Feb. 28, 1939. C. DEPEW ET AL 2,148,538

ELECTRON DISCHARGE DEVICE

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FIG. 1

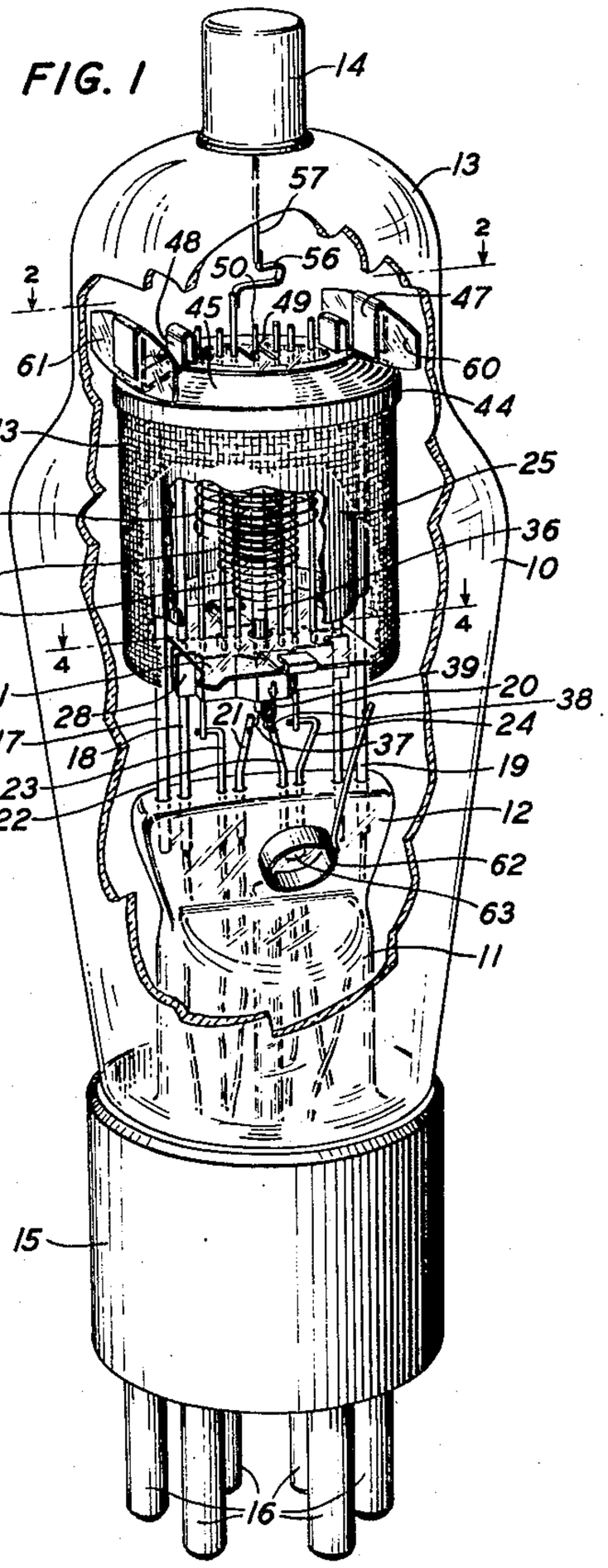


FIG. 3

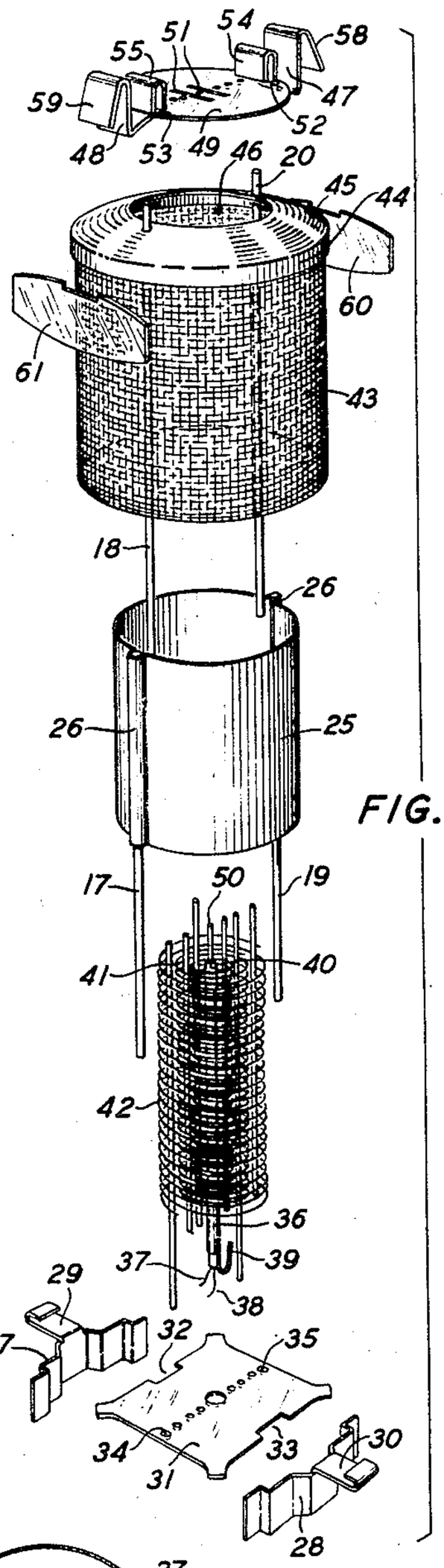
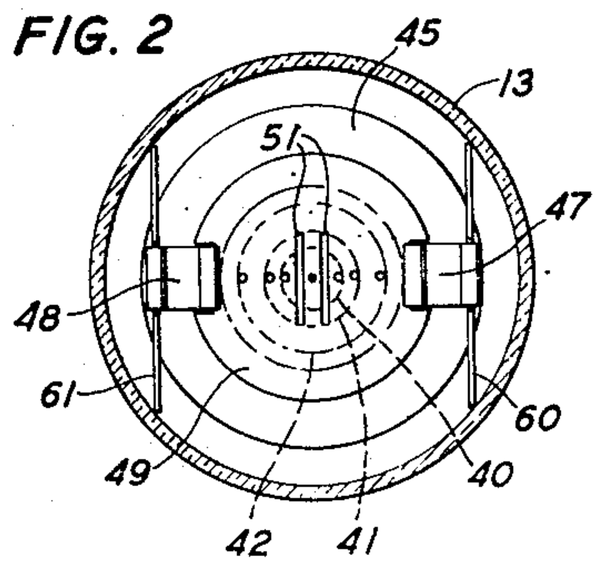


FIG. 2



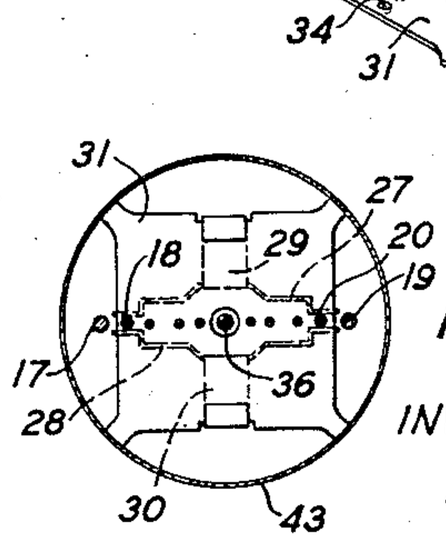


FIG. 4

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FIG. 5

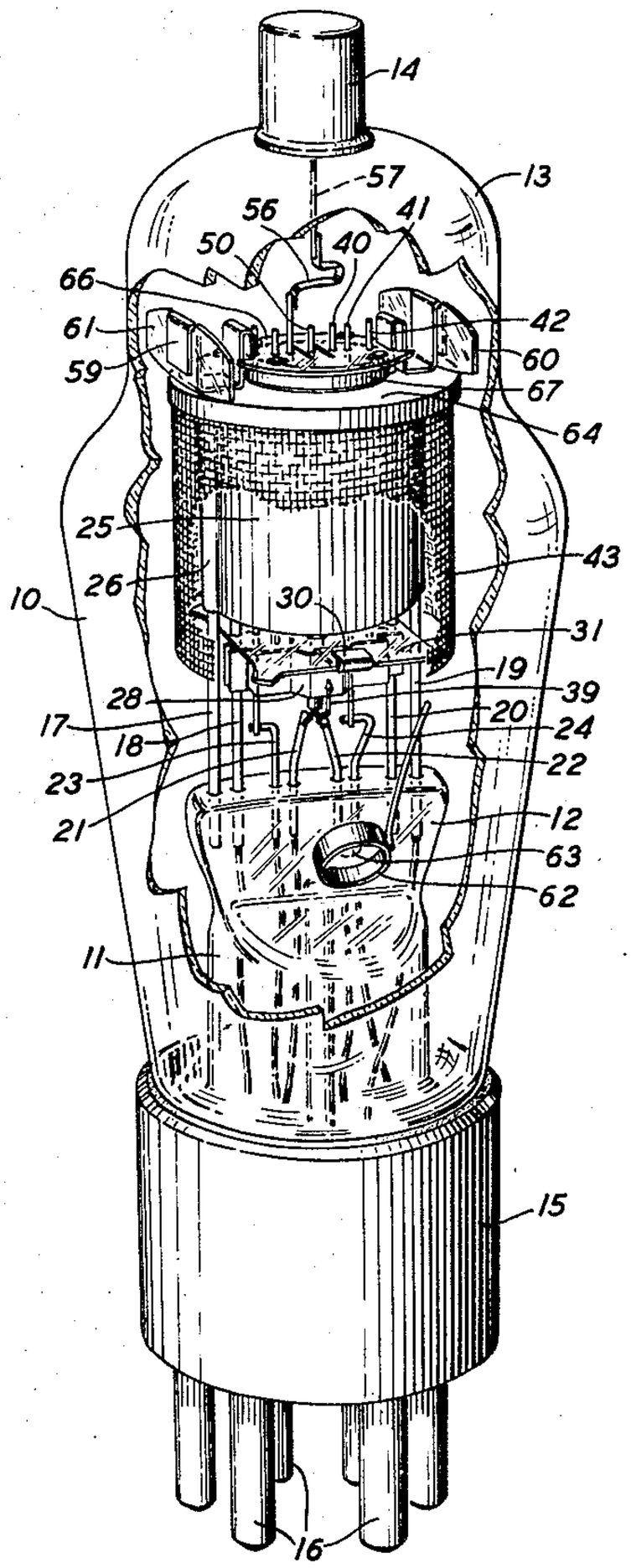

FIG. 6

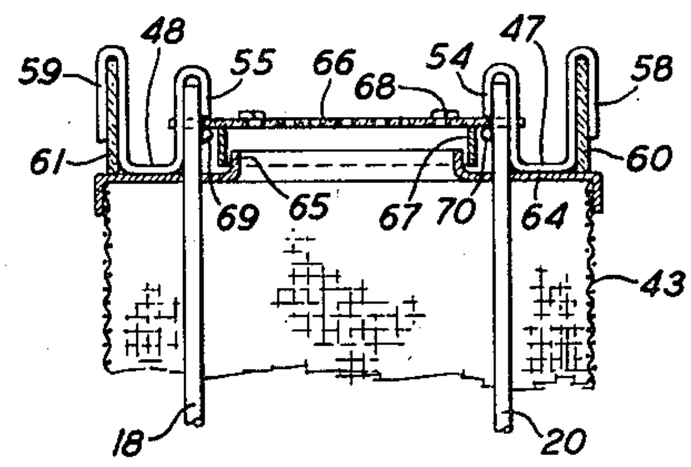

FIG. 7

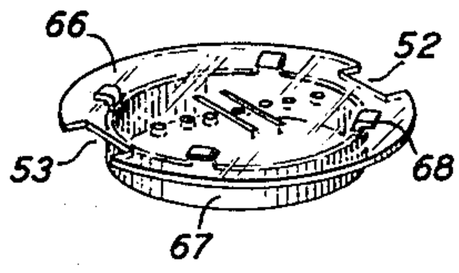

FIG. 8

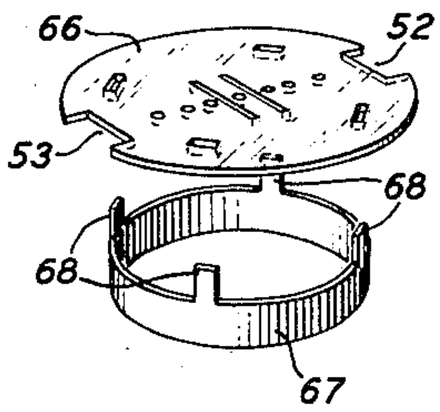

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FIG. 9

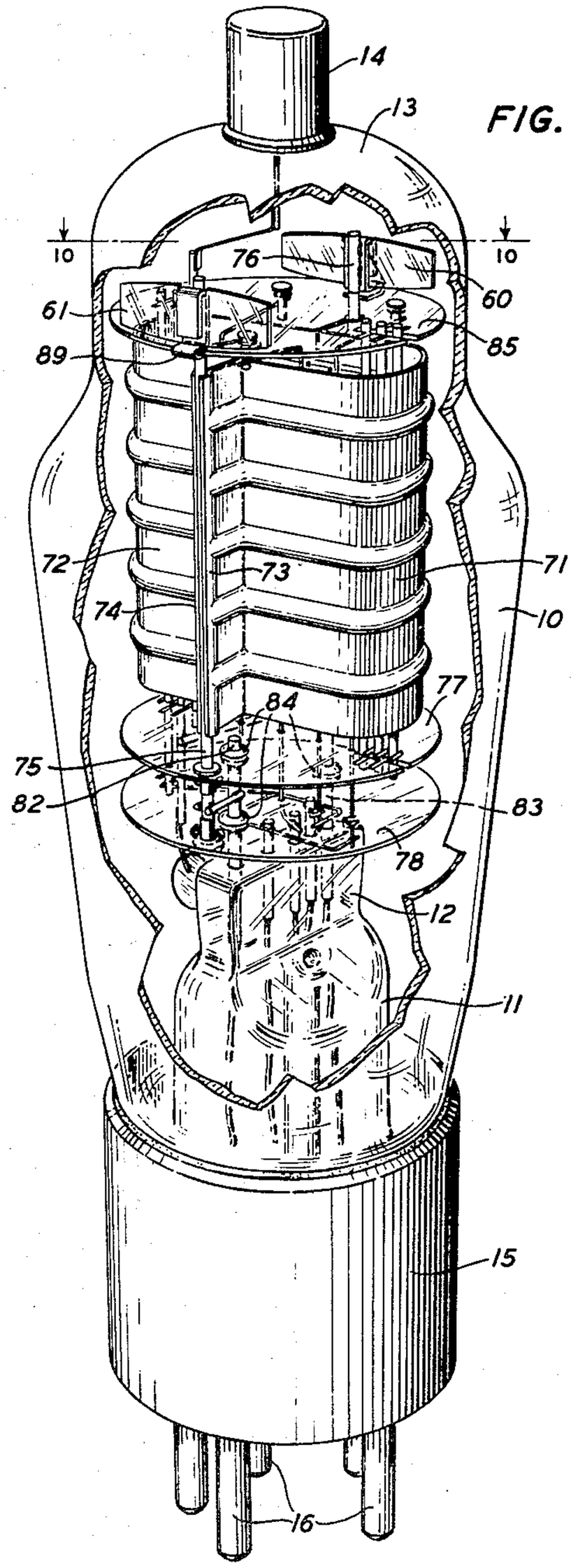
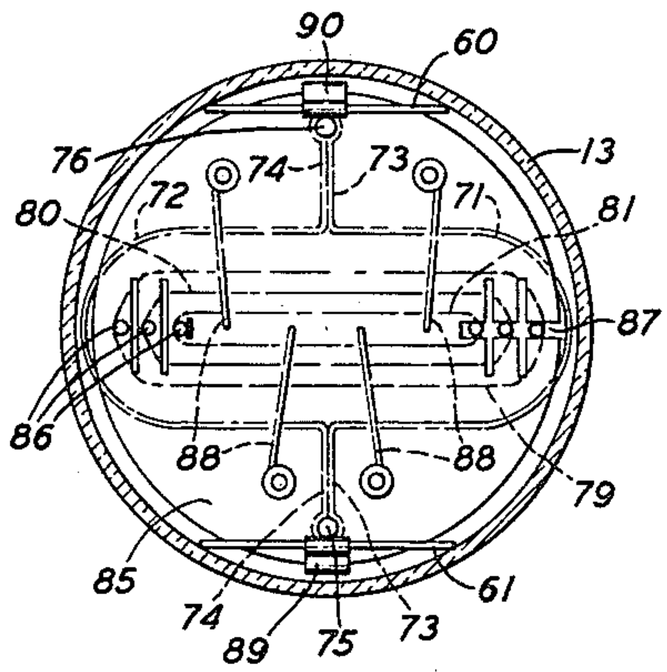


FIG. 10



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Patented Feb. 28, 1939 2,148,538

UNITED STATES PATENT OFFICE

2,148,538

ELECTRON DISCHARGE DEVICE

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Application September 7, 1934, Serial No. 743,058

16 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices and more particularly to devices of the multi-grid type.

An object of the invention is to assemble the electrodes in a device to operate at high efficiency over a long period of operating life.

A further object of the invention is to eliminate vibration in the electrode structure and thereby maintain the electrical characteristic of the device constant at all times.

Another object of the invention is to compensate for manufacturing variations in the diameter of the enclosing vessel within which the electrode assembly is mounted.

In accordance with this invention an electron discharge device comprises an enclosing vessel in which the electrode unit is mounted on the stem by rigid supports and the unit is provided with resilient members which engage the wall of the vessel to eliminate vibration of the unit. The electrode assembly comprises a pair of supports on the stem which are secured to an outer screen electrode which encloses the other electrodes of the device. A spacer disc is mounted on the top of the screen electrode and a spacer plate coextensive with the disc is supported adjacent the lower end of the screen electrode by an elongated shield attached to the parallel supports. The spacer plate is provided with equally spaced extensions which frictionally engage the inner surface of the outer screen electrode to maintain it in accurate position free from vibrations. A heater type cathode and a grid, or a plurality of grids, are mounted in coaxial relation within the screen electrode and are held in proper relation by the top disc and lower spacer plate. A cylindrical anode is situated between the outer screen electrode and the supports therefor and is supported independently from the stem by two supports which extend through the gaps between the lower spacer plate and the outer screen electrode.

A feature of the invention relates to the maintenance of the outer screen electrode and elongated shield adjacent the stem at cathode potential by a connection of these elements to the cathode, to eliminate the presence of disturbing fields in the surrounding medium in the vessel.

A further feature of the invention relates to the mounting of vibration-eliminating members on the electrode assembly to engage the wall of the vessel. This arrangement comprises a plurality of bent metallic clips mounted on the electrode assembly at diametrically opposite points and adapted to hold a pair of narrow strips in parallel relation with the ends thereof adapted to engage the wall of the vessel. The resiliency of the strips compensates for dimensional variations in the diameter of the end portion of the vessel and the arrangement of the strips avoids chipping of the edges which causes difficulty in the evacuation process. This assembly avoids the excessive heating of the strips when high frequency inductive heating is employed in the evacuation process since the narrow strips are substantially free from contact with the metallic parts of the assembly and are arranged transverse to the inductive field and therefore are not liable to be heated to elevated temperatures.

A further feature of the invention relates to the registering of all the electrodes except the anode or plate from two main support rods extending from the stem. This arrangement is realized by supporting the outer screen assembly, which forms a base for the top insulating spacer disc, and the elongated shield, which forms a base for the lower spacer plate, from two internal support wires which extend from the stem. Such an assembly produces a structure in which the electrodes are accurately registered in proper spaced relationship and also facilitates the fabrication of the electrode unit for mass production.

Other features of the invention reside in the fabrication of the electrode assembly in which the top insulating disc is held in position by the metallic clips which support the narrow spacer strips. The position of the lower spacer plate is obtained by outwardly extending clips on the elongated shield which are bent around the plate to support it.

These and other features of the invention will be clearly understood from the following detail description taken in connection with the accompanying drawings which show in:

Fig. 1 a completely assembled device in perspective embodying all the features of this invention and having portions of the enclosing vessel and the electrodes broken away to illustrate the internal construction more clearly;

Fig. 2 is a plan view of the top of the device taken on the line 2—2 of Fig. 1 and illustrating the arrangement of the vibration eliminating strips with respect to the electrode assembly and the wall of the vessel;

Fig. 3 is an exploded view in perspective of the various electrode units embodied in the structure of Fig. 1;

Fig. 4 is a plan view of the lower spacer plate and assembly taken on the line 4—4 of Fig. 1;

Fig. 5 is a perspective view of a modified form

of the invention in which the spacer element is associated with the screen assembly;

Fig. 6 is a partial view in cross-section of certain structural details of Fig. 5 illustrating the modification of the electrode unit shown in Fig. 1;

Fig 7 is a perspective view of the spacer element and shield ring shown in Figs. 5 and 6;

Fig. 8 illustrates perspectively the dissociated elements of the assembly shown in Fig. 7;

Fig. 9 shows in a perspective view another embodiment of the invention with portions of the enclosing vessel broken away to show the electrode unit assembly; and

Fig. 10 is a cross-sectional view on the line 10—10 of Fig. 9 illustrating the arrangement of the electrode unit in the vessel and the support thereof from the wall of the vessel.

Referring to the drawings, and to Fig. 1 particularly, there is shown one embodiment of this invention as applied to a pentode type tube in which a highly evacuated bulb constitutes the enclosing vessel of the device. This consists of a glass container, known in the trade as an "ST" bulb, having a downwardly tapered portion 10, which is closed at one end by a reentrant stem 11 terminating in a press 12, and at the other end is provided with a dome-shaped portion 13 supporting a terminal cap 14. A base 15 is attached to the end of the tapered portion 10 adjacent the stem and is provided with a plurality of terminal prongs 16 arranged in a circular boundary which form the external connections for the leading-in wires from most of the electrodes in the device.

In order to realize the simplicity of assembling the complicated electrode unit of a pentode device, for instance, in accordance with this invention, and also to appreciate the compactness and symmetry of the structure, a detailed exposition of the assembly of the device, as shown, will be set forth to reveal the merits of this invention. It is well known in vacuum tube manufacture that the electrode assembly originates with the formation of the stem in which the supports and leading wires are sealed in the press. In accordance with this invention the press 12 of the stem 11 is provided with two pairs of long support wires 17, 18, 19 and 20, situated at opposite ends of the press, and four short wires 21, 22, 23 and 24 which are sealed in the press between the long wires, the short wires 21 and 22 being adjacent the center portion of the press, the wire 23 being intermediate the wire support 18 and the wire 21, and the wire 24 being positioned between the short wire 22 and the long support wire 20. A cylindrical nickel plate electrode or anode 25, preferably carbonized, to easily dissipate the heat generated in the device, is provided with diametrically opposite longitudinal ridges 26 which form pockets for the support wires 17 and 19 and facilitate the mounting and welding of the anode to the support wires. It will be noted that the supports for the anode terminate at the top of the anode so that the anode is solely and rigidly supported from the stem.

After the anode is secured in position a pair of metallic plates 27 and 28, shown more clearly at the bottom of Fig. 3, are welded to opposite sides of the support wires 18 and 20 a short distance below the bottom edge of the anode 25, as shown in Fig. 1. These plates are arranged with their surfaces parallel to the axis of the stem 12 and form an elongated channel or box shield between the support wires 18 and 20 which decreases in area from the center to the support wires. The plate 27 is provided with an integral outwardly extending portion 29 which is bent at right angles at the upper edge of the metallic plate 27 and a similar outwardly extending portion 30 which projects in an opposite direction from the plate 28. The flat surfaces of the portions 29 and 30 and the edges of the plates 27 and 28 form a supporting base for a rectangular shaped insulating spacer member or mica plate 31. The spacer plate 31 is rigidly held in position by the ends of the portions 29 and 30 which are bent over the notches 32 and 33 to prevent movement of the spacer member. The spacer member is additionally lined up by the holes 34 and 35 which register with the support wires 18 and 20. The spacer member is also provided with a number of punched holes for the support of the other electrodes.

Usually, in a pentode type tube there are three grids in addition to the central cathode and the spacing of these elements is determined by the spacing of the punched holes along the diameter of the member 31 coincident with the holes 34 and 35. The large central hole receives an indirectly heated cathode 36 which is provided with the usual internal heater element having terminations 37 and 38 which are secured to the leading-in wires 21 and 22, respectively. The cathode 36 is also provided with an extension or bent wire 39 which is welded to the outer surface of metallic plate 28, as shown in Fig. 1. After the cathode is placed in position, the various grids, which have been previously wound, are placed in the respective holes determined by the spacer member 31. The inner grid 40 which immediately surrounds the cathode 36 is the control electrode and is formed of a helical wire welded to two upright supports. In order that this grid may perform a desirable function in the control of the flow of electrons from the cathode to the anode, the grid may be formed with a non-uniform pitch in the turns of the helix. This can be accomplished by winding the upper and lower sections of the grid with a closely spaced uniform pitch in the winding while the intermediate section is provided with a coarser pitch of winding. This arrangement provides a variable characteristic for the control of the amplification which is so desirable in automatic volume control systems.

The control grid is coaxially surrounded by a shield or screen grid 41. This grid is a helical conductor of closely spaced uniform turns throughout which are secured to two parallel supports, the lower ends of which pass through the holes adjacent the holes for the control grid in the spacer member 31. It should be noted that one of the support wires for the screen grid 41 is longer than the other in order that it may be welded to the short wire 24 extending from the press 12. The third grid or suppressor grid 42 is also a helical wire conductor wound in a uniform coarse pitch on a pair of vertical supports which fit into the holes in the spacer member 31 adjacent the holes 34 and 35. The support of the grid 42 adjacent the rigid wire 18 is longer than the other support in order that this support may be attached to the short wire 23 in the stem 12. It will be realized from the above description that the cathode and the grids are accurately spaced in proper relation in the spacer member 31 and all of these elements except the control grid are rigidly secured to suitable connections in the stem of the device.

All of the electrode elements are surrounded by an external shield or outer screen electrode

in the form of a wire mesh cylinder 43 in order to protect the elements against stray fields which may accumulate on the wall of the enclosing vessel 10. The external shield 43 is secured at the top to the inner surface of a downwardly extending flange 44 forming the boundary of a truncated dome-shaped metallic disc 45, having a large central aperture 46. The disc 45 is provided with a pair of small apertures on opposite sides of the aperture 46 which register with the support rods 18 and 20. These support rods are welded to U-shaped metallic members or clips 47 and 48 which have their bases conforming to the slope of the disc 45 and are welded thereto. The lower end of the outer shield is frictionally engaged by the corner extensions of the lower spacer member 31, to prevent the setting up of vibrations in the outer screen assembly when shocks are transmitted to the device.

When the outer screen assembly is placed in position the cathode and the various grids may be easily lined up by threading the supporting wires of the grids through the corresponding holes in a top spacer member or disc 49, which may also be formed of mica. The top of the cathode sleeve 36 is provided with a short wire 50 which enters the center hole in the mica spacer 49 between the parallel slots 51 therein. These slots increase the insulating path between the cathode and the control grid which has a conductor brought out through the top of the vessel. The mica disc 49 is provided with oppositely disposed peripheral notches 52 and 53 in line with the row of punched holes for receiving the various electrodes and these notches register with the inner edges of the U-shaped metallic members or clips 47 and 48 to accurately locate the mica disc in position. Due to the fact that the mica disc 49 rests on the inner rim of the dome-shaped disc 45 and is prevented from rotative movement by the U-shaped clips, and the further fact that the folded extensions 54 and 55 on the metallic clips lie parallel with the vertical surfaces of the U-shaped members and have their edges bearing on the disc, it is apparent that the mica spacer disc 49 is rigidly held in position and displacement thereof is prevented. A yielding connection 56 and a leading-in wire 57 are connected to the long supporting wire of the control grid 40 projecting through the top spacer disc 49 and the leading-in wire 57 is sealed through the top of the dome portion 13 of the vessel and connected to the terminal cap 14.

In order to eliminate vibration of the whole electrode assembly in accordance with this invention, the U-shaped metallic members 47 and 48 on the external shield assembly are provided with outwardly extending portions 58 and 59 which form clips to receive upright elongated resilient strips 60 and 61 which are provided with notches to fit in the upper portion of the clips with the lower surface thereof resting on the top of the disc 45 with the extensions 58 and 59 frictionally holding the strips in position. The strips 60 and 61 may be of metal or mica, and as shown in Fig. 2, have their attenuated edges engaging the dome portion 13 of the vessel. The parallel arrangement of the strips 60 and 61 insures a four-point contact between the electrode unit and the wall of the vessel, to increase the rigidity of the electrode assembly and prevent shocks or vibrations being communicated to the electrodes to alter the spacing between them.

The outer shield 43 and the elongated box shield which supports the spacer plate 31 are both supported by the rods 18 and 20 and are electrically connected to the cathode 36 through the connection 39 and the upright rod 18 serves as a conductor for these elements by being connected to one of the external prongs on the base 15. It is, therefore, evident that the shields are maintained at the potential of the cathode and therefore protect the positive charged elements against extraneous fields which may be present in the vessel. The elongated shield also surrounds the extensions of the screen grid 41 and the suppressor grid 42 and tends to protect the control grid against any disturbing effects. This shield also protects the control grid against hum noise caused by the heater leads which supply current to the heater element within the cathode. The anode 25 is supplied with a suitable voltage through the supporting rod 19. This rod also carries a metallic cup 62 which forms a receptacle for a getter pellet 63, such as magnesium. This getter is flashed by high frequency induction heating in the final evacuation stages of manufacture of the tube.

An advantage of this invention with respect to the arrangement of the vibration eliminating strips at the top of the electrode assembly is that when high frequency is employed for thoroughly out-gassing the metallic elements of the device and the strips are formed of resilient metal, very little heating occurs in the strips due to the fact that they are arranged at right angles to the inductive field produced within the electrode assembly. The minimum amount of heating caused by conduction in the strips is not sufficient to cause any detrimental effect. Obviously, if the strips are formed of mica substantially no heating is produced even by conduction. While the spacer members 31 and 49 are preferably formed of mica, it is evident that these parts may be formed of other insulating material.

The device shown in Fig. 5 is similar in substantially all respects to the device shown in Fig. 1 except for the assembly at the top of the electrode unit. In this arrangement the outer screen grid 43 is connected to a peripheral flange on an annular metallic disc 64 which is provided with an upturned rim or collar 65 and forms a central aperture through which project the supports of the various grids and the cathode which constitute the internal electrodes associated with the anode 25. The cathode and the various grids are spaced in coaxial relation to the anode by a spacer disc 66, of mica, similar to the disc 49, described in connection with Fig. 1, but carrying a suspended annular ring or shield 67 which is attached to the disc 66 by integral projections 68 that extend through suitable slots in the disc and are bent over as shown in Fig. 7 to fasten the collar 67 to the disc.

In assembling the upper mica spacer disc 66 in the electrode unit of Fig. 5 it rests on two oppositely disposed stub wires 69 and 70 which are welded crosswise a short distance from the ends of the long support wires 18 and 20. In this position the slots 52 and 53 slide over the edges of the inner portions of the U-shaped clips 47 and 48 while the suspended shield ring fits over the guiding collar 65 on the metallic disc 64. The inner bent portions 54 and 55 of the clips have their lower edges in contact with the surface of the disc 66 and therefore the disc is held in accurate position to receive the supports of the grids and the cathode. In this arrangement the suspended shield 67 provides an additional pro-

tective screen in the area adjacent the supports of the grids and therefore increases the shielding effect of the outer shield to a greater extent.

In Fig. 9 the feature of the invention relating to the four-point contact of the electrode unit with the vessel is shown as applied to a device of higher power rating in which the electrode unit embodies a reinforced anode formed of two symmetrical U-shaped portions 71 and 72 which are joined together by integral flange portions 73 and 74 on opposite sides of the structure to form a hollow elongated space for the reception of the other cooperating electrodes of the device. The outer extremities of the facing flange portions 73 and 74 are formed into a longitudinal groove which embrace support rods 75 and 76 and are held therein, for instance, by welds. The lower ends of the rods are secured to parallel mica spacer discs 77 and 78 which align the supports for three internal grids 79, 80 and 81, coaxially positioned within the anode, and a central filamentary cathode (not shown). The electrode unit is rigidly attached to the press 12 by two short wires 82 and 83 which extend through the parallel mica discs 77 and 78 and are attached thereto by eyelets 84. The electrodes are held in spaced relation at the other end of the unit by a mica disc 85 in which the ends of the supports of grids 79, 80 and 81 are maintained in a transverse axial line by the apertures 86 on one side and the slot 87 on the opposite side. The bights of the filamentary cathode are tensioned by hooks 88 extending below the mica disc 85. This assembly is described in more detail and claimed in U. S. Patent 2,111,602, issued March 22, 1938, to V. L. Ronci.

In accordance with this invention the electrode unit in the enclosing vessel shown in Fig. 9 is maintained in a non-vibrating position by an assembly in which the upper mica disc 85 is held in cooperative relation to the anode 71 by a pair of oppositely disposed metallic clips 89 and 90 which have a short hook portion engaging the edge of the disc while a vertical portion is welded to the support rods 75 and 76. The clips also support the parallel upright resilient strips 60 and 61 which are held in position by the downwardly bent extensions of the clip. It will be seen from Fig. 10 that the edges of the strips 60 and 61 engage the wall of the dome portion 13 of the vessel and thereby eliminate vibration of the electrode unit in the vessel.

While various features of the invention have been disclosed either as combined in a single device or one or more features disclosed in another device, it is to be understood that the invention is not limited to the specific structures shown in the drawings since it is obvious that such features may be embodied in other devices radically different from those disclosed without departing from the scope of this invention as set forth in the appended claims.

What is claimed is:

1. An electron discharge device comprising a vessel having a stem, an electrode unit supported from said stem, a pair of metallic clips above and attached to the top of said electrode unit, and transverse upstanding resilient strips frictionally held by said clips, the short edges of said strip engaging the wall of said vessel.

2. An electron discharge device comprising an enclosing vessel having a stem, a pair of supports extending from said stem, a metallic shield adjacent the ends of said supports, a cylindrical shield suspended from said metallic shield, a spacer member on said metallic shield, a rectangular spacer member carried by said supports adjacent the lower end of said cylindrical shield, a cathode and a grid located between said spacer members, an anode adjacent said grid, and supports extending from said stem for said anode and passing freely between said cylindrical shield and said rectangular spacer member.

3. An electron discharge device comprising an enclosing vessel having a stem, a pair of supports extending from said stem, a metallic disc secured to the ends of said supports, a spacer member supported by said disc, a cylindrical shield suspended from said disc, a second spacer member carried by said supports adjacent the lower end of said cylindrical shield and frictionally engaging said cylindrical shield, a cathode and a grid supported by said spacer members, and an anode between said grid and said cylindrical shield, supported from said stem.

4. An electron discharge device comprising an enclosing vessel having a stem, a pair of supports extending from said stem, a metallic disc having a central aperture secured to said supports, a cylindrical shield suspended from said disc, a spacer member on said disc, a second spacer member carried by said supports and having a plurality of extensions engaging the inner surface of said cylindrical shield, a cathode and a grid located between said spacer members, and an anode between said grid and cylindrical shield, supported solely from said stem.

5. An electron discharge device comprising a vessel having a stem, a shield electrode having an apertured closure portion at one end, a pair of supports projecting from said stem within said electrode and attached to said closure portion adjacent the aperture, a cathode and a grid within said electrode, a metallic shield surrounding one end of said cathode and attached to said supports, insulating spacing means carried by said closure portion and said metallic shield for supporting said cathode and grid, an anode located between said shield electrode and grid, and a second pair of supports projecting from said stem to said anode for supporting said anode independent from the other electrodes.

6. An electron discharge device comprising a vessel having a stem, a cathode, a grid and an anode coaxially supported beyond said stem, a shield electrode enclosing the cathode grid and anode, a spacer member in contact with the outer surface of said shield electrode at one end for spacing said cathode and grid, a second spacer member in contact with the inner surface of said shield electrode at the other end and engaging said cathode and grid, and supports in said stem for said anode projecting between said second spacer member and said shield electrode.

7. In an electron discharge device an electrode assembly including a plurality of electrodes, a metallic shield surrounding said electrodes, a spacer member on said shield for said electrodes, spacing means on said assembly engaging the wall of the device, and metallic members supported on said metallic shield having portions for holding said spacer member to said shield and other portions for supporting said spacing means.

8. An electron discharge device comprising an enclosing vessel having a stem, an electrode unit supported from said stem including an outer shield, a spacer member for other electrodes in the unit extending parallel to the top of said outer shield, a pair of uprights extending from said stem supporting said outer shield and spacer

member, and a shield ring suspended from said spacer member for shielding the space between said outer shield and spacer member.

9. An electron discharge device comprising an enclosing vessel having a stem, a pair of supports extending from said stem, an apertured shield carried by said support at one end thereof, a cylindrical shield attached to said apertured shield, an elongated box shield attached to said supports adjacent said stem, said box shield having outwardly extending central projections, an insulating spacer plate resting on said box shield and held in position by said projections, a cathode centrally positioned in said spacer plate, a helical grid having supports extending through said spacer plate, an anode positioned between said cylindrical shield and said grid, an insulating spacer disc supported on said apertured shield for spacing the supports of said cathode and grid, and means connecting said cathode to said elongated shield, said cathode box shield and cylindrical shield being electrically connected together.

10. In a discharge device, an electrode unit comprising a cathode, a grid and an anode, top and bottom insulating members for spacing said cathode and grid within said anode, a shield member surrounding the ends of said cathode and grid adjacent one end of said anode, said shield member having outwardly extending arms supporting the bottom insulating member, and means connecting said cathode to said shield.

11. An electron discharge device comprising an enclosing vessel having a stem and a dome portion, a multi-electrode unit supported from said stem including a pair of supports at opposite ends of said stem, a cylindrical anode attached to said supports, a second pair of supports adjacent the anode supports, an annular dome-shaped disc attached to said second pair of supports beyond said anode, said disc having a peripheral flange portion, a cylindrical mesh shield secured to said peripheral flange portion and enclosing said anode, an insulating plate adjacent one end of said cylindrical shield having portions in engagement therewith, an elongated metallic shield attached to said second pair of supports and forming a base for said insulating plate, an insulating disc seated on said dome-shaped disc, a central cathode and a plurality of grids spaced by said insulating disc and said plate, a connection between said cathode and said elongated shield, a pair of resilient rectangular strips arranged at opposite points on the perimeter of said dome-shaped disc and extending perpendicularly thereto, and metallic clips attached to said dome-shaped disc for securing said insulating disc and said resilient strips thereto.

12. An electron discharge device comprising a vessel having a stem, an electrode unit supported from said stem, transverse upstanding resilient strips beyond said unit, and a pair of metallic clips having a vertical portion frictionally engaging the laterally intermediate portions of said strips and a portion parallel to the top of said unit secured thereto, the short edges of said strips engaging the wall of said vessel.

13. An electron discharge device comprising a vessel having a stem, an electrode unit supported from said stem, a spacer member for the electrodes on top of said unit, a pair of transverse spacing strips adjacent the edge of said spacer member at diametrical points, and metallic supports engaging said member and strips, said supports having an upright folded portion adjacent said member and an upright portion of larger area folded around one edge of each strip.

14. An electron discharge device comprising a vessel having a stem, an electrode unit supported at one end from said stem, a pair of upright resilient strips having their ends engaging the wall of said vessel to steady said unit therein, and a pair of vertically mounted clips extending above said unit and attached to the top thereof, each clip having a portion frictionally engaging a strip at an intermediate point.

15. In combination, an enclosing vessel having a stem at one end and a dome portion at the other end, a mount for a heatable element supported by and extending from said stem, a pair of upstanding resilient spacer strips beyond said mount and in contact with the dome portion of said vessel, and a pair of metallic clips on said mount, each clip having a vertical portion engaging the intermediate portion of a strip and a portion parallel to the top of said mount secured thereto.

16. In combination, an enclosing vessel having a stem at one end and a dome portion at the other end, a mount for a heatable element supported by and extending from said stem, said mount having a plurality of insulating spacer members for supporting said element, a pair of transverse resilient insulating strips beyond said mount and having their ends engaging the dome portion of said vessel, and a pair of vertically mounted metallic clips extending above said mount and attached to one of said spacer members, each clip having a portion frictionally engaging a strip at an intermediate point.

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