 mils or .0085 inch. The space relation between the cathode and grid is, therefore, of the order of .0205 inch, and the spacing between the grid and anode is of the order of .050 inch. The support of the grid, as heretofore described in accordance with this invention, stabilizes the concentricity of the grid with respect to the anode and therefore insures constant characteristics of the discharge path between these elements but prior to this invention, there was great difficulty in maintaining the axial position of the cathode with respect to the grid, due to the elongation thereof under varying temperature conditions which is generally compensated by the cantilever spring 21 which maintains the cathode under uniform tension. However, mechanical and temperature stresses in the spring cause lateral displacement of the spring and therefore changes the axial position of the cathode with respect to the cooperating electrodes. This difficulty is overcome, in accordance with this invention, by the provision of limit projections or posts on the insulating block 30 to prevent lateral movement of the spring 21 and thereby insure axial symmetry of the cathode with respect to the cooperating electrodes.

These limit posts are formed as integral projections 37 and 38 which extend upright from the edge of the insulating plate 30 in parallel relation on opposite sides of the spring 21 and intermediate the ends thereof between the cathode 17 and the support 22. The integral posts form a guiding slot 39 in which the spring 21 is freely movable in a vertical direction since the spring diameter is .025 inch and the slot width is .028 inch. However, the spring is considerably limited in lateral movement and consequently the filamentary cathode 17 is accurately maintained in axial position with respect to the cooperating electrodes. This construction insures constant linearity of the cathode with respect to the grid thereby maintaining the electrical constants of the device more uniform to produce higher efficiencies in the power output.

While the invention has been described in connection with a particular embodiment of the features disclosed in the device, it is, of course, understood that various modifications may be made in the detail assembly without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising an enclosing vessel containing a plurality of electrodes including a linear filamentary cathode, conductors in said vessel connected to one end of the respective electrodes, a conductor and a tension means attached thereto connected to the other end of said cathode to support said cathode linearly with respect to said other electrodes, and a support member on the opposite end of another of said electrodes, said member having guiding means restricting lateral movement of said tension means whereby the linearity of said cathode is maintained constant.

2. An electron discharge device comprising an enclosing vessel containing a plurality of electrodes including a linear filamentary cathode, conductors in said vessel connected to one end of the respective electrodes, a conductor and a tension spring attached thereto connected to the

other end of said cathode to support said cathode linearly with respect to said other electrodes, and an insulating support on the opposite end of another of said electrodes, said support having guiding means restricting lateral movement of said spring whereby the linearity of said cathode is maintained constant.

3. An electron discharge device comprising an enclosing vessel containing a plurality of electrodes including a linear filamentary cathode, conductors in said vessel connected to one end of the respective electrodes, a conductor and a cantilever spring attached thereto connected to the other end of said cathode to support said cathode linearly with respect to said other electrodes, an insulating support on the opposite end of another of said electrodes, and posts extending from said support forming a guideway for said spring to restrict lateral movement thereof.

4. An electron discharge device comprising an enclosing vessel containing a plurality of electrodes including a linear filamentary cathode, conductors in said vessel connected to one end of the respective electrodes, a conductor and a cantilever tension spring attached thereto connected to the other end of said cathode to support said cathode linearly with respect to said other electrodes, and an insulating support on the opposite end of another of said electrodes, said support having integral projections in close parallel relation forming a slot for said spring, said spring being freely movable in said slot in a direction coincident with the tension applied thereto.

5. An electron discharge device comprising an enclosing vessel containing a plurality of electrodes including a linear filamentary cathode, conductors in said vessel connected to one end of the respective electrodes, a conductor and a cantilever tension spring attached thereto connected to the other end of said cathode for supporting said cathode linearly with respect to said other electrodes, and an insulating spacer member on the opposite end of another of said electrodes, said member having integral projections in close parallel relation forming a slot for said spring, said slot having a width slightly greater than the diameter of said spring.

6. An electron discharge device comprising an enclosing vessel containing a plurality of electrodes including a linear filamentary cathode, conductors in said vessel connected to one end of the respective electrodes, a conductor and a cantilever tension spring attached thereto connected to the other end of said cathode to support said cathode linearly with respect to said other electrodes, said spring extending in a direction toward the electrodes at an angle to the axis thereof, an insulating spacer member on the opposite end of another of said electrodes, and integral projections on said spacer member mounted on opposite sides of said spring intermediate said cathode and said conductor supporting said spring.

7. An electron discharge device comprising a vessel enclosing a plurality of electrodes including a filament and a grid surrounding said filament, an insulating spacer member having an opening embracing one end of said grid, a cantilever tension spring attached to said filament and extending outwardly adjacent one side of said spacer member, and limiting means on said spacer member positioned on opposite sides of said tension spring and intermediate the ends there-

of to prevent lateral displacement of said spring with respect to the axial line of said grid.

8. An electron discharge device comprising an enclosing vessel containing a plurality of electrodes including a filamentary cathode and a cylindrical grid surrounding said cathode, collar members on opposite ends of said grid, a supporting conductor parallel to said grid, an insulating spacer carried by said supporting conductor and engaging one of said end collars, and a strap connector extending between said conductor and the collar member on the opposite end of said grid.

9. An electron discharge device comprising a vessel enclosing a plurality of electrodes including a filamentary cathode and a cylindrical grid surrounding said cathode, said grid having collars on opposite ends thereof, a supporting conductor parallel to said grid, an insulator member having an opening forming an annular seat for a collar on one end of said grid, and a metallic connector having a portion attached to the side of said conductor and a portion attached to the rim of said other collar on said grid, the con-

ductor being bent at right angles intermediate said portions.

10. An electron discharge device comprising an enclosing vessel, a linear filamentary cathode mounted therein parallel to the axis of said vessel, a cylindrical grid surrounding said cathode and uniformly spaced therefrom, a cylindrical anode surrounding said grid, conductors in said vessel connected to one end of the respective electrodes, a conductor and a cantilever tension spring attached thereto connected to the other end of said cathode to support said cathode linearly with respect to said other electrodes, an insulating spacer plate having an opening engaging the opposite end of said grid and being supported by the grid conductor, a metallic strap extending between said grid conductor and the opposite end of said grid, and integral upright posts on said plate forming a guiding slot for said spring, said posts being mounted on one edge of said plate in line with the projection of said cantilever spring.

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