

Dec. 1, 1936.

J. P. LAICO

2,062,319

ELECTRON DISCHARGE DEVICE

Filed Feb. 9, 1935

2 Sheets-Sheet 1

FIG. 1

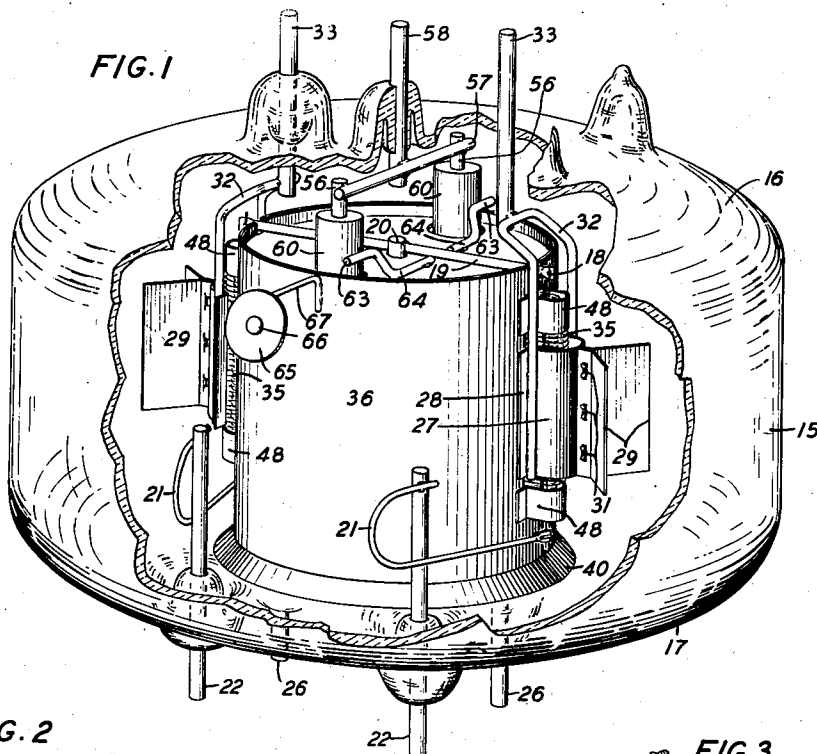


FIG. 2

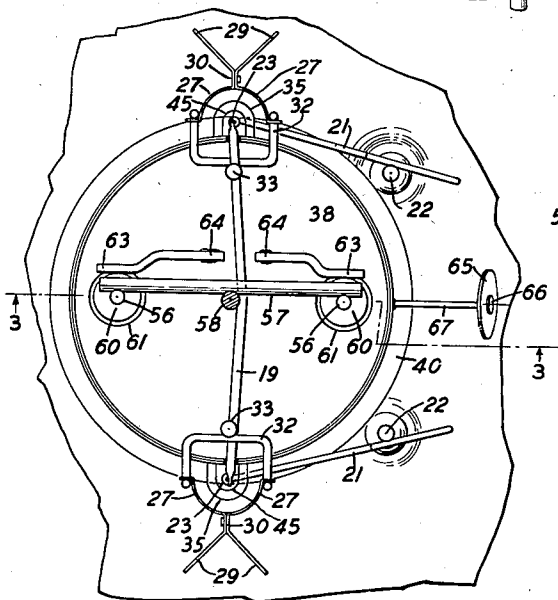
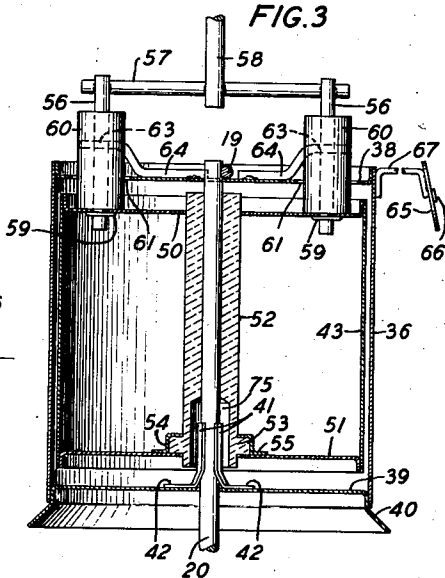


FIG. 3



INVENTOR
J. P. LAICO
BY
Halter C. Kiesel
ATTORNEY

Dec. 1, 1936.

J. P. LAICO

2,062,319

ELECTRON DISCHARGE DEVICE

Filed Feb. 9, 1935

2 Sheets-Sheet 2

FIG. 6

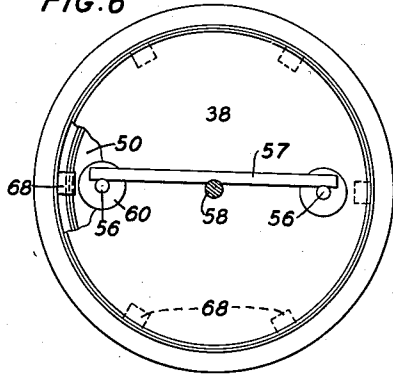


FIG. 8

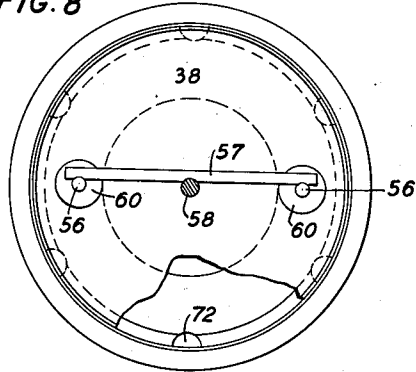


FIG. 7

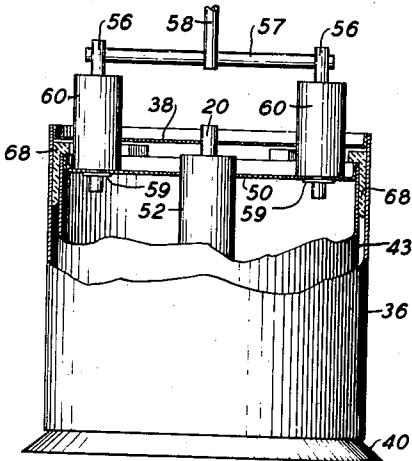


FIG. 9

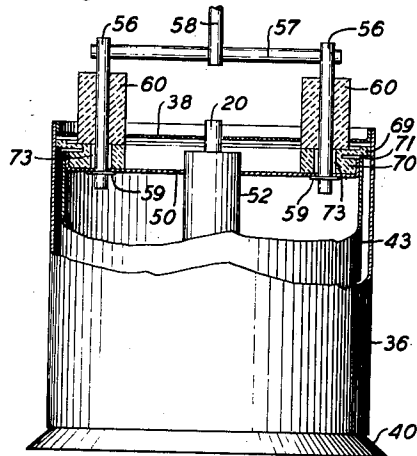


FIG. 4

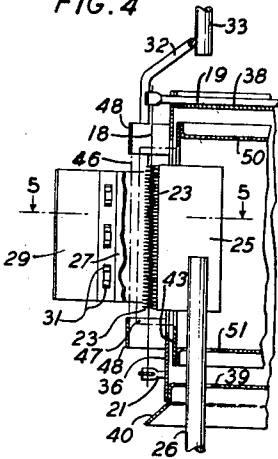


FIG. 5

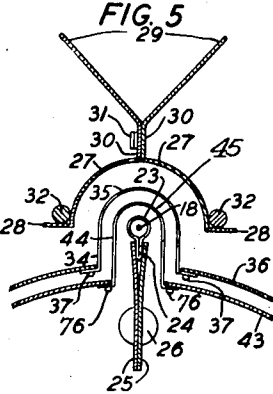
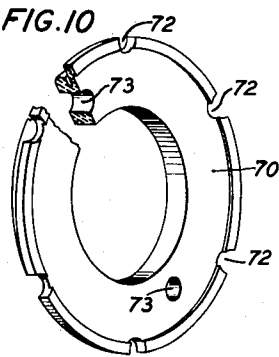


FIG. 10



INVENTOR
J. P. LAICO
BY
Halter C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

2,062,319

ELECTRON DISCHARGE DEVICE

Joseph P. Laico, Brooklyn, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application February 9, 1935, Serial No. 5,688

15 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices, and more particularly to such devices including a plurality of electrically associated electrode units within a single enclosing vessel and adapted for amplification of ultra-high frequency impulses, for example, impulses of frequencies corresponding to wave-lengths of the order of one meter or less.

In electron discharge devices capable of amplifying frequencies of the order noted above, it is necessary that the electrode spacings be very small, for example, of the order of 20 mils. Material difficulty is experienced in the obtaining of such small spacings and difficulty is encountered also in maintaining the spacings substantially constant inasmuch as the electrodes are heated to high temperatures during the operation and evacuation treatment of the devices and the expansion and contraction of the electrodes occasioned by such heating may not be uniform.

One object of the invention is to expedite the construction of electron discharge devices wherein the electrode spacings are very small.

Another object of this invention is to insure substantially uniform expansion and contraction of electrode structures in an electron discharge device whereby the spacing therebetween is maintained substantially constant and, therefore, uniform operating characteristics are obtained.

In one embodiment of this invention, an electron discharge device, which may be of the general type disclosed in the copending application of Arthur L. Samuel, Serial No. 750,287, filed October 27, 1934, comprises an enclosing vessel and a plurality of pentode units within the enclosing vessel. The shield or screen electrodes of the several units are electrically connected by suitable members and the suppressor electrodes are similarly connected by suitable members, the first and second members being disposed adjacent each other and forming a condenser coupling the screen and suppressor electrodes.

In accordance with one feature of this invention, the connecting members for the shield and suppressor electrodes are metallic cylinders disposed one within the other and preferably coaxial with each other. Each of the cylinders includes a plurality of apertures adjacent which the electrodes, which may be wire grids, are mounted, the apertures in one cylinder being in alignment with the corresponding apertures in the other cylinder.

In accordance with another feature of the invention, the cylinders are individually supported so that each may expand and contract independently of the other. In a specific embodi-

ment, the cylinders may be held in coaxial relation by an insulating member or guide fixed to one cylinder and extending through an aperture in an end disc on the other cylinder. One cylinder may be supported by members engaging one end thereof and the other cylinder may be supported by members engaging the opposite end thereof so that the cylinders may expand and contract longitudinally without substantial restraint and independently of each other.

In accordance with still another feature of the invention, means are provided for maintaining the cylinders in coaxial relation without interfering with the free longitudinal expansion and contraction thereof. Such means may be, for example, arcuate insulating spacing strips disposed between the cylinders at one or both ends of the cylinders or alternatively may be annular spacing members disposed at one or both ends of the cylinders and having surfaces contacting with walls of the cylinders.

The invention and the various features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of an electron discharge device illustrative of one embodiment of this invention, portions of the enclosing vessel being broken away to show the electrode assemblies more clearly;

Fig. 2 is a fragmentary top view of the electrode structures in the device illustrated in Fig. 1;

Fig. 3 is a partial elevational view of the screen and suppressor electrode assemblies of the device shown in Fig. 1, in cross-section along line 3—3 of Fig. 2;

Fig. 4 is a detail view in elevation of one of the electrode units of the device shown in Fig. 1, partly in cross-section and partly broken away;

Fig. 5 is an enlarged view in cross-section along line 5—5 of Fig. 4 showing the configuration and relative disposition of the electrodes;

Fig. 6 is a plan view of a modification of the screen and suppressor electrode assemblies shown in Fig. 3, a portion of the suppressor electrode assembly being broken away to show details of construction more clearly;

Fig. 7 is an elevational view of this modification, partly in cross-section and partly broken away;

Fig. 8 is a plan view, partly in broken outline, of another modification of the screen and suppressor electrode assemblies shown in Fig. 3;

Fig. 9 is an elevational view of the modifica-

tion illustrated in Fig. 8, partly in section and partly broken away; and

Fig. 10 is a detail view in perspective of an insulating member, partly in section, incorporated in the assembly shown in Figs. 8 and 9.

Referring now to the drawings, the electron discharge device shown in Fig. 1 comprises an enclosing vessel having a cylindrical portion 15 and end walls 16 and 17, and enclosing a plurality of pentode units adapted to be connected in push-pull. Each of the pentode units includes a cathode, a control grid encompassing the cathode, an anode, and a screen and a suppressor electrode disposed between the control grid and the anode and screen and suppressor electrodes having portions coaxial with the cathode.

The cathode of each pentode unit may be a linear filament 18, for example, of thoriated tungsten, which is secured at one end to a rigid wire or rod 19 carried by a metallic standard or rod 20 sealed into and extending through the lower end wall 17 of the enclosing vessel. Each filament 18 is secured at its other end to a resilient J-shaped wire 21 carried by a rigid wire or rod 22 sealed into and extending through the lower end wall 17.

Each cathode is encompassed by a control electrode which, as clearly shown in Figs. 4 and 5, may be a helical wire grid having a substantially cylindrical portion 23 coaxial with the filament 18 and a flattened portion 24 integral with the cylindrical portion 23. The flattened portion 24 extends between two metallic plates 25 and is suitably secured thereto, as by welding. Each of the plates 25 extends into a slot in a rigid metallic support or wire 26 which is sealed into the lower end wall 17 and serves as a leading-in conductor for the control electrode. The plates preferably are of relatively large area and form a fin which serves to radiate heat from the grid 23 rapidly and thereby to maintain the grid at a relatively low and safe temperature during operation of the device.

Disposed in juxtaposition to each control electrode is an anode which may be formed of two metallic sheets each including an arcuate portion 27 having a flange 28, a fin portion 29 of relatively large area for increasing the rate of heat radiation from the anode, and an intermediate portion 30. The two sheets may be secured together by tabs 31 integral with one of the intermediate portions 30, extending through apertures in the other intermediate portion 30 and clamped against the latter portion. As shown clearly in Fig. 5, the arcuate portions 27 form a semi-cylinder, which preferably is coaxial with the corresponding filament 18 and grid 23. Each anode is rigidly supported by a hairpin or U-shaped wire 32 secured to the flanges 28 and suspended from a rigid wire or rod 33 which is sealed in and extends through the end wall 16 and serves as a leading-in conductor for the anode.

A suppressor electrode is disposed between each control electrode and anode and may comprise a grid composed of a plurality of parallel U-shaped wires 34 each having a substantially semi-circular portion 35 coaxial with the corresponding grid 23 and filament 18. The ends of each of the wires 34 extend through a rectangular aperture in a metallic cylinder 36, and are bent against and secured to the inner wall of the cylinder together with wires 37. If, as in the embodiments of the invention shown in the draw-

ings, the device comprises but two pentode units, these units preferably are disposed diametrically opposite each other with respect to the metallic cylinder 36. The cylinder is provided at its upper end with a flanged metallic closure disc 38 to which the wire 19 connecting the upper ends of the filaments 18 is welded, so that the cylinder, and hence the suppressor grids 34, will be at substantially cathode potential. At its lower end, the cylinder 36 is provided with a flanged metallic closure disc 39 having an outwardly flaring portion or skirt 40 which preferably extends to immediately adjacent the lower end wall 17 of the enclosing vessel and thereby increases the shielding between the anodes and the leading-in conductors 26 for the control electrodes. The suppressor electrode assembly, that is, the assembly including the cylinder 36 and the grids 34, is supported on the standard or rod 20 by metallic brackets having arcuate or grooved arms 41 secured to the standard 20 and other arms 42 secured to the lower closure disc 39. The standard or rod 20 extends through close-fitting central apertures in the closure discs 38 and 39 so that tilting of the suppressor electrode assembly is prevented. Rotation of this assembly, as will be apparent from Fig. 1, is prevented by the wire or rod 19 which extends through and fits in slots in the flange of the closure disc 38 and in the cylinder 36, the wire or rod 19 being secured, as previously noted, to the disc 38.

Disposed within the suppressor electrode assembly is a screen electrode assembly comprising a metallic cylinder 43 which is disposed coaxial with the cylinder 36 and is provided with diametrically opposite rectangular apertures in alignment with the corresponding apertures in the cylinder 36. A screen grid is disposed adjacent each of the apertures in the cylinder 43 and may comprise a plurality of parallel wires 44 having a substantially semi-circular portion 45 within and uniformly spaced from the semi-cylindrical portion 35 of the corresponding suppressor grid and coaxial with the corresponding control grid 23 and filament 18. The wires 44 of each screen grid extend through one of the apertures in the cylinder 43 and the ends thereof are bent against and secured to the inner wall of the cylinder 43 together with wires 76.

As shown in Fig. 4, the suppressor grid, indicated by a broken line 46 is shorter than the screen grid, indicated by the broken line 47. In order to increase the shielding between corresponding control grids and anodes, metallic U-shaped bands 48 of the same form as the wires 35 are provided at the ends of the suppressor grids, these bands extending beyond the ends of the screen grids and electrically sealing the clearance opening between the ends of the screen and suppressor grids.

The cylinder 43 is provided at its ends with flanged closure discs 50 and 51 having central apertures in which a cylindrical insulating member or sleeve 52 slidably encompassing the standard or rod 20, is fitted so that the cylinder 43 is positioned coaxial with the cylinder 36. The insulating member or sleeve 52 is provided with an integral rectangular collar portion or flange 53 which fits within a rectangular cup 54 having a flange 55 secured to the disc 51. This construction prevents rotation of the cylinder 43 relative to the insulating sleeve 52. As shown in Fig. 3, the insulating sleeve 52 is provided with an oversized bore or recess 75 into which the arms 41 extend so that the cylinders 43 and 36 may be

rotated relative to each other as described hereinafter.

The screen electrode assembly, that is, the assembly including the cylinder 43 and the screen grids composed of the wires 44, 45, is supported at its upper end by rigid metallic rods or wires 56 suspended from a metallic cross-piece 57 carried by a wire or rod 58 sealed in and extending through the upper wall 16 of the enclosing vessel and serving as a leading-in conductor for the screen grids. The wires or rods 56 may be secured to the disc 50 as by short metallic stubs or projections 59 on the rods or wires 56, which may be welded to the disc 50.

The rods or wires 56 may be encompassed by tubular insulating sleeves 60 which rest upon the disc 50 and extend through oversized apertures 61 in the disc 38. The insulating sleeves 60 are frictionally engaged by the ends 63 of wires or metallic members 64 which are secured, as by welding, to the disc 38. In the fabrication of the device, after the screen electrode assembly has been positioned within the suppressor electrode assembly, the metallic members 64 may be flexed so that the cylinder 43 is rotated relative to the cylinder 36 and the screen grids are accurately aligned with and spaced from the corresponding suppressor grids.

The cylinders 36 and 43, it will be apparent, constitute a condenser coupling the screen and suppressor grids, support the screen and suppressor grids, and serve as electrical connections between the several screen grids and between the several suppressor grids. If the device is utilized at ultra-high frequencies it is essential for satisfactory operation that the spacing between the cylinders 36 and 43 and between corresponding screen and suppressor grids be small and also remain substantially constant during the operation of the device. The requisite small and accurate spacing is obtained as described hereinbefore. During the operation of the device and also during the outgassing of the electrodes during the evacuation treatment of the device, the screen and suppressor electrode assemblies become heated to an appreciable extent and consequently expand and contract both laterally and longitudinally. It has been found that the cylinders 36 and 43 because of their form, expand and contract substantially uniformly without buckling so that they do not contact with each other and the spacing therebetween and hence the capacitance of the condenser formed thereby is maintained substantially constant. Furthermore, inasmuch as the screen and suppressor electrode assemblies are supported separately of each other longitudinally, the cylinders 36 and 43 may expand and contract longitudinally independently of each other, the coaxial relation of the two cylinders being maintained by the insulating sleeve 52 which is slidable on the standard or rod 20. Thus, the construction in accordance with this invention prevents short-circuiting between the screen and suppressed electrode assemblies and assures the maintenance of a substantially constant spacing between the cylinders 36 and 43 and between corresponding screen and suppressor grids.

A metallic disc 65 having a pellet 66 of a getter material, such as magnesium, thereon is supported from the cylinder 36 by a bent wire 67 and may be heated, as by high frequency induction, during the evacuation treatment of the device whereby the getter material is vaporized and

fixes residual gases within the enclosing vessel.

In a modified embodiment of this invention illustrated in Figs. 6 and 7, a plurality of L-shaped insulating spacer members 68 may be frictionally fitted between the cylinders 36 and 43 to further insure maintenance of the desired spacing between the cylinders. Although in Fig. 7, the insulating members 68 are shown at but one end of the cylinders 36 and 43, they may be utilized at both ends of the cylinders.

In another modified embodiment illustrated in Figs. 8 and 9, an insulating ring, shown in detail in Fig. 10, may be utilized at one or both ends of the cylinders 36 and 43 for further assuring maintenance of the desired spacing of the cylinders. The ring comprises two portions 69 and 70, one of which fits within the cylinder 36 and the other of which fits within the flange of the disc 50. The two portions preferably are separated by an undercut portion 71 which increases the insulating path through the ring, between the cylinders 36 and 43. The ring is provided with peripheral notches 72 to facilitate rotation thereof during fabrication of the electrode assembly, and also with apertures 73 for allowing passage of the rods or wires 56.

Although specific embodiments of the invention have been shown and described, it will be understood, of course, that modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electrode assembly for electron discharge devices, comprising a plurality of cylindrical members disposed one within another and having juxtaposed apertures in lateral walls thereof, and grid electrodes mounted on said members and in said apertures.
2. An electrode assembly for electron discharge devices, comprising a pair of coaxial metallic cylinders each having diametrically opposite apertures, corresponding apertures in said cylinders being in alignment, U-shaped grids mounted on one of said cylinders and overlying the apertures therein, and grid members mounted on the other of said cylinders adjacent the apertures therein.
3. An electrode assembly for electron discharge devices, comprising a plurality of grid electrodes disposed one within another, a metallic cylindrical member supporting one of said electrodes, and another metallic cylindrical member supporting another of said electrodes, said cylindrical members being coaxial and disposed one within the other and forming a condenser.
4. An electron discharge device comprising a plurality of electrode units each of which includes a pair of grid electrodes, a cylindrical metallic member supporting one grid electrode of each unit, and another cylindrical member supporting another grid electrode of each unit, said cylindrical members being mounted one within the other.
5. An electron discharge device comprising a plurality of metallic cylinders having aligned apertures, said cylinders being disposed one within another and forming a condenser, and a plurality of electrode units each having an electrode supported by one of said cylinders and overlying one of the apertures therein and having also another electrode supported by another of said cylinders and overlying one of the apertures therein.
6. An electron discharge device comprising a plurality of electrode units each including a cathode, an anode, and two grid electrodes, a metallic

cylindrical member having a plurality of apertures therein and supporting one grid electrode of each of said electrode units, each grid electrode overlying one of said apertures, and another cylindrical member within said first cylindrical member and having apertures in alignment with said first apertures, said second cylindrical member supporting the other grid electrode of each of said units, each of said other grid electrodes overlying one of said second apertures.

7. An electron discharge device comprising a plurality of electrode units each including a cathode, a control electrode, an anode, a screen electrode, and a suppressor electrode, a cylindrical metallic member electrically connecting the screen electrodes of said electrode units, and another cylindrical member electrically connecting the suppressor electrodes of said electrode units, said cylindrical members being mounted one within the other and forming a condenser.

8. An electrode assembly for electron discharge devices, comprising a plurality of cylinders disposed one within the other, an electrode mounted on each of said cylinders, the electrode on one cylinder being in cooperative relation to the electrode on another cylinder, supporting means engaging one of said cylinders at one end only, and other supporting means engaging said other cylinder at the opposite end only, said first and other supporting means providing the sole longitudinal support for said cylinders.

9. An electrode assembly for electron discharge devices, comprising a pair of cylinders disposed one within the other, electrodes supported by each of said cylinders, the electrodes supported by one cylinder being in juxtaposition to corresponding electrodes supported by the other cylinder, means spacing said cylinders, and means supporting said cylinders separately from each other.

10. An electrode assembly for electron discharge devices, comprising a pair of cylinders disposed one within the other and having juxtaposed apertures in lateral walls thereof, electrodes supported individually by said cylinders and overlying said apertures, means maintaining said cylinders in coaxial relation but allowing free longitudinal expansion and contraction thereof, means supporting one of said cylinders, and means supporting the other of said cylinders separately from said one cylinder.

11. An electrode assembly for electron discharge devices, comprising a standard, a pair of cylinders encompassing said standard and disposed one within the other, electrodes mounted on each of said cylinders, the electrodes on one cylinder being cooperatively disposed with corresponding electrodes on the other cylinder,

means supporting one of said cylinders from said standard, means including a member slidably mounted upon said standard positioning the other of said cylinders with respect to said first cylinder, and means supporting said other cylinder separately from said first cylinder.

12. An electrode assembly for electron discharge devices, comprising a pair of hollow members disposed one within the other, an electrode mounted on each of said members, the electrode on one member being in cooperative relation to the electrode on the other member, means supporting said cylinders, and means including a flexible member coupling said hollow members allowing relative rotation thereof whereby the position of the electrode on one hollow member may be adjusted relative to the electrode on the other hollow member.

13. An electrode assembly for electron discharge devices, comprising a pair of cylinders disposed one within the other, an electrode supported by each of said cylinders, the electrode on one cylinder being disposed in juxtaposition to the electrode on the other cylinder, means maintaining said cylinders in spaced relation, and means including an adjustable member holding said cylinders in relative angular relation.

14. An electrode assembly for electron discharge devices, comprising a standard, a pair of cylinders encompassing said standard and disposed one within another, said cylinders having closure discs at each end, an electrode mounted upon each of said cylinders, the electrode on one cylinder being in juxtaposition to the electrode on the other cylinder, means supporting one of said cylinders upon said standard, an insulating sleeve encompassing said standard and extending through the closure discs of the other of said cylinders for maintaining said other cylinder in spaced relation to said first cylinder, and means including a flexible member mounted on one of the closure discs of said first cylinder for maintaining said cylinders in fixed angular relation.

15. An electron discharge device comprising an enclosing vessel, a cathode, an anode, and a control electrode within said enclosing vessel, a leading-in conductor for said control electrode extending through one wall of said enclosing vessel, and a hollow metallic member encompassing said control electrode and said leading-in conductor, said member including a cylinder having an aperture therein and a grid mounted on said cylinder adjacent the aperture therein and disposed in juxtaposition to said control electrode, and said cylinder having a portion extending to immediately adjacent said wall.

JOSEPH P. LAICO.