May 7, 1935. J. E. CLARK 2,000,163

METHOD OF MOUNTING ELECTRODES

Filed Aug. 4, 1934

FIG. 1

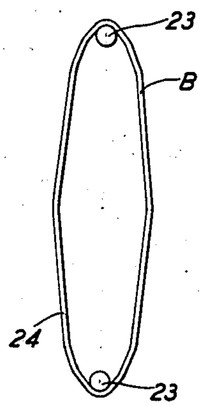


FIG. 2

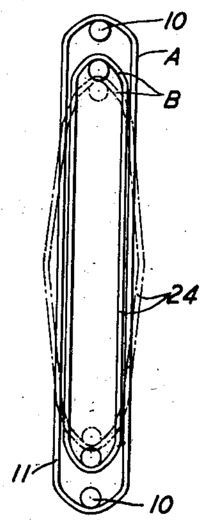


FIG. 3

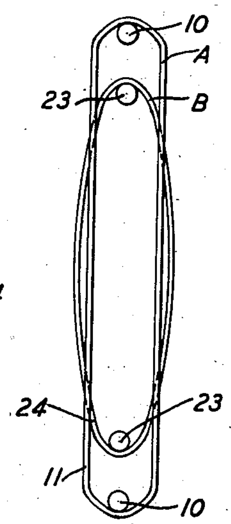


FIG. 4

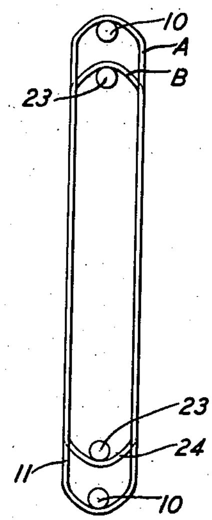


FIG. 5

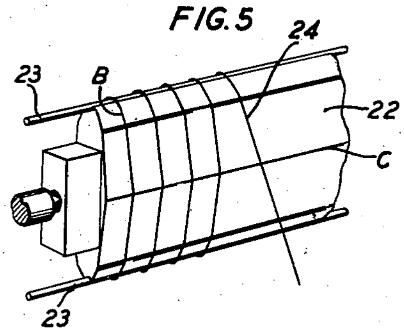


FIG. 6

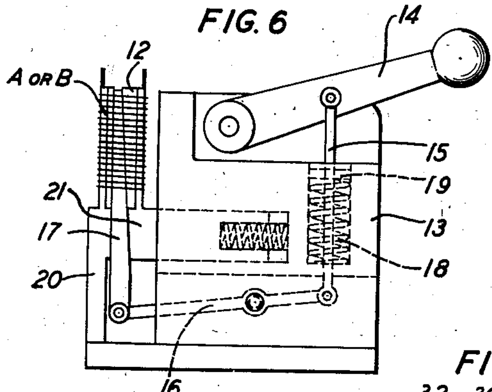


FIG. 7

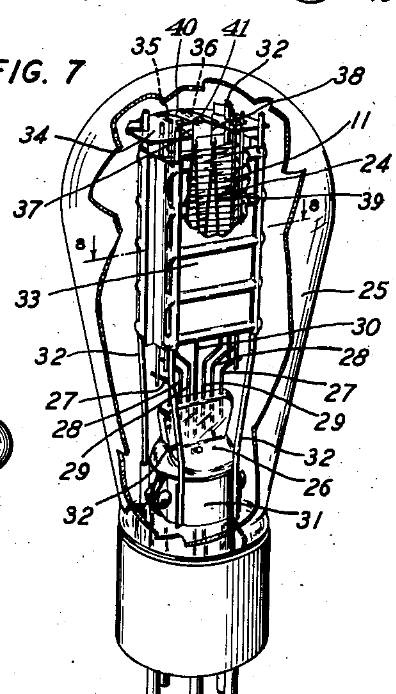
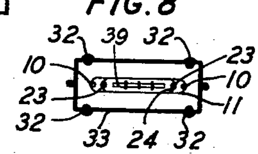


FIG. 8



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METHOD OF MOUNTING ELECTRODES

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6 Claims. (Cl. 250—27.5)

This invention relates to methods of mounting electrodes of electron discharge devices, and more particularly to the mounting of dual grids of multi-electrode discharge devices.

An object of this invention is to secure accurate and uniform space relationship between the lateral wires of two grid electrodes of closed formation arranged in coplanar relation with other cooperating electrodes in electron discharge devices.

In power type electron discharge devices, low internal impedance between the electrodes is a prime requisite for operating efficiency. This impedance is easily obtained in three-electrode devices when the grid and anode are formed of flattened cylinders with the largest areas thereof close to an energized electrode, such as a thermionically active cathode, arranged in a central plane surrounded by the grid and the anode. Obviously, when another grid is interposed in the discharge path between the cathode and the anode, the impedance is increased by locating the anode further away from the cathode, unless the second grid occupies the same planar position as the original grid. Usually, the grids are helically wound on support rods and this structure, while most efficient for operating and manufacturing purposes, presents certain difficulties when it is desired to intermesh two similar grids so that the lateral wires of one of the grids alternate in the same plane with the lateral wires of the other grid.

According to one aspect of this invention, the two grids are accurately aligned in coplanar relation by a method of assembly which insures positive parallel relationship between the individual lateral turns of the two grids when mounted in permanent position. The method of fabrication consists in winding the two grids as separate units, placing one within the other so their lateral turns alternate and then stretching or tensioning the grids along one dimension on a form or arbor to a point just beyond their elastic limits. This stretching brings the lateral turns of both grids in contact with both sides of the arbor and the degree of stretching insures a permanent set in the lateral turns so that they remain parallel when the tension and arbor are removed.

According to a more specific method of this invention, the inner grid, or the grid having the smaller dimensions, is wound on an oval arbor so that the lateral turns have an initial bowed form, while the outer grid is wound on a flat arbor. In order to assemble the grids, they are removed from the arbors and the inner grid is stretched or tensioned to a degree insufficient to induce a permanent set in the lateral turns but sufficient to conform the lateral turns to a parallel relationship and spacing so that the grid may be inserted within the lateral turns of the outer grid. When the lateral turns of the inner grid are positioned in alternate relation with the lateral turns of the outer grid the tension on the inner grid is released and the inner grid laterals assume their initial bowed form between the laterals of the outer grid. The final operation consists in applying tension to one or both grids, but particularly to the inner grid, to such a degree as to produce a permanent set in the laterals of this grid whereby these laterals are spaced apart exactly the same as the laterals of the outer grid. This is produced on an arbor to insure accurate alignment of both grids.

These and other features of the invention will be more clearly understood from the following detailed description taken in connection with the accompanying drawing in which:

Fig. 1 shows a plan view of the winding form of the inner grid;

Fig. 2 is a plan view of a composite arrangement of the inner and outer grids illustrating in dotted lines the original form of the inner grid as shown in Fig. 1 and its subsequent form when stretched and placed within the outer grid;

Fig. 3 is similar to Fig. 2 but illustrates a plan view of the two grids after the inner grid is intermeshed with the outer grid and the tension is released;

Fig. 4 illustrates a plan view of the final form of the two grids after stretching with the lateral wires of both grids in uniform parallel planes;

Fig. 5 is a perspective view of the type of arbor or form upon which the inner grid is wound;

Fig. 6 illustrates the stretching apparatus for tensioning the grid structures;

Fig. 7 is a perspective view of a discharge device embodying the dual grid structure of this invention with a portion of the enclosing vessel and the anode broken away to show the arrangement of the grids; and

Fig. 8 is a cross-sectional view on the line 8—8 of Fig. 7 showing the relationship of the dual grids with respect to the cathode and anode of the device.

This invention pertains to the type of grid electrode in which a plurality of closely spaced wire loops of substantially rectangular shape are arranged on two parallel rigid wires which form upright supports for the grid, the center portions of the short sections of each loop being welded or secured to the upright supports. Usually this type of grid is wound on an arbor or form having the desired configuration of the finished grid with the supporting wires held in grooves at opposite sides of the arbor and the fine wire wound around the arbor and the supports, the laterals of the fine wire grid being uniformly and accurately spaced with respect to the pitch of winding of the fine wire and the axial line of the grid configuration.

When it is realized that the control characteristics of a discharge device, such as a detector or an amplifier, are determined by the relative spacing of the grid laterals and their relation with respect to the associated electron source and the anode in the device, it is evident that any distortion of the grid laterals will cause irregular control action in the device and fail to attain the highest efficiency for the operation of the device. Furthermore, in view of the fact that the flattened cylindrical form of grid is the most efficient configuration from a manufacturing and operating standpoint in high power devices, it is evident that this configuration does not readily permit its adaptation to a coplanar structure in which two grids are arranged in such a manner that their laterals are equidistant from opposite sides of the cathode and the anode of a discharge device.

According to this invention, a method of mounting two coplanar grids of the flattened cylindrical form is set forth and the various steps of combining these grids into a single unit is shown in Figs. 1 to 4, inclusive, in which A represents the outer grid and B represents the inner grid. The grid A is wound on a metallic arbor or form having flattened sides with a pair of parallel supporting wires **10** positioned in the grooves at opposite edges of the arbor and a fine wire **11** wound continuously and evenly spaced around the support wires **10** and the arbor which is rotated. Since the various operations in the mounting of the two grids in accordance with this invention depends on minute variations in dimensions, which are not readily apparent from the figures in the drawing, it will clarify the understanding of this invention if reference is made to the actual measurements and materials and the specific series of operations in forming the grid structures in accordance with one embodiment of the invention. For instance, the support wires **10** may be made of .040 inch nickel wire about $2\frac{9}{16}$ inches long. These are placed in the grooves on a flat arbor having a thickness such that the distance between the inner surfaces of the wire **11**, which may be of .005 inch molybdenum is .110 inch. The wire **11** is wound around the arbor and the support wires **10** with a pitch of 12.9 turns per inch and a total of 25 turns are wound to form the grid structure. The width of the grid from center to center of the support wires **10** on the arbor is .874 inch. After the grid turns are secured to the support wires **10** by any suitable means, such as welding, the completed grid is removed from the arbor and placed on a split arbor **12** shown in Fig. 6 which forms a removable part of the stretching device **13**.

This device consists of a base having a lever **14** secured to a pivoted plunger **15** which is connected at one end to a lever beam **16** attached to a spreader member **17**. A spring **18** held in a socket of the base of the device engages a disc **19** attached to the pivoted plunger **15** to return the lever **14** to a normal position after depression thereof. The split arbor **12** consists of a rigid section **20** and a yielding section **21**. The yielding section **21** is caused to move away from the stationary section **20** by the upward movement of the spreader member **17** which enters the space between the rigid section **20** and the yielding section **21** of the arbor. The grid A after winding is placed on the split arbor **12** and stretched to just beyond its elastic limit so that the distance between centers of the support wires **10** is changed from .874 inch to .900 inch. This stretching is performed to insure exact laterality between the consecutive turns of the fine wire on the supports.

The inner grid B is wound on an arbor **22** having a substantially oval configuration as shown in Fig. 5. The support wires **23** of this grid may be formed of .040 inch nickel wire and have a length of $2\frac{7}{16}$ inches. These wires are placed in the grooves at opposite edges of the arbor **22**, the distance between centers of the supports being .702 inch and the distance between the edges C of the arbor **22** being 11/64 inch A molybdenum wire **24** having a diameter of .005 inch is wound around the arbor **22** and the supports **23** with a pitch of 12.9 turns per inch and a total of 25 turns to complete the winding of the inner grid B. The fine wire **24** is secured to the supports **23** by welding the wire to the supports at the contacting points therebetween. The inner grid B is removed from the arbor **22** and placed on a split arbor in the stretching device **13**, the portions of the split arbor being changed, however, for this grid, since it is not intended to stretch the grid B to its final set form in this operation. Therefore the shape of the portions of the split arbor are such that it is relatively thin and merely engages the surfaces of the supports **23** and does not engage the lateral sections of the grid. Pressure is then applied to the lever **14** to stretch the grid B to such a form, as shown in Fig. 2 in solid line, that the laterals are brought parallel to each other and the dimension between the surfaces of the laterals is .093 inch inside. This stretching, however, is not carried to the extent of the elastic limit of the wire and therefore the deformation of the grid B is not a final set condition. When the inside dimension of .093 inch is secured between the laterals of the grid B the previously stretched A grid is very carefully advanced over the grid B to envelop it until the grid laterals of the grid A alternate with the grid laterals of the grid B. When this relationship is attained the stretching pressure is released and the grid B assumes a position as shown in Fig. 3 in which the laterals of the grid B revert to substantially their original bowed form but these laterals are arranged in alternate relation between the laterals of the grid A.

After the composite grid structure is removed from the stretching device the sections of the split arbor are changed to substitute sections having a thickness equal to the width of the grid A, namely, .110 inch. After these sections are secured in position the two grids are threaded over the split arbor, the arbor being situated in the central portion of the confines of the two grids. Pressure is then applied to the lever **14** to stretch the inner grid B to just beyond the elastic limit of the fine wire **24** and the grid B is stretched from its original width between centers of the supports 23, namely, .702 inch to .720 inch. This stretching operation in combination with the diameter of the split arbor 12 sets the laterals of the grid B to the same diameter of the grid A, namely, .110 inch. The pressure is relieved by releasing the lever 14 and the two grids are removed from the arbor in a condition as shown in Fig. 4 which is the final operation in forming the grids. It will be seen from Fig. 4 that the grid laterals of the grid B are coplanar with the laterals of the grid A and the stretching operation insures that the laterality of the adjacent wires of both grids is accurate and uniform and consequently the laterals of both grids will be in coplanar relation with respect to other cooperating electrodes in a device such as shown in Fig. 7.

This device comprises an enclosing vessel 25, highly evacuated, and provided with an inwardly projecting stem 26 which supports a number of pairs of bent wires 27, 28 and 29 and a central wire 30. The stem 26 also supports a clamping collar 31 which carries four upright rods 32 which enter longitudinal grooves in a stamped box-shaped metallic anode 33. Two of the supports 32 carry a pair of metallic clips which fasten a semicircular mica disc 34 thereto, the disc having a wedge-shaped cut-out portion in the center thereof. A pair of narrow metallic strips 35 and 36 are clamped to the narrow width of the mica disc 34 and extend in a parallel direction from the periphery of the disc toward the longitudinal edge of the wedge-shaped cut-out portion. These strips are secured in position by the upturned ends of the strips which are registered in notches cut in the periphery of the disc and the longitudinal edge of the cut-out portion. The ends of the strips adjacent the periphery of the disc extend at an upward angle and two parallel resilient wires 40 and 41 are secured at one end to the upturned ends of the strips 35 and 36, respectively. The free ends of the wires 40 and 41 carry downwardly extending hooks 37 and 38 which engage the bights of an M-shaped ribbon filament 39, which is arranged in a central plane of the anode 33 with the free ends of the filament attached to the pair of bent wires 29 in the stem and the mid-portion attached to the straight wire 30.

The coplanar grids, made in accordance with this invention, surround the filament 39 and are equally spaced with respect to the filament and the anode 33 by having the lower ends of the support wires 10 of the outer grid A rigidly secured to the bent wires 27 in the stem and the upper ends registered in an aperture at one side of the disc 34 and in a slot at the other side of the disc. The support wires 23 of the inner grid B are secured at the lower end to the bent wires 28 and at the other end are registered in an aperture in alignment with the support wire 10 of the outer grid at one side of the disc and arranged in the slot adjacent the support wire 10 on the other side of the disc. This assembly permits the grids to expand and contract during operation but maintains them in coplanar relation, as shown in Fig. 8, with respect to the filament 39 and the anode 33. Furthermore, the laterals of both grids on opposite sides of the filament are accurately aligned in a vertical direction and are uniformly spaced laterally with respect to each adjacent turn of the grids due to the positive stretching method of this invention in forming the grids.

While the various steps of forming the grids heretofore described specify the stretching of the grids individually, it is, of course, understood that both grids may be finally stretched together in one operation. Furthermore, the invention is not limited to the specific form of the flattened cylindrical grid nor to the original relative shape of the two grids before stretching. Therefore, the methods in this invention are only to be limited within the scope of the appended claims.

What is claimed is:

1. The method of assembling hollow grids for discharge devices which comprises forming an inner and an outer grid, placing the inner grid within the outer grid with the laterals in alternate relation, and stretching the grids to a point beyond the elastic limit to secure a permanent set in the laterals, whereby the laterals of one grid will be in the same plane as the laterals of the other grid.

2. A method of fabricating grids of the enclosed type which comprises winding two grids separately, one of the grids having a form in which the diameter in one direction is less than that in a transverse direction, the other grid having an oval form in which the smaller diameter is greater than the lesser diameter of the first grid and the larger diameter is smaller than the larger diameter of the first grid, expanding the second grid along its larger diameter, introducing the expanded grid into the first grid, equalizing the position of one of the grids to locate the laterals thereof intermediate the laterals of the other grid, permitting the expanded grid to return to its original form, elongating the oval grid, and gauging the smaller dimension thereof to the lesser dimension of the other grid.

3. A method of assembling wire wound grids for discharge devices which comprises winding an inner grid on an oval arbor, winding an outer grid on a flat arbor, removing the arbors, initially tensioning the inner grid, placing it within the outer grid while in a stretched condition, positioning the laterals of the inner grid in alternate relation to the laterals of the outer grid, releasing the tension on the inner grid so the laterals thereof return to the original oval form, inserting a flat arbor within the boundaries of both grids, and finally stretching at least the inner grid to substantially the elastic limit of the wire to conform the laterals of both grids to a permanent position against the faces of the arbor.

4. A method of correlating two grids of the continuous wound type which comprises winding a wire grid of rectangular formation, stretching said grid to set the laterals thereof, winding a second wire grid with bowed sides, exerting internal pressure on said second grid at right angles to the bowed sides, inserting the second grid within the boundary of the rectangular grid, relieving the pressure on said second grid when the turns thereof are positioned in relation between the turns of the rectangular grid, and finally straightening the bowed sides of said second grid in substantial alignment with the sides of said rectangular grid.

5. A method of correlating two grids of the continuous wound type which comprises winding a wire grid of rectangular formation, winding a second grid form with bowed sides, temporarily reducing the thickness of the second grid form to a degree less than the thickness of the rec-

tangular grid, telescoping the two grids, permitting the second grid to assume its original formation with the laterals thereof alternating with the laterals of the rectangular grid, and finally stretching both grids until the laterals thereof are coplanar.

6. The method of fabricating intermeshed grids for electron discharge devices, which comprises stretching one grid to just beyond its elastic limit, stretching a second grid to a point below its elastic limit, placing the second grid within the first grid, then threading the second grid into the first grid and thereafter stretching the second grid to just beyond its elastic limit.

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