Dec. 17, 1946. L. B. CURTIS 2,412,800

ELECTRON DISCHARGE DEVICE

Filed Aug. 5, 1943

Fig. 1.

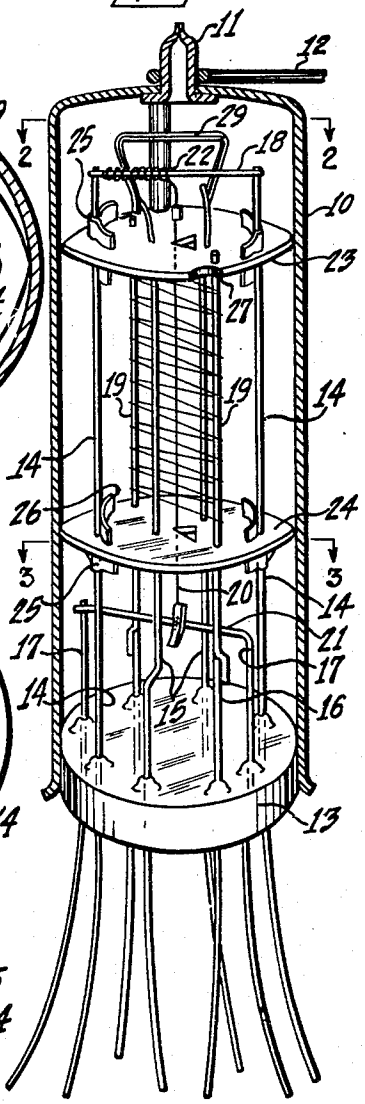


Fig. 2.

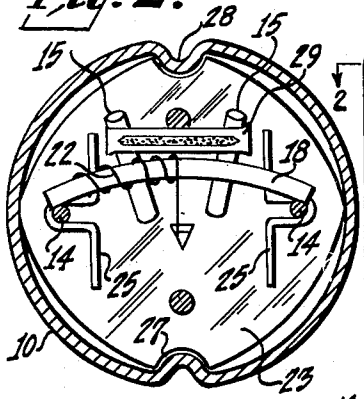


Fig. 3.

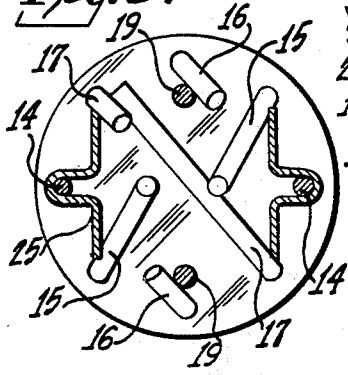
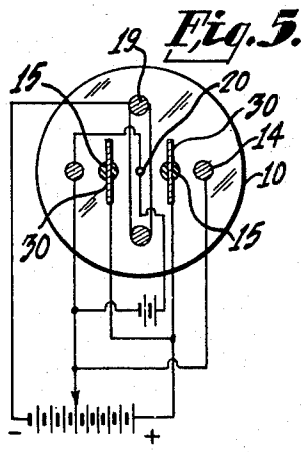


Fig. 5.



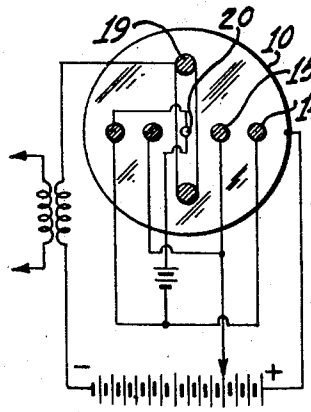


Fig. 4.

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Patented Dec. 17, 1946

2,412,800

UNITED STATES PATENT OFFICE

2,412,800

ELECTRON DISCHARGE DEVICE

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Application August 5, 1943, Serial No. 497,456

7 Claims. (Cl. 250—27.5)

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My invention relates to electron discharge devices and more particularly to electron discharge devices such as pentodes which have a plurality of cold electrodes.

The principal object of my invention is to provide a very rugged electron discharge tube which is simple in construction, consists of only a few parts, and is capable of resisting not only very severe longitudinal and transverse shocks, but also stresses due to rotation about the longitudinal axis of the tube. Another object is to provide a rugged tube of this character which is suitable for mass production and can be made in large quantities by conventional factory methods.

An electron discharge tube such as a pentode of conventional construction has desirable electrical characteristics but does not have the mechanical strength to resist very severe longitudinal and transverse shocks. The mount of such a tube can be reinforced in various ways to make it strong enough to resist such shocks but such reinforcement requires so many parts and additions that manufacture of the tube, especially on a large scale is very difficult and costly.

My invention will best be understood in connection with the accompanying drawing in which I have shown one form of pentode in which my invention is embodied and in which Figure 1 is a view in longitudinal section with the mount of the tube shown in elevation; Figure 2 is a cross-section along the line 2—2 of Figure 1; Figure 3 is a cross-section along the line 3—3 of Figure 1; Figure 4 shows diagrammatically in cross-section the electrodes of the tube of Figure 1 with suitable electrical connections; and Figure 5 is a diagrammatic cross-section showing of the tube illustrated in Figure 1 connected to operate as a triode.

The particular form of electron discharge tube illustrated in Figure 1 is of the external anode type with a metal shell or anode 10 having brazed to the upper end an exhaust tube 11 of copper heremtically sealed by cold welding under great pressure. An anode lead 12 is connected to the shell 10 preferably at the metal exhaust tube 11. The lower end of the metal shell or envelope is closed by a glass stem 13 hermetically sealed into the shell and having eight lead-in conductors in the form of continuous rods sealed into and extending through it and positioned at substantially equally spaced points on a circle concentric with the stem to provide four pairs of leads, 14, 15, 16 and 17, the leads of each pair being at diametrically opposite points on the stem and

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projecting vertically from the stem and extending lengthwise of the shell 10.

The mount of the pentode comprises a filament coaxial with the anode 10, a conventional control grid surrounding the filament, an accelerating electrode consisting solely of two rods, one on either side of the grid in a plane transverse to the plane of the grid side rods, and a suppressor electrode consisting solely of two rods, one on either side of the accelerating electrode and in the same plane. The two rods of the accelerating electrode constitute leads for passing current through an electrically flashed getter 29, and the suppressor electrode constitutes a current supply lead to the upper end of the filament.

The outer or suppressor electrode next to the anode consists solely of a pair of straight rod conductors or leads 14 sealed into and through the stem 13 to project vertically from the stem and extend longitudinally of the anode to near its top or upper end. The two leads 14 extend at their lower ends through the stem 13 at diametrically opposite points, and are connected at their free or top ends by a rigid cross-bar 18 transverse to the shell and parallel to but remote from the stem. The pair of inner leads 14 with the top cross-bar 18 constitute the suppressor electrode of the pentode. This electrode, which is connected to the upper end of a filamentary cathode and functions as a filament lead and top support for the filament, is in the general form of a fork with the two prongs firmly embedded in the stem at diametrically opposite points. The electrode is very rigid and very firmly anchored in place, so that it exhibits great resistance to displacement by shocks, especially those in the direction of the axis of the shell.

The accelerating electrode inside the outer electrode consists solely of the pair of rod conductors or leads 15 sealed into and extending through the stem at two other diametrically opposite points. These two inner leads 15 have reverse bends near the stem to bring straight intermediate portions of these inner leads into alignment and into the plane of the pair of rods 14 constituting the outer electrode. The conductors or rods 15 which form an accelerating electrode inside and in the same plane as the outer electrode may also be used as leads for passing current through an electrically flashed getter.

The pair of leads 16 sealed into the stem at two other diametrically opposite points carry a grid of conventional construction having grid side rods 19, which are in a plane at right angles to the plane of the rods or inner leads which con-

stitute the other electrodes, so that the grid rods and the rods of the other electrodes are in planes at right angles to each other. The grid side rods 19 are preferably welded practically end on to the leads 16.

In the illustrative tube shown in the drawing the cathode 20 is a 1.4 volt filament, preferably of tungsten wire coated with barium and strontium oxides and treated in the conventional way. The cathode is coaxial with the shell, in the plane of the rods 14 and 15, and extends through the grid midway between the grid side rod 18 so that the cathode is surrounded by the control grid as in the conventional tube.

The pair of leads 17 sealed into the stem 13 at diametrically opposite points constitute a filament bottom support, and are joined by a bottom cross-bar 21, which may conveniently be an arm or extension of one of the leads 17 extending parallel to the stem and having its free end welded to the other cathode support lead 17, thus forming an extremely rigid and strong support structure.

The filament or cathode 20 is firmly supported at the bottom on the cathode support leads 17 by means of a filament bottom tab welded to the lower end of the filament and to the bottom cross-bar 21. The upper end of the filament has a top tab by which the upper end of the filament is secured, preferably by welding, to the free end of a coiled torsion spring 22 wound around the top bar 18 with its other end fastened to the bar. The top bar is preferably curved to provide the proper free length for the end of the torsion spring 22. The filament is stretched between the bottom bar 21 and the top bar 18 by the torsion spring which is so set that the filament is held taut under considerable tension so that the natural frequency of vibration of the filament will be high.

The mount structure thus described is very rugged, but is made more rugged by top and bottom insulating spacers 23 and 24 preferably of sheet insulation, such as mica, and each having at the center a triangular hole through which the filamentary cathode 20 extends and is drawn taut with the ends above and below the spacers at a slight angle of about 15 degrees to the spacers so that the filament is firmly seated in the apex of each triangular hole and is held firmly in place. The spacers have holes into which the conductors 14 and 16 and the grid side rods 19 are fitted, and are firmly fixed or clamped to the rods 14 by clips 25 welded to the rods 14 and resting against the outer surfaces of the spacers and by stops 26 welded to the rods 14 and resting on the inner surfaces of the spacers. The top spacer 23 fits into the shell 10 and thus steadies the upper end of the mount against transverse displacement.

The electrode assembly is firmly supported at the lower end of the shell 10 by the stem 13 and at the upper end by the top spacer 23 and the shell. Rotation of the mount within the shell is prevented by interlocking the top spacer 23 to the shell, preferably by notches or recesses 27 in the edge of the spacer snugly fitting over ribs 28 on the interior of the shell. These ribs may conveniently be made by grooving the shell from the outside with a roller. As these ribs 28 fit firmly into the notches 27, which have the same shape as the ribs, the top spacer is firmly held against transverse motion in the shell and also is very firmly supported against displacement due to rotation with the shell.

The tube is exhausted in the usual way through the exhaust tube 11 and the conventional type of getter used in metal shell tubes may be provided. I prefer to use an electrically flashed getter such as disclosed in U. S. Patent No. 2,173,258, Lederer, issued September 19, 1939, in which the getter is placed in a getter holder or trough 29 which may for example be made of a one mil sheet of molybdenum. This getter trough, preferably mounted on the upper ends of the inner leads or rods 15 constituting the accelerating electrode, contains a getter which flashes when the temperature of the trough 29 is raised by passing current through it, which may conveniently be done by using the leads or rods 15 as current supply conductors. This construction is simple and strong, and has the advantage that for flashing the getter may be heavy enough to heat the rods 15 to degas them during the exhaust of the tube.

As best appears from Figure 4, the tube is a pentode of the external anode type which has fewer parts, is easier to assemble and is very much more sturdy and rugged than the conventional pentode. When the control grid is biased negatively and the accelerating electrode is at some positive voltage, usually somewhat less than the plate voltage on the shell 10, and the outer electrode is at cathode potential and thus acts as a suppressor electrode, the electrons leaving the cathode are modulated by the signal on the control grid, accelerated by the electrode consisting solely of the rods 15, and pass the suppressor consisting of the rods 14 to the plate. The rods 14 and the control grid side rods 19 tend to suppress secondary electrons from the plate and as a result, the plate voltage plate current characteristic of the tube has a well defined knee and resembles closely the similar characteristic of a conventional pentode. The tube may to advantage be used as a pentode for resistance coupled amplifiers.

A tube in accordance with my invention and of substantially the rugged structure shown in Figure 1 may be made as a very rugged triode by changing the connections to those shown in Figure 5, in which the shell 10 is no longer an electrode, but merely the bulb of the tube, and the rods 14 are only a filament support and lead. For the triode I find it advisable to flatten the inner leads 15 and thereby provide a two part anode consisting in effect of two narrow sheets or slats 30 set parallel to the grid 19 and intercepting more of the electron discharge than the round inner leads 15.

In a tube constructed in accordance with my invention all of the parts are simplified as much as is feasible, and all are supported directly on and anchored to the stem in such a way that stresses produced in the electrodes by sudden and severe shocks particularly along the axis of the tube are transmitted directly to the stem and along the electrodes in the direction in which they are the strongest. The stress exerted upon the straight electrodes 14 and 15 by a severe longitudinal shock is transmitted lengthwise of the electrodes to the stem directly and not through welded or other joints. The electrodes are tied together so firmly by the spacers and the mount is so firmly fixed in the shell that extremely severe transverse shocks will not distort or displace the electrode assembly. The interlock between the electrode assembly and the shell obtained by the use of the ribs 28 insures that stresses due to rotation of the shell cannot produce any harmful effects.

Tubes have been made in accordance with my

invention having a shell 10 about one inch long and about ⅜ inch in diameter and made of drawn mild steel about 10 or 12 mils thick. These tubes have as pentodes shown electrical characteristics approximating those of conventional pentodes, have withstood without harm both longitudinal and transverse shocks of a severity that would have destroyed pentodes of the strongest conventional construction, and are useful in resistance coupled amplifiers.

I claim:

1. An electron discharge tube comprising a tubular anode, a rectilinear cathode coaxial with said anode, a control grid electrode surrounding said cathode and comprising a pair of grid side rods parallel to said cathode, an accelerating electrode next to and outside said control grid and consisting of a pair of rods parallel to said cathode one on either side of said control grid in a plane transverse to the plane of said control grid side rods, and a third electrode next to and outside said accelerating electrode and consisting of a pair of rods parallel to said cathode and in the plane of the rods of said accelerating electrode.

2. An electron discharge device comprising a tubular envelope, a disc-shaped header closing one end of the envelope, a plurality of straight lead-in conductors sealed through said header and spaced at diametrically opposite points on a circle concentric with said header and extending substantially parallel to the longitudinal axis of the envelope, a transverse bar next to said header joined to a pair of diametrically opposite conductors, another transverse bar remote from the header joined to another pair of diametrically opposite conductors, and a cathode disposed longitudinally of said envelope and supported at its ends on said transverse bars.

3. An electron discharge tube comprising a planar stem, a tubular anode fixed to said stem, a rectilinear cathode coaxial with said anode, a control grid electrode surrounding said cathode and comprising a pair of grid side rods parallel to said cathode, an accelerating electrode next to and outside said control grid and consisting solely of a pair of rods sealed into said stem and parallel to said cathode one on either side of said control grid in a plane transverse to the plane of said control grid side rods, and a third electrode next to and outside said accelerating electrode and consisting solely of a pair of rods sealed into and projecting from said stem parallel to said cathode and in the plane of the rods of said accelerating electrode.

4. An electron discharge mount comprising a planar stem, four pairs of rigid rod conductors sealed into said stem on a circle and projecting vertically from said stem and parallel to one another throughout the major part of their length, at least one conductor of each pair extending through said stem, a transverse bar next to said stem joined to one pair of diametrically opposite conductors, a second transverse bar remote from said stem and joined to a second pair of diametrically opposite conductors, a filamentary cathode secured at its ends to said transverse bars and parallel to said rod conductors, a grid electrode surrounding said cathode and comprising two grid side rods joined end on to a third pair of conductors, the active portions of the other conductors being in substantially the same plane transverse to the plane of said grid side rods, an electrically conductive getter support remote from the stem and joined to the pair of conductors next to said grid, and an insulating spacer for said rods intermediate their ends.

5. An electron discharge mount comprising a stem, three pairs of straight leads projecting from said stem parallel to one another, the leads of each pair sealed into said stem at diametrically opposite points on a circle, a grid electrode having two side rods joined end on to one pair of leads, a second pair at right angles to the plane of said grid and extending beyond the upper end of said grid, a transverse bar above said grid joining the upper ends of said second pair of leads, a transverse bar between said grid and said stem joining the third pair of leads, a straight cathode extending through and surrounded by said grid electrode and joined at its ends to said transverse bars, a fourth pair of continuous leads extending through said stem and having straight portions next to and outside of said grid, said straight portions being positioned between said grid and said second pair of leads in alignment with and parallel to said second pair of leads, and a conductive getter support joined to said fourth pair of leads.

6. An electron discharge device comprising a tubular envelope, a header closing one end of the envelope, a plurality of spaced circularly arranged lead-in conductors sealed into said header and extending substantially parallel to the longitudinal axis of the envelope, a bottom transverse bar next to said header joined to a pair of diametrically opposite conductors, a top transverse bar remote from the header and joined to another pair of diametrically opposite conductors, a cathode coaxial with said envelope and supported at its ends on said transverse bars, a grid electrode surrounding said cathode and comprising a pair of grid side rods in a plane transverse to the plane of said second pair of conductors, a third pair of conductors interposed between said second pair of conductors and said grid in alignment with and in the plane of said second pair of conductors, a sheet spacer extending transversely of said envelope above said grid and below said top transverse bar and having holes into which said conductors and said grid side rods are fitted, said spacer fitted into said envelope and having notches in its edge, said envelope having internal longitudinal ribs fitted into said notches.

7. An electron discharge device comprising a tubular envelope, a header closing one end of the envelope, a plurality of lead-in conductors sealed into said header and spaced on a circle concentric with said header and extending substantially parallel to the longitudinal axis of the envelope, a bottom transverse bar next to said header joined to a pair of diametrically opposite conductors, a top transverse bar remote from the header and joined to a second pair of diametrically opposite conductors, a cathode coaxial with said envelope and supported at its ends on said transverse bars, a grid electrode surrounding said cathode and comprising a pair of grid side rods in a plane transverse to the plane of said second pair of conductors, and a third pair of conductors interposed between said second pair of conductors and said grid in alignment with and in the plane of said second pair of conductors, said third pair of conductors being flattened along their length in registry with said grid and parallel to said grid to provide an extended electron collecting surface.

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