

March 2, 1965

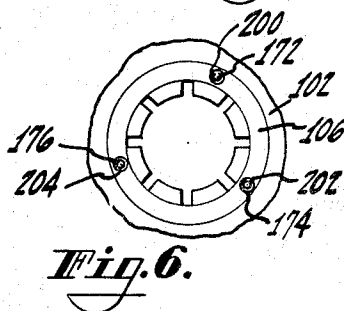
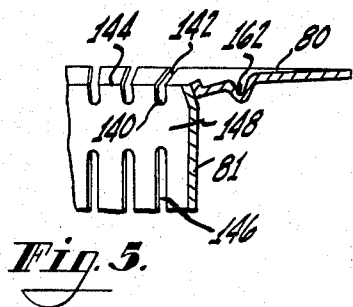
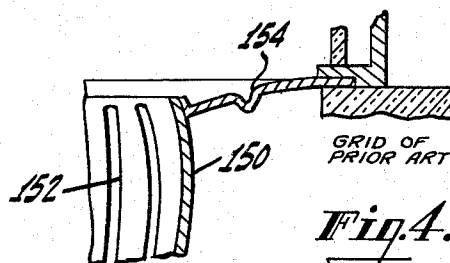
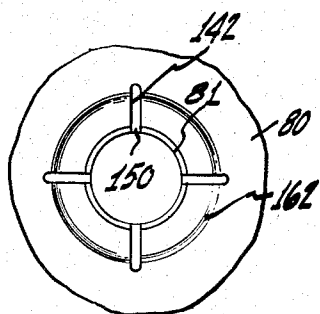
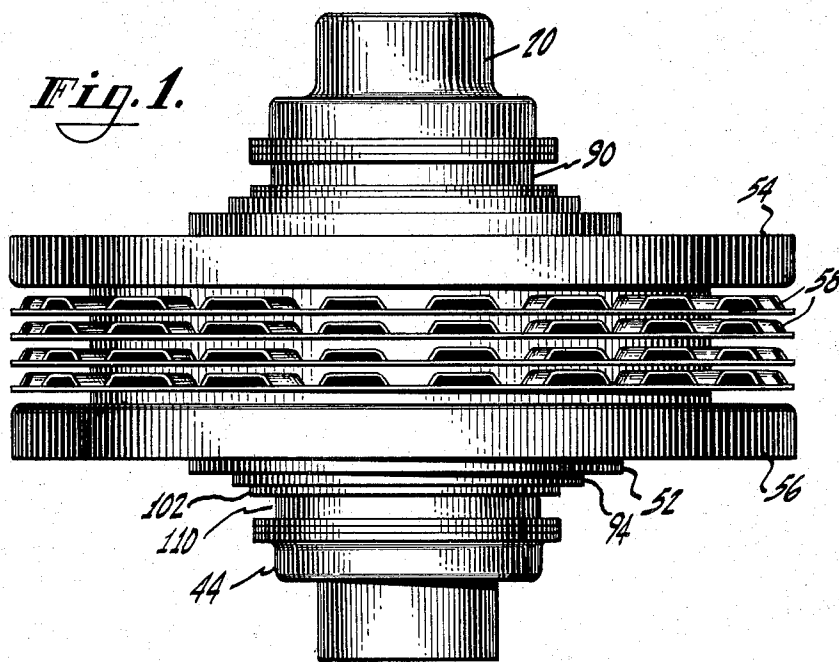
J. W. GAYLORD

3,172,001

HIGH FREQUENCY HIGH POWER ELECTRON DISCHARGE DEVICE
AND ELECTRODE MOUNT THEREFOR

Filed Sept. 28, 1960

3 Sheets-Sheet 1



INVENTOR.
John W. Gaylord

BY
L. A. Laren

Attorney

March 2, 1965

J. W. GAYLORD

3,172,001

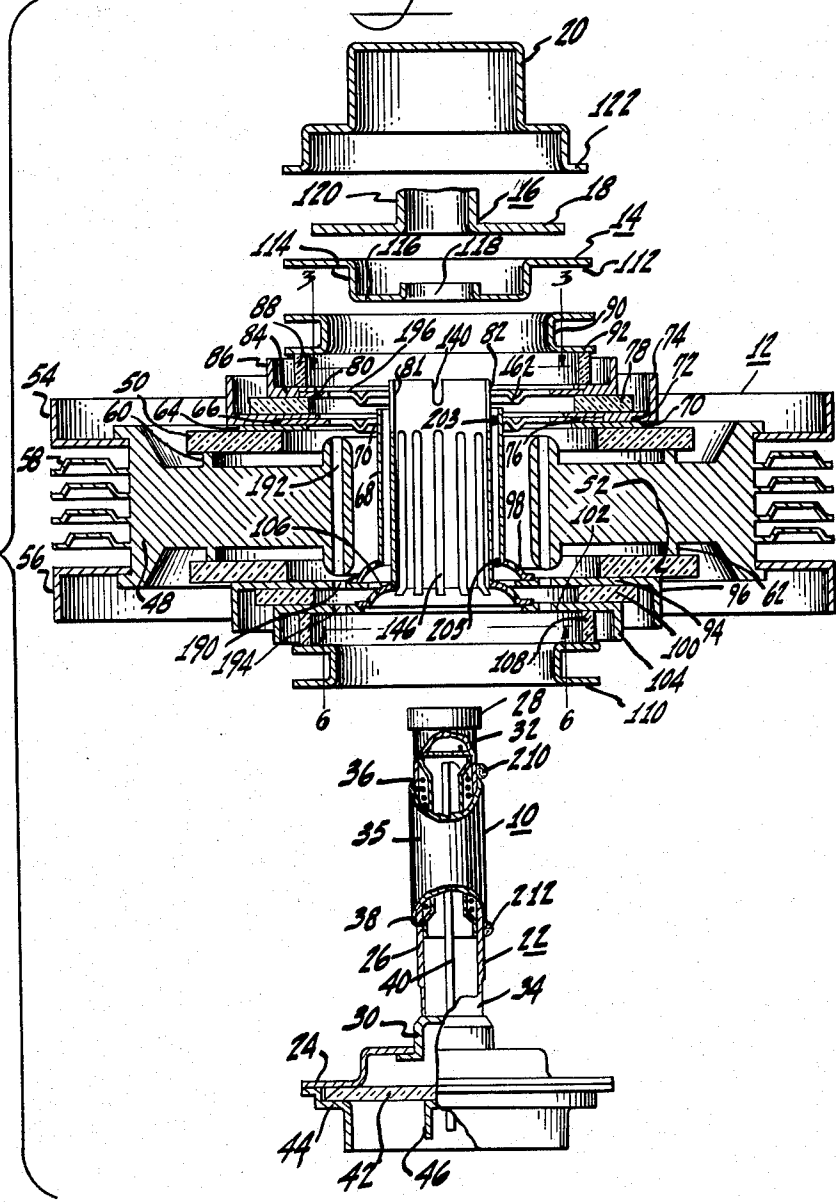
HIGH FREQUENCY HIGH POWER ELECTRON DISCHARGE DEVICE

AND ELECTRODE MOUNT THEREFOR

Filed Sept. 28, 1960

3 Sheets-Sheet 2

Fig. 2.



INVENTOR.
John W. Gaylord
BY
L. A. Larsen
Attorney

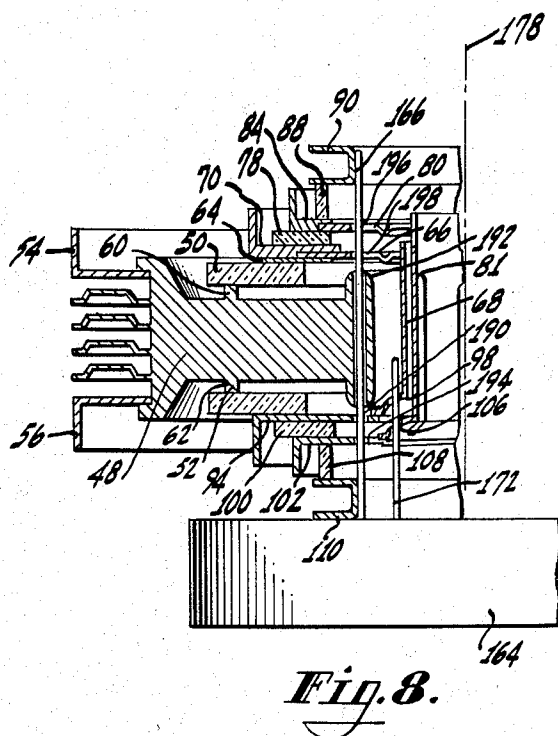
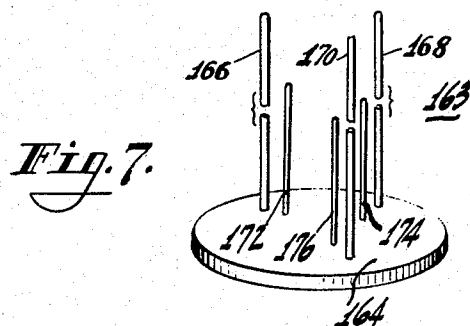
March 2, 1965

J. W. GAYLORD
HIGH FREQUENCY HIGH POWER ELECTRON DISCHARGE DEVICE
AND ELECTRODE MOUNT THEREFOR

3,172,001

Filed Sept. 28, 1960

3 Sheets-Sheet 3



INVENTOR.
John W. Gaylord
BY
L. A. Lauen
Attorney

1

3,172,001

HIGH FREQUENCY HIGH POWER ELECTRON DISCHARGE DEVICE AND ELECTRODE MOUNT THEREFOR

John W. Gaylord, Lancaster, Pa., assignor to Radio Corporation of America, a corporation of Delaware

Filed Sept. 28, 1960, Ser. No. 59,060

9 Claims. (Cl. 313-247)

The present invention relates to an electron discharge device of relatively compact size and capable of producing a relatively high useful power output at relatively high frequencies. The relatively high power output is of the order of 40 watts, and the relatively high frequencies are of the order of 3000 megacycles per second. More specifically, the invention concerns an electron discharge device having the foregoing characteristics and in which transit time of electrons is not fundamental to the primary mode of operation, but which, as in the case of a tetrode having a coaxial array of electrodes, may establish an upper frequency limit for the intended mode of operation.

Several problems are involved in adapting a tetrode type of device having a coaxial array of electrodes, to the relatively high power and high frequency service aforementioned. In such device, the transit time of electrons determines the maximum frequency of operation. Consequently, a relatively high operating frequency requires a relatively short electron transit time. Such short transit time, in turn, requires relatively close spacing between electrodes of the device. Such close spacing imposes a structural burden on the electrodes to prevent contact and consequent shorts therebetween. This burden becomes particularly severe when the device is used in an environment involving substantial impact shocks.

Power tubes to which the present invention relates, have heretofore employed a tubular indirectly heated cathode surrounded in coaxial fashion by a control grid and screen grid. As a consequence of the appreciable heat to which these electrodes are subjected in operation, it has not been feasible to support the electrodes at both ends thereof. Thus, it has been found desirable to support such electrodes at one end only thereof, thereby leaving the other end free to expand and contract in response to temperature cycles of the device. The resultant cantilever mounting of the electrodes reduces the ability of the electrode structure to sustain the burden of preventing contacts therebetween, particularly at the free end portions thereof. Therefore, an appreciable spacing has been required heretofore, between the electrodes of power tubes of the type described, to assure freedom from shorts therebetween. This in turn has limited such tubes to relatively low frequencies of operation.

Another limitation characterizing power tubes under consideration is a consequence of the fact that the cantilever mounting of the electrodes has restricted circuit connections to one end only, of the electrodes, which has resulted in the placement of the maximum voltage swing at an axial end of the active electrode areas. This not only has circuit disadvantages, but imposes an appreciable power limitation on a tube.

Accordingly, it is an object of the invention to provide an improved electron discharge device operable at relatively high frequencies with a relatively high power output, under conditions involving severe impact shocks.

A further object is to provide a compact, high power electron discharge device of the tetrode type in which the electrodes thereof are ruggedly supported.

Another object is to provide an electron discharge device in which elongated coaxial electrodes are accessible at both ends thereof to circuit connecting elements.

2

A further object is to provide a novel and advantageous method of assembling an electron discharge device to assure desired close and accurate spacing between electrodes thereof.

These and other objects are realized in an electron discharge device wherein one or more tubular electrodes are fixedly supported at one end thereof, and resiliently supported at the other end. The resilient supporting means in one example comprises a relatively thin, diaphragm-like metal disc fixed peripherally to the envelope of the device and preferably under axial pressure to produce a tension on the electrode fixed to a central opening therein. Such tension precludes the possibility of application of axially compressive stresses to the electrode when the latter expands axially in response to heat. While the disc referred to is resilient in axial directions even in the absence of the axial pressure referred to, it is relatively rugged in radial directions. Consequently, when two tubular electrodes are ruggedly mounted at one group of adjacent ends thereof, and engaged at the other group of adjacent ends by discs of the type described, they are effectively restrained from relative radial movement either in response to impact shocks or to expansions in response to heat. This assures the preservation of an initially fixed radial spacing between the electrodes and permits such spacing to be extremely small without danger of shorts between the electrodes.

Besides contributing to a fixing of the spacing between electrodes, the arrangement described renders it feasible to effect electrical circuit connections to both end portions of the electrodes. This has advantages contributing to the operation and high power capability of a compact device in which such arrangement is used.

According to another feature of the invention, each tubular electrode engaged by the diaphragm-like metal disc is provided with a structure to prevent the transmission to the electrode of deforming forces during flexures of the disc. In one example and where a grid electrode is involved, such structure involves the provision of axial slots in the end portion of the electrode engaged by the disc and in axial displacement from the active and apertured portion of the electrode. This provides an imperforate portion between the end portion engaged by the disc and the apertured portion of the electrode. This imperforate portion serves to impede the transmission to the active electrode portion of deforming forces applied to the end portion referred to during flexures of the disc.

According to a further feature, the disc itself is provided with a structure wherein deforming flexures are absorbed entirely by the disc and therefore requires no contributing means, such as end slots in the electrode engaged, for absorbing deforming stresses. An example of this feature comprises a disc formed to dish shape and having a central opening for receiving an end portion of an electrode such as a tubular cathode. In this example, the annular folds in the disc required for its dish shaped structure, effectively isolate strains in the disc from the engaged electrode.

According to a method aspect of the invention, a sub-assembly, including closely spaced electrodes and fixing means therefor, is prepared by first loosely assembling the elements thereof, properly locating the elements while loosely assembled and then simultaneously fixing the elements with respect to each other in properly located positions.

Further objects and features will become apparent as the present description of an embodiment of the invention proceeds.

In the drawing, to which reference is now made for a description, by way of example, of an electron discharge device according to the invention:

FIG. 1 shows a side elevation of an electron discharge device incorporating the invention;

FIG. 2 is a sectional exploded view of the several sub-assemblies of which the tube of FIG. 1 is comprised;

FIG. 3 is a fragmentary view taken along the line 3—3 of FIG. 2;

FIG. 4 is a fragmentary sectional view of an ordinary tubular electrode undergoing deformation in response to an axial contraction;

FIG. 5 is a view similar to that of FIG. 4, except that a tubular electrode according to the invention is shown and which is substantially free from deformation on axial contraction;

FIG. 6 is a fragmentary view taken along the line 6—6 of FIG. 2 and shows orienting apertures in one element of an electron tube according to the invention;

FIG. 7 is a perspective view of a jig useful in assembling one of the sub-assemblies shown in FIG. 2; and

FIG. 8 is an axially broken away view of a sub-assembly mounted on the jig shown in FIG. 7.

One example of an electron discharge device according to the invention is shown in FIG. 1. This device is relatively compact in size, having a length of about two inches and a diameter of about two and one half inches. In spite of its small size, a constructed experimental device has operated at a frequency of the order of 3000 megacycles per second with a power output of the order of 40 watts. Furthermore, the device combines a relatively high order of ruggedness with its relatively small size, as a consequence of a novel double ended structure to be described in the following. And finally, the foregoing desirable characteristics are incorporated in a grid type of electron discharge device having concentric electrodes and in which the transit time of electrons determines the upper frequency limit.

The structure of an electron tube embodying the invention will become apparent from a consideration of FIGS. 1 and 2. The elements of the structure of the completed tube shown in FIG. 1 are preferably assembled in several stages, one of which is shown in FIG. 2. At the stage of manufacture shown in FIG. 2, the elements of the tube are incorporated in several sub-assemblies. The structure of each sub-assembly according to the invention is determined from the standpoints of facility of manufacture of such sub-assembly, and ease of combination of the several sub-assemblies to form a finished device.

The several sub-assemblies shown in FIG. 2, comprise a cathode sub-assembly 10, a grid-anode sub-assembly 12, and three elements assembled individually and comprising a cathode support 14, an exhaust tubulation 16 having a flange 18, and a cover 20 for shielding the end of tubulation 16 after tip-off.

The cathode sub-assembly 10 includes a sleeve 22 fixed to a flange 24. The sleeve 22 may be made of nickel and includes an intermediate portion 26 and end portions 28, 30 having a wall thickness of about 10 mils and portions 32, 34 having a wall thickness of about 1 mil for service as heat dams between the intermediate portion 26 and the end portions referred to. The heat dams prevent the loss of appreciable heat from the intermediate and active portion 26 of the cathode. The active portion 26 of the cathode is coated with suitable emitting material 35, such as barium and strontium oxides either directly or in the form of a matrix.

The cathode sub-assembly 10, also includes a heater structure comprising a coil 36 of insulated wire, such as tungsten. One end of the heater coil is electrically connected to a tubular metal support 38 fixed to the inner wall of the cathode sleeve 22, and the other end is connected to a conducting rod 40 supported at both ends, one end being supported on an insulating disc 42, made of ceramic for example, supported between flanges 24 and 44. The end portion of rod 40 protruding through the disc 42, is fixed to a metal flange 46.

The grid-anode sub-assembly 12 includes a group of individual elements fixed in assembled relation in two steps. The group of elements comprising anode 48 made of solid copper, for example, insulating rings 50, 52 made of ceramic, for example, metal flanges 54, 56, and heat exchange elements 58, are first assembled and fixed to form an initial anode sub-assembly, the rings 50, 52 being fixed by means of suitable metal-to-ceramic seals to annular flanges 60, 62 extending from the anode 48.

The other individual elements of the grid-anode sub-assembly provide a symmetric assembly of elements on the two ends of the initial anode sub-assembly to constitute a double ended device in which each electrode is adapted to be connected to circuit elements, not shown, at both ends thereof. Thus, the other individual elements mounted above the initial anode sub-assembly as viewed in FIG. 2, comprise a metal ring 64, resting on and sealed to ceramic ring 50 and extending inwardly of the ceramic ring referred to. A metallic diaphragm-like support 66 rests at a peripheral portion thereof on the ring 64. The diaphragm support has a central opening through which extends the upper end of a tubular screen grid 68. The grid is fixed to the diaphragm by means of a suitable solder body 70. An annular metal flange 72 having a circuit element engaging portion 74, is provided with a recess 76, to allow the flange to sealingly engage the ring 64 as well as an upper peripheral portion of diaphragm 66. A ring 78 made of ceramic or the like rests on and is sealed to the flange 72. A second diaphragm 80 includes a peripheral portion resting on ring 78, and has a central opening receiving the upper portion of a tubular control grid 81 to which the diaphragm is fixed by a suitable solder body 82. Sealingly engaging the ring 78 and the diaphragm 80 is a metal flange 84 having a circuit engaging portion 86. A ring 88 made of ceramic or the like, is sealed to the flange 84. A U-shaped metal ring 90 is sealed at one flange 92 thereof to the ceramic ring 88 and constitutes the upper terminal element of the grid-anode sub-assembly aforementioned.

The other individual elements of the grid-anode sub-assembly 12 mounted below the initial anode sub-assembly, includes a metal flange 94 sealed to ceramic ring 52 and having a circuit engaging portion 96. The inner peripheral portion of flange 94 is provided with a recess receiving the lower and flanged portion 98 of the screen grid 68 and to which it is fixed by means of a suitable solder. Below flange 94 and sealed thereto at one side thereof is a ring 100 made of ceramic or the like. To the other side of the ring 100 is sealed a metal flange 102 having a circuit engaging portion 104 and a recessed inner peripheral portion to which is fixed by means of suitable solder, a flange 106 extending from the lower end portion of central grid 81. One side of a ring 108 made of ceramic or the like is sealed to the flange 102, and the other side of the ring is sealed to a U-shaped metal ring 110 forming the lower terminal element of the grid-anode sub-assembly.

The individual element comprising cathode support 14 and forming one of the elemental sub-assemblies of an electron tube according to the invention, constitutes a dish shaped structure comprising a flange 112 having an edge portion adapted to sealingly engage the upper surface of metal ring 90, as viewed in FIG. 2. The support 14 also includes a cylindrical portion 114 and a bottom portion 116 having an opening 118 adapted to receive snugly the upper portion 28 of the cathode sub-assembly aforementioned. The support 14, by virtue of its dish shaped structure, is adapted to restrain effectively lateral translations of the upper end of the cathode, and to permit longitudinal movements of the cathode in response to temperature induced expansions and contractions of the cathode.

The exhaust tubulation 16 made of copper for example, comprising another of the individual elements constituting a sub-assembly in the fabrication of an electron tube

according to the invention, is adapted to be sealed at flange 18 thereof, to the upper edge portion of cathode support 14.

After the electron tube has been exhausted and the tubular portion 120 of the exhaust tubulation 16 has been pinched off to form a vacuum tight closure, the cover 20, made of copper, for example, and forming the final sub-assembly, is sealed at flange 122 thereof partly to an edge portion of flange 18 of the exhaust tubulation, and flange 112 of the cathode support 14, for effectively integrating these elements.

In one example, the elements constituting the sub-assemblies aforementioned, had the following composition. The anode 48 was made of solid copper. The ceramic rings 50, 52, 78, 88, 100 and 108 were made of high alumina content ceramic. The flanges 72, 84, 94, and 102 and the metal rings 90, 110, were made of copper clad alloy known commercially as Kovar. The grids 68, 81 were made of copper. The grid support diaphragms 66, 80 and cathode support 14 were composed of a copper plated alloy known commercially as Nichrome.

For making the several seals between the ceramic and metal members, to form the grid-anode sub-assembly 12, the ceramic members were preconditioned by being coated with molybdenum and then nickel plated. A silver-copper solder known commercially as BT solder, was employed for sealing the coating ceramic members to their associated metal members. For fixing the grids 68, 81 to their supports 94, 102 and 66, 80 BT solder was applied by an eyedropper to the regions to be joined. After application of the solder as indicated, the grid-anode sub-assembly was supported on a jig to be described and heated to a temperature of about 820° C. in a hydrogen furnace to soften the BT solder.

The several elements comprising the cathode sub-assembly 10 are joined, in one example, prior to the application of the emitting coating 35, to avoid damage from heat involved in the use of BT solder aforementioned heated to the temperature indicated.

The final seals between the several sub-assemblies to constitute the finished electron tube are made at temperatures below that used in making the aforementioned prior seals and bonds with BT solder. Such prior seals are thereby preserved from harm when effecting the later seals and bonds between the sub-assemblies. One way in which such later seals and bonds are effected is by locally heating portions of the parts to be bonded, to fusion temperature to produce a weld therebetween. The localized character of the heating reduces the heat quantity involved to a value insufficient to adversely effect the previously made seals and bonds.

When the several sub-assemblies have been joined to form the electron tube shown in FIG. 1, the several electrodes thereof are engaged by lead-ins at both ends thereof to render the tube a double-ended structure. This double-ended feature and its advantages will become apparent from a consideration of each of the electrodes. Thus, the anode 48 is adapted to be connected at the lower end thereof to a circuit element by means of annular lead-in 56, and at the upper end thereof by lead-in 54. The screen grid 68 is connected at its lower end to lead-in 94 and its upper end to lead-in 72. In like manner, the control grid 81 is associated with lower lead-in 102 and upper lead-in 84. The lower end of the cathode 34 is connected to the U-shaped ring 110 serving as a lead-in to the lower end of the cathode, and to the U-shaped ring 90 constituting a lead-in to the upper end of the cathode.

This double-ended construction of the electron tube according to the invention is characterized by both mechanical and electrical advantages. The mechanical advantages involve ruggedness of support of the electrodes resulting from engagement of the electrodes by support members at both ends thereof. Such engagement effectively restrains vibration of the entire of each of the electrodes. And in so far as concerns the tubular cathode,

and control and screen grids, the double ended support is accompanied by freedom from structural distortions, such as buckling, on expansions and contractions of these electrodes.

As a consequence of the rugged support of the electrodes, initially established spacings therebetween are preserved during tube operation. Such spacings may be relatively small to permit operation at frequencies of the order of 3000 megacycles per second.

Of particular significance in attaining the rugged tube structure aforementioned are the structures of the control grid 81, the screen grid 68 and the diaphragm supports 66, 80, according to the invention. As shown in FIGS. 3 and 5 in connection with the control grid 81 and diaphragm support 80, both the grid and the diaphragm are provided with slots 140, 142, respectively which may be in registering relation. According to the invention, slots 140 have bottoms relatively closely spaced from the upper edge 144, as shown in FIG. 5, and appreciably spaced from elongated grid apertures 146 and control grid 81. As a result, an imperforate portion 148 is provided between the slotted end-portion of the grid and the perforated portion thereof. This imperforate portion serves to isolate the perforated portion of the grid from deforming stresses, and to limit deformation of the grid, on flexures of the diaphragm support 80, to a relatively small edge region traversed by the slots 140. Furthermore, the slots 142 in the diaphragm, permit the diaphragm to flex to a degree required by the deformation of the edge portion referred to.

To facilitate flexures of diaphragm 80, an annular groove 162 may be provided therein.

The foregoing references to control grid 81 and diaphragm 80, also apply to screen grid 68 and its associated support diaphragm 66.

FIG. 4 shows an undesirable condition of a grid 150 in which slots 152 constituting grid perforations, extend substantially the full length of the grid. It will be seen that the grid is deformed throughout a substantial longitudinal portion thereof in response to flexures of diaphragm 154. This condition is avoided in accordance with the invention as aforementioned.

For mounting the elements constituting sub-assembly 12 (FIG. 2) a jig 163 shown in FIG. 7 may be used. The jig includes a base 164 from one face of which two groups of pins extend, the pins in each group being disposed in a circular array. One group comprises pins 166, 168, 170. The other group comprises pins 172, 174, 176 in a circular array concentric with and within the circular array of pins 166, 168, 170. The pins in the latter outer array are appreciably longer than pins 172, 174, 176 of the inner array for a purpose to be described. While three pins are referred to in the foregoing example, at least two pins in each group are required for a practice of the invention.

As shown in FIG. 8, depicting a portion of sub-assembly 12 to one side of the longitudinal axis 178 of the sub-assembly, the relatively long pins 166, 168, 170 enter preformed apertures in certain of the elements of the sub-assembly and the relatively short pins 172, 174, 176 enter prearranged apertures in others of the elements. To facilitate the assembling operation, ceramic discs 50 and 52 are sealed to annular projections 60, 62 extending from the anode 48, by the use of conventional sealing techniques, and with the use of a suitable jig (not shown) prior to assembling of the parts on jig 163 (FIG. 7).

The parts received on or oriented by the longer pins referred to, comprise the U-shaped ring 110, the two grid flanges 94, 102, the anode 48, the two diaphragm supports 66, 80 and the upper U-shaped ring 90 as shown in FIG. 8. The U-shaped rings 90, 110, have an inner diameter for snug engagement with the pins 166, 168, 170. The grid flange 102 has three openings, for example, one of which 194, is shown in FIGS. 2 and 8 for receiving the three pins 166, 168, 170. Grid flange 94 has similar open-

ings, one of which 190 is shown in FIG. 8. The anode 48 and diaphragms 66, 80 are also provided with three openings for receiving pins 166, 168, 170, one group of registering openings being shown in FIGS. 2 and 8. Thus, the anode opening 192 is in register with openings 190, 194 in grid flanges 94, 102 and with openings 196, 198 in the diaphragms 80, 66.

As shown in FIG. 8, the parts received by the shorter pins 172, 174, 176, comprise the grids 68, 81 the respective lower conical end portions 98, 106, of which have openings for receiving the pins referred to. As shown in FIG. 6 with respect to grid end portion 106, apertures 200, 202, 204 therein receive pins 172, 174, 176. This orients the two grids generally with respect to a predetermined axis of the tube. For more accurately orienting the grids 68, 81 to provide a relatively close spacing therebetween, the screen grid 68 may be provided with projections at each end portion thereof spaced therearound by a magnitude for example, of 120°. Two of such projections 203, 205 are shown in FIG. 2. After the sub-assembly 12 is brazed, the projections 203, 205 are removed, as by eroding the region of the screen grid in which the projections are located, by electrical discharge machining. Another way in which the spacing between the two grids can be accurately determined is by placing between the grids a plurality of iron wires (not shown) having a diameter equal to the spacing desired between the two grids, and chemically removing the wires after the sub-assembly 12 has been brazed.

The order in which the elements referred to are assembled on the jig to provide a loose sub-assembly 12, is the order in which they appear from the bottom of the sub-assembly shown in FIGS. 2 and 8. In this way, a previously loaded part does not block the mounting of subsequent parts on the jig.

With the parts constituting the sub-assembly 12 thus assembled on the jig and with suitable solder, such as BT solder before mentioned, between or in contact with engaging elements, they are brazed in a hydrogen furnace at a temperature of about 820° C. to soften the solder for good seal formation.

Prior to the brazing step, it is advantageous to apply a downward pressure on the diaphragm supports 66, 80, so that when these supports are brazed to the grids 68, 81 they will apply a continuing tension to the grids both when cold, and when hot during operation of the tube. In this way, a compression force on the grids is avoided thereby contributing to assurance of freedom from grid deformation. In the tube under consideration, an axial downward displacement of the diaphragms 66, 80 at the region of their apertures of a magnitude of .010 inch has proven satisfactory for this purpose. However, the amount of downward displacement beyond this value is not critical, since the resultant increase in tensional force on the grids is not harmful. But the degree of downward deflection of the diaphragms should not be of a magnitude as to result in contact either between the diaphragms themselves, or between the lower diaphragm 66 and the anode 48.

Another way in which a satisfactory amount of tension of the diaphragms 66, 80 on the grids can be achieved is to simply allow the grids to expand longitudinally more than their supporting envelope during the brazing step and allow adequate slippage between the grids and the diaphragms. The solder used will freeze long before the tube temperature is reduced to a normal operating value (i.e. from 300 to 400° C.) and greater contraction of the grids after such freezing than of the envelope will provide the desired tension force on the grids both during operation and when cold.

After the parts comprising the sub-assembly 12 (FIGS. 2 and 8) have been brazed, the resultant self-supporting subassembly is removed from the jig 163 (FIG. 7) and the remaining elements of the tube are integrated therewith in the following manner.

The cathode sub-assembly 10 (FIG. 2) is extended into control grid 81 until flange 24 engages the ring 110. Bumps or projections disposed in groups of three, equidistantly spaced around axially spaced portions of the cathode sleeve 26, serve properly to orient the cathode within the control grid 81. Two of such bumps 210, 212, are shown in FIG. 2. These bumps are made of a material that readily decomposes under tube exhaust temperatures and is driven off during exhaust. One material found suitable is known commercially as Lucite. The flange 24 is then brazed to ring 110 by heat produced locally by radio frequency, for example, to avoid rupture of the brazes previously formed in sub-assembly 12.

Thereafter, the dish-shaped diaphragm 14 is positioned over the ring 90 and with the head 28 of the cathode sleeve entering opening 118 in the diaphragm. The exhaust tubulation 16 is then positioned over the diaphragm 14, so that flange 112 of the diaphragm is sandwiched between the flange 18 of the exhaust tubulation and the ring 90. A localized brazing heat, as by radio frequency, is then applied to braze together the elements of the sandwich.

After the tube has been evacuated and the exhaust tubulation 120 tipped off, the cover 20 is positioned over the tipped off tubulation, with the flange 122 engaging the flange 18, to which it is brazed by the local application of heat. This completes the fabrication of an electron tube in accordance with the invention.

What is claimed is:

1. An electron discharge device having an envelope comprising alternately disposed electrode lead-ins and insulating members, a tubular electrode within said envelope, relatively rigid support means at one end of said electrode fixed to one of said lead-ins, and relatively flexible annular support means fixed to the other end portion of said electrode and connected to another of said lead-ins, said annular support being flexed toward said rigid support when said electrode is relatively cold for providing a tensile force on said electrode which is released partly only, as said electrode expands axially in response to heat, said other end portion of said tubular electrode including an annular imperforate region and parallel slots extending from said imperforate region to the adjacent end of said electrode portion.

2. An electron discharge device according to claim 1, and wherein said rigid support has components extending radially and parallel to the axis of said device, and includes a flange circumferentially coextensive with said one of said lead-ins.

3. An electron discharge device according to claim 1 and wherein said flexible support comprises a diaphragm fixed to said electrode in a region which is circumferentially co-extensive with said electrode.

4. An electron discharge device having an envelope comprising alternately disposed electrode lead-ins and insulating members, a tubular electrode within said envelope, a relatively rigid support means at one end of said electrode and fixed to one of said lead-ins, and relatively flexible annular support means fixed to the other end portion of said electrode and connected to another of said lead-ins, said flexible annular support means comprising a diaphragm fixed to said electrode in a region which is circumferentially coextensive with said electrode, said diaphragm and said electrode having registering slots for accommodating deformations thereof on flexures of said diaphragm, said diaphragm being flexed toward said rigid support when said electrode is relatively cold for providing a tensile force on said electrode which is released partly only, as said electrode expands axially in response to heat.

5. An electron discharge device according to claim 4, and wherein said slots in said electrode extend only a relatively short distance from the end of the electrode engaged by said diaphragm, for reducing the area of the deformation accommodating portion of said electrode,

whereby a desirably relatively large adjacent active area of the electrode is preserved from deformation.

6. An electron discharge device comprising an envelope having a side, an annular electrode lead-in extending through said side, a plurality of concentric tubular electrodes within said envelope, and a flexible annular metallic support fixed to and extending between said lead-in and one end portion of one of said electrodes, said support having an annular fold and having a slot extending across said fold for releasing forces on said support produced on flexures thereof.

7. A sub-assembly for an electron discharge device, comprising a tubular electrode, a plurality of annular members defining an envelope enclosing said electrode and coaxial therewith, two of said members being disposed at the ends of said sub-assembly and having a first inner radius smaller than that of the others of said members, said electrode having a second inner radius smaller than said first inner radius, said electrode having a plurality of angularly spaced openings extending there-through parallel to the axis of said electrode and disposed in an annular array having a radius corresponding to the inner radius of said two of said members, whereby said electrode and said members are adapted to be stacked on a jig having rectilinear mandrels adapted to engage the inner sides of said two of said members and the openings in said electrode, and said sub-assembly is free from openings through a side thereof.

8. A sub-assembly for a double ended electron discharge device comprising a plurality of concentric tubular electrodes, an envelope enclosing said electrodes, said envelope comprising a plurality of annular members, two of said members engaging opposite ends of the outermost of said electrodes, the inner radii of said two of said members being larger than the inner radius of said outermost electrode, end portions of said envelope comprising arrays of said members in which said members have progressively smaller inner diameters toward the ends of said envelope, the inner radii of the end ones of said members being substantially equal to each other and larger than the inner radius of said outermost electrode, the electrode next adjacent to said outermost electrode having an annularly flanged end portion having an outer radius smaller

than the inner radius of said outermost electrode, said outermost electrode having a plurality of openings disposed in a first annular array having an outer radius corresponding substantially to the inner radius of said end ones of said members, said annularly flanged end portion having a plurality of openings therein disposed in a second annular array coaxial with said first array and having a smaller outer radius than the inner radius of said outermost electrode, whereby said electrodes and said members are adapted to be assembled in accurate coaxial relation on a jig having pins disposed in two coaxial arrays corresponding to the locations of the openings in said outermost and said next adjacent electrodes when said electrodes are in accurate coaxial relation.

9. A grid mount comprising a tubular metal structure having a first imperforate portion extending from one end thereof, a first perforated portion extending from the other end thereof, a second imperforate portion extending from said first perforated portion, and a second perforated portion extending between said first and second imperforate portions, a relatively rugged support fixed to said first imperforate portion for restraining axial and radial displacements of said one end portion of said structure, and a metal diaphragm engaging said first perforate portion for ruggedly restraining radial displacements while permitting axial displacements of said other end of said structure, said diaphragm having perforations merging with the perforations of said first perforated portion for adjusting said diaphragm and said other end portion to distortions produced on axial displacement of said structure, said second imperforate portion isolating said second perforated portion from said distortions.

References Cited in the file of this patent

UNITED STATES PATENTS

2,024,585	Laico	Dec. 17, 1935
2,395,835	Bareiss	Mar. 5, 1946
2,609,517	McCullough	Sept. 2, 1952
2,683,237	Scullin	July 6, 1954
2,935,783	McCullough et al.	May 10, 1960
2,941,109	Senior et al.	June 14, 1960
3,045,142	Ekkers	July 17, 1962