

May 16, 1950

R. C. GEE ET AL

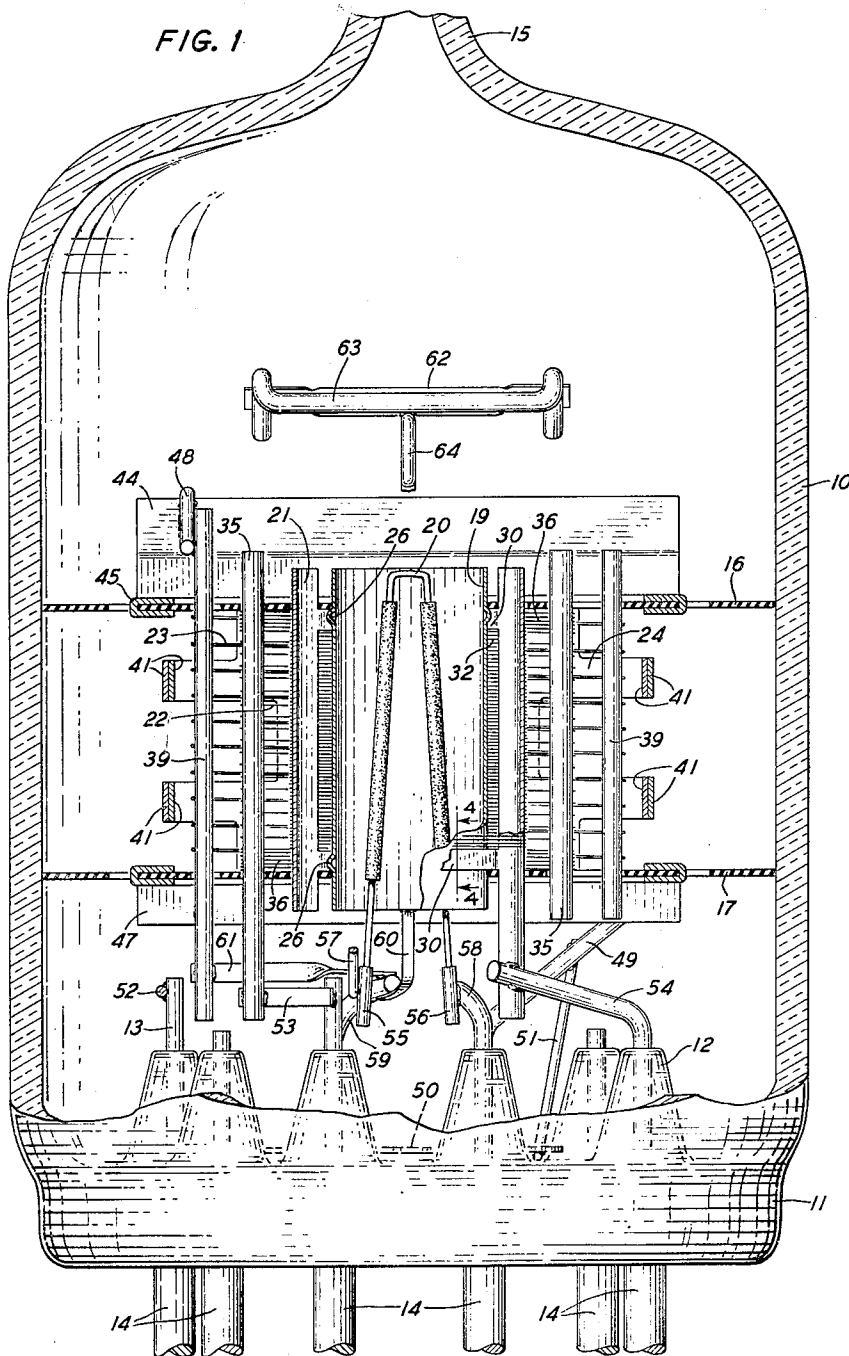
2,507,706

ELECTRONIC DISCHARGE DEVICE

Filed Jan. 17, 1948

3 Sheets-Sheet 1

FIG. 1



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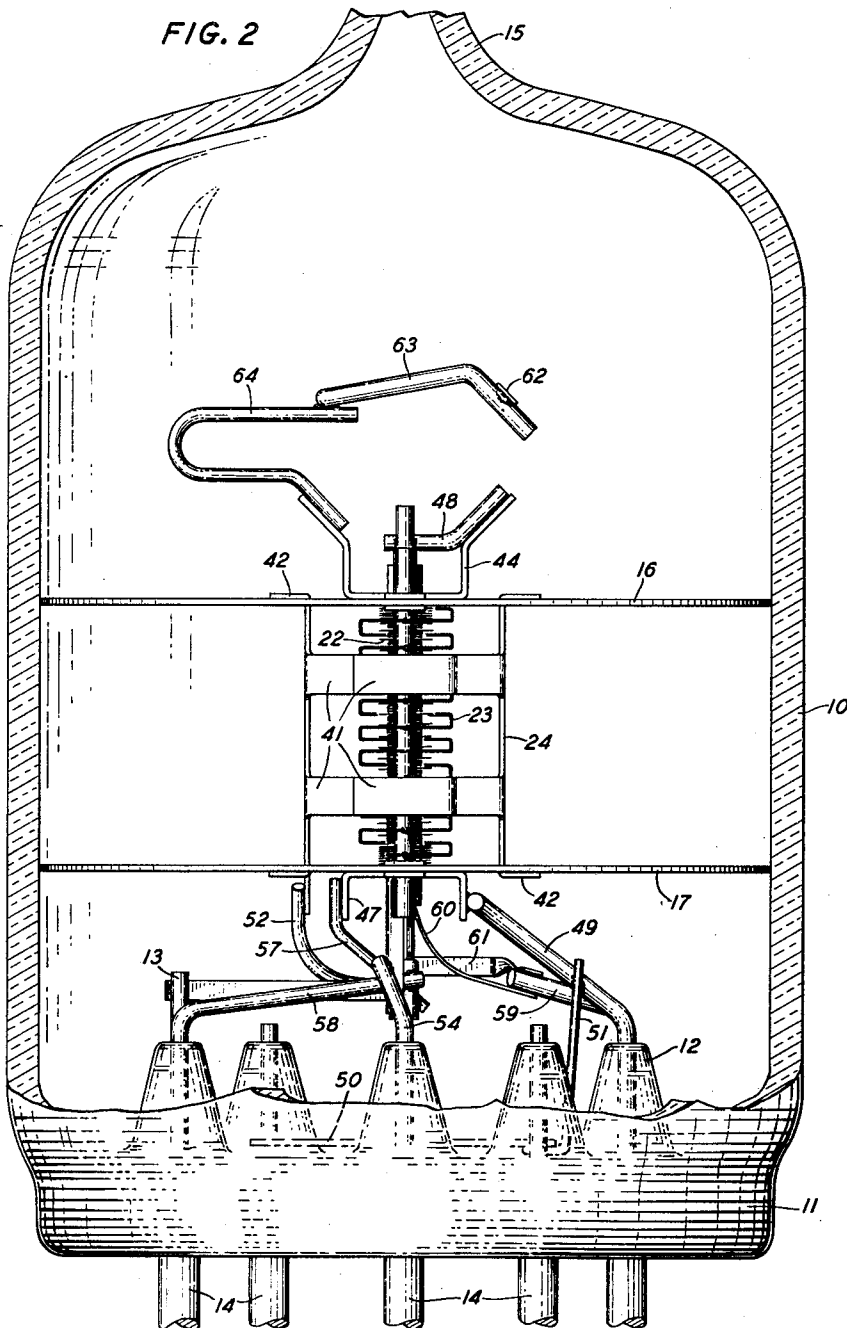
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FIG. 3

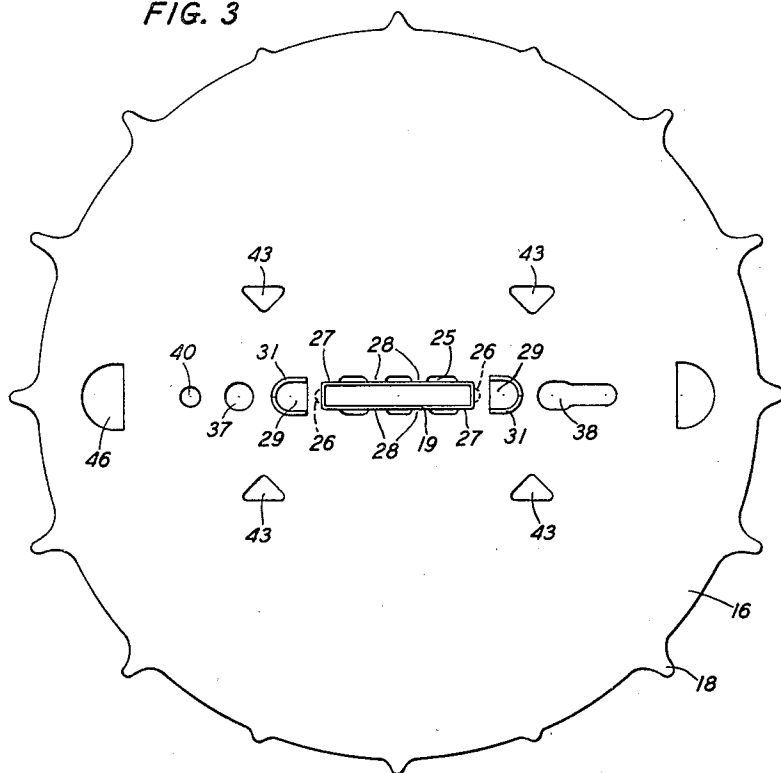
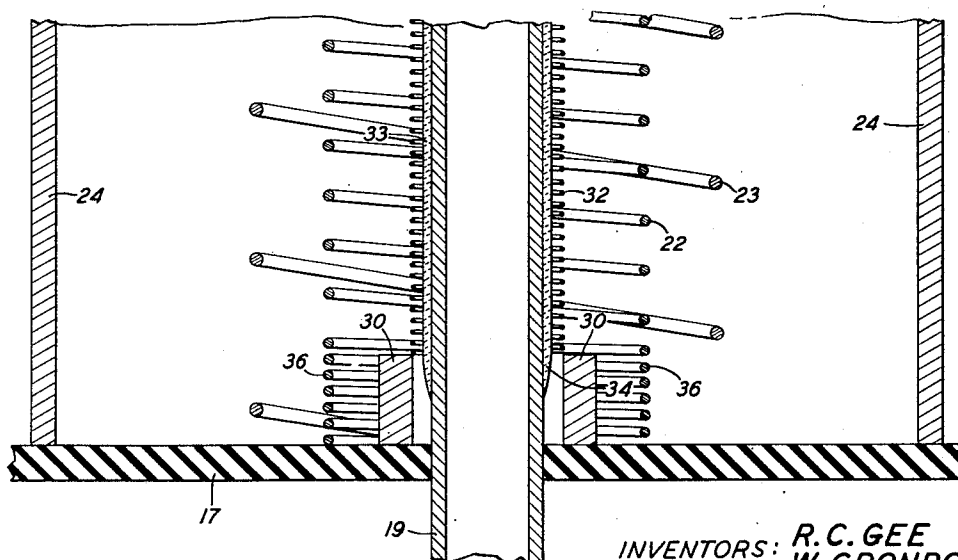


FIG. 4



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UNITED STATES PATENT OFFICE

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ELECTRONIC DISCHARGE DEVICE

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10 Claims. (Cl. 250—27.5)

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This invention relates to electronic discharge devices and more particularly to such devices of the micro-midget multi-element type especially useful in very high and ultra-high frequency translating systems.

The static characteristics of electronic discharge devices determine the scope of use and the efficiency of operation in low frequency applications. However, the requirements encountered in the very high and ultra-high frequency ranges, for example in the 100 to 500-megacycle range, impose conditions which can only be satisfied by extremely precise correlation of the elements to provide the essential electrical constants whereby the highest efficiency is attained. The most important characteristic for general use is the transconductance. The transconductance depends on the spacing between the cathode, control grid and screen grid, the diameter of the grid wire, the spacing thereof, the electrode area and the potentials applied to the electrodes. In order to attain a high transconductance, it is necessary to reduce the diameter of the control grid wire to a point where the wire is not self-supporting when wound in grid form. Therefore, the fine fragile wire is wound on a support frame which maintains the collateral relation of the grid and cathode constant at very close spacing, for example of the order of $2\frac{1}{2}$ mils. In addition, the grid laterals must be relatively close together along the length of the grid to secure the desired controlling action upon the electron stream emanating from the cathode.

This arrangement presents certain difficulties due to the strengthening configuration of the frame which introduces solid metallic portions between the cathode and anode at opposite ends of the grid structure. These portions increase the grid-plate capacity so that the performance of the device is degraded in some applications.

An object of this invention is to reduce the plate-grid capacitance in discharge devices employing frame grid structures.

Another object of the invention is to secure extremely high transconductance in high frequency discharge devices.

A further object of the invention is to maintain constant spacial relation between the closely parallel surfaces of the cathode and control grid in electronic discharge devices.

Another object of the invention is to facilitate the assembly of the micro-dimensional elements in such devices so that uniform characteristics may be attained in mass unit production.

These objects are realized in accordance with features of this invention in an electronic discharge device of the micro-midget type having a frame type grid assembly, by including shielding sections on the screen or positively biased grid adjacent the control grid to reduce the parasitic

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capacity of the control grid in relation to the anode. A specific manner in which this is accomplished is to terminate the usual lateral winding of the screen grid by closely wound turns of wire at opposite ends to effectively shield the stray capacity fields caused by the solid strap material of the frame grid structure. Since the closely spaced shielding sections of the screen grid extend over the width of the bracing portions of the control grid their effect is cancelled due to the fact that the closely spaced turns at opposite ends form a barrier to the establishment of a capacitance between the solid surfaces of the anode and the bracing straps of the control grid.

A feature of the invention relates to the assembly of the screen grid in correlation with the frame control grid whereby the shielding sections of the screen grid extend completely between the inner lateral edges of the bracing straps and the mica spacers supporting all the electrodes in order to reduce the capacitance between the bracing straps and the anode.

Another feature of the invention pertains to the maintenance of critical collateral space relation between the large area cathode surface and the closely spaced control grid laterals. As these elements are only spaced apart by a distance of the order of $2\frac{1}{2}$ mils it is essential that the cathode be held in its proper position. This is accomplished by accurately forming the slots in the spacing mica discs on opposite ends of the unitary assembly to accommodate the semicircular form of the frame grid structure and providing limited contact fingers on the micas in the opening for the flat cathode so that the cathode cannot move laterally in its relation to the control grid. These fingers abut against the flat portions of the cathode surfaces on opposite sides and at the top and bottom thereof so that the cathode is accurately spaced in constant relation to the lateral wires of the control grid structure.

These and other features and advantages of the invention will be more clearly set forth in the following detailed description of an illustrative embodiment shown in the accompanying drawings in which:

Fig. 1 is an elevational view partly in section, on a greatly enlarged scale, of an electronic discharge device embodying this invention, a portion of the vessel being broken away;

Fig. 2 is a side view in elevation of the device of Fig. 1 with the vessel broken away and the electrode unit shown in full lines to illustrate the assembly of the device;

Fig. 3 is a plan view of the spacing insulator employed in the device of Fig. 1, showing the accurately cut apertures for the support of the electrode elements in the unit and the configuration of the cathode opening in combination with the cathode element; and

Fig. 4 illustrates, on a greatly magnified scale, a section of the lower portion of the electrode unit, taken on the line 4—4 of Fig. 1, the relatively close tolerances which must be maintained between the electrodes in the micro-midget device and the shielding effect of the screen grid in relation to the frame type control grid, this figure being shown in partly diagrammatic form in the interest of clarity.

Referring to the drawings, the electronic discharge device of micro-midget dimensions embodying this invention is shown in Fig. 1 on an enlarged scale of about 10 to 1 to clearly illustrate the components of the unitary electrode assembly mounted within the receptacle. Although the electrode unit, exclusive of mounting projections, occupies less than half of the space in the receptacle, and the unit includes spacer discs to fit the inner wall of the receptacle, some realization of the actual size of the electrode unit may be gained by reducing the dimensions shown by a factor of 10. Then the unit has dimensional limits of approximately one-half inch length, one-half inch width and one-quarter inch thickness. Since the unit includes a multiplicity of coaxial electrodes of which the central cathode and surrounding control electrode must be proportionally smaller in two dimensions, namely, width and thickness, it is evident that extremely precise tolerances must be maintained in the fabrication of these elements to realize the close spacial relation in the unitary assembly. For example, the cathode has a major axis of .150 inch, a minor axis of .0245 inch and a length of .330 inch. The anode has a major axis of .470 inch, a minor axis of .190 inch and a length of .253 inch with the cooperating grid electrodes therebetween having correspondingly smaller dimensions. When these micro-dimensional elements are combined in coaxial symmetry in which the control grid is laterally spaced from the cathode surface a relatively close distance of the order of .0025 inch and the other electrodes are similarly spaced at varying distances from each other, it is evident that precision is required in the mounting and relationship of these elements to attain the electrical constants required in the operation of the device.

The device, as shown in Fig. 1, includes a highly evacuated vitreous enclosing vessel 10, of cylindrical configuration, having a molded or cast stem 11 sealed to the base end, the stem having integral internal embossments 12 forming pillar reinforcements for a plurality of hermetically sealed lead-in wires or conductors 13 which terminate exterior to the stem as rigid terminal pins 14 adapted to engage socket contacts for coupling the device in various applications. The opposite end of the vessel is closed by a sealing tubulation 15 for processing the device in the final assembly in which the tubulation is sealed to a vacuum pump station to remove air and occluded gases and create a high vacuum within the vessel after which the tubulation is sealed off.

The electrode unit or mount within the vessel is resiliently supported from the cylindrical wall of the vessel through mica spacer discs 16 and 17 which are provided with spaced projections 18 around the periphery, as shown in Fig. 3, to engage the inner wall and laterally support the unit in fixed position in the vessel. The unit is anchored therein by rigid connection of the electrodes to the lead-in wires in the stem. The mica discs 16 and 17 are precision cut, as shown in Fig. 3, with various shapes of slots and aper-

tures to provide accurately aligned support openings which aid, in part, in determining the relationship and spacial cooperation of the respective electrodes involved in the particular mount assembly.

The cathode 19 forms the central main electrode of the unit and is rectangular in cross-section to provide a large surface for the emission of electrons toward the other electrodes in the unit. An internal insulated heater element 20, of hairpin formation, is enclosed by the cathode to indirectly heat the cathode and raise the cathode to the proper temperature for electron emission. A frame type control electrode 21, which is disclosed in more detail and claimed in a copending application, Serial No. 2,433, filed January 15, 1948, of E. J. Walsh, surrounds the cathode and is mounted in relatively close spacial relation to the cathode surface to attain the desired high transconductance. A screen grid 22 encircles the control electrode and another wire wound grid or suppressor electrode 23 is spaced about the screen grid. A sheet metal rectangular-shaped anode 24 having cut-out side portions is mounted in surrounding relation to the other internal electrodes to complete the electrode assembly of the device.

Since the cathode 19 and control grid 21 are mounted in relatively close spacial relation and must be maintained in this relation in substantial constancy to secure high efficiency and high transconductance in the device, it is evident that accuracy and mounting facilities must be provided.

In accordance with one feature of this invention, the cathode and control electrode relation is maintained in constant symmetry so that mechanical vibrations of the cathode do not alter the collateral spacing of these electrodes. This is accomplished by the configuration of the mounting slots in the mica spacer discs, as shown in Fig. 3. The elongated slot 25 is formed in the center of the disc and extends along one diameter equal to the major transverse dimension of the cathode 19, the latter being provided with bead projections 26 which fit against the inside surface of each disc to support the cathode between the top and bottom spacer discs of the unit assembly. The long sides of the slot 25 are provided with corner angles 27 equivalent to the minor transverse dimension of the hollow cathode so that the cathode is securely locked in position within the slot. In addition, the same sides of the slot are formed with oppositely disposed and inwardly projecting broad flat surface integral fingers or contact lugs 28 which engage the major surfaces of the cathode and insure rigid mounting thereof. However, the wider spaces or openings in the slot 25 between the fingers reduce the area of contact between the cathode sleeve and the slot effectively to reduce the conduction of heat from the cathode to the mica spacer discs. This reduction in conduction loss is essential to provide uniform heating of the active cathode surfaces and to effect economy in power input to the cathode. Heat conduction loss into the spacer discs would be excessive were the slots 25 made to engage snugly the entire periphery of the cathode sleeve; yet, if the slots were made large enough to provide loose fit of the cathode within them, thus achieving mere random point contact between cathode and discs to realize the desired reduction in heat conduction path, then the cathode could not be positioned accurately with respect to the control grid and would be sub-

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ject to relatively sizeable migrations because of external mechanical impulses. This rigidity of mounting of the cathode in a lateral direction is to prevent variation in relation of the cathode with respect to the closely spaced lateral wires of the control grid adjacent thereto, the spacing between them being only .0025 inch.

When the cathode is secured in position between the mica spacer discs, the control grid 21 is mounted around it. This grid is formed of a metallic frame having semicircular upright portions 29 which are joined together by bracing straps 30 adjacent opposite ends. The upright portions 29 are fitted into apertures 31 of similar-shaped outline in the mica discs and the straps 30 abut against the inner surfaces of the discs to rigidly support the grid in relation to the cathode surface. The frame structure of the control electrode insures constant laterality of the fine grid helix wire 32 closely adjacent the large area of the flat cathode surface. The bracing straps not only increase the rigidity of the frame assembly and form a broad base in contact with the mica spacer discs but also provide a sharp cut-off in the emission characteristic of the cathode. This is the case because the emission coating 33 on the cathode surface, as shown in Fig. 4, is not uniform at the extremities, as indicated at 34, and the wide straps 30 of the control grid correct for this defect by blocking the extremities of the cathode coating thereby preventing passage of emission from the end portions of the cathode.

The bracing straps 30 of the control grid 21, however, introduce stray capacitance effects between the cathode and the anode since they present relatively large metallic masses in the space between these electrodes, and thereby increase the capacity coupling between the input and output circuits of the device. This effect is overcome, in accordance with another feature of this invention, by forming shielding portions on the ends of the screen grid which immediately surround the ends of the control electrode. This is accomplished by terminating the winding 22 along the support wires 35 of the screen grid with closely spaced turns of the same wire employed in winding the screen grid. The shielding portions 36, as shown clearly in Fig. 4, which represents a cross-section through all the electrodes on a scale of 50 to 1, with respect to the actual size of the electrode assembly, form barriers between the fields of the straps 30 and the anode 24 so that the capacity effect of the straps is cancelled or materially diminished to a value which may be tolerated.

The screen grid 22 may be spaced from the control grid lateral wires 32 a distance of 18 mils and is mounted with the support rods 35 in apertures 37 and 38 in the mica discs. It will be noted that the elongated aperture 38 permits expansion of the grid structure with temperature changes.

The suppressor grid 23 has the lateral turns relatively widely spaced in relation to the intermediate portion of the screen grid and the very close spacing of the lateral turns of the control grid. This grid 23 is mounted on a pair of support wires 39 which extend into apertures 40 on one side of the cathode and 38 on the other side, the latter aperture permitting expansion of the grid 23 laterally in the plane of the major lateral dimensions of the electrodes. The suppressor grid may be spaced approximately 16 mils from the screen grid 22.

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The anode 24 is formed of two plate sections which lie parallel to the major dimensions of the other electrodes and may be spaced approximately 44 mils from the suppressor grid surface. The anode sections are provided with pairs of strap portions 41 which extend from the side edges and these are bent at right angles with adjacent angular straps joined together, preferably by welding, to form a box-shaped construction. The opposite ends of the plate sections of the anode are provided also with projecting ears 42 which fit into apertures 43 in the mica discs and are bent over the outer surfaces of the discs to lock these discs to the anode.

The unit assembly is completed by mounting a transverse top metallic shield 44, of U-shaped cross-section, by clips 45 which fasten the shield to the mica disc 16 through the apertures 46. A similar shield 47 extends across the outer surface of the bottom mica disc 17 and is attached thereto in a similar manner. The top shield is connected to the suppressor grid by a stub wire 48 while the lower shield 47 is connected to a terminal pin in the stem by the bent conductor 49. In addition, a disc shield 50 is supported in spaced parallel relation to the disc stem within the confines of the glass pillars 12 and is connected to the conductor 49 by a wire 51.

The anode is connected to a terminal pin by stub wire 52. The long support wire 35 of the screen grid is attached to another terminal pin by a strap 53 and the control grid long frame strut is connected to conductor 54 in the stem. The heater element 20 has the two projecting ends 55 and 56 connected respectively to lower shield 47 by stub wire 57 and conductor 58 in the stem. The cathode is joined to a conductor 59 by a resilient nickel alloy strip 60 and the suppressor grid is tied to the same conductor as the cathode by a transverse strip 61.

A getter strip 62 is mounted on a U-shaped frame 63 to form a closed loop which may be heated by high frequency induction methods to vaporize the getter material from the strip and the loop is supported by a bent wire 64 from the top shield 44.

The above-described construction of the micro-dimensional unit assembly in the device provides a unitary rugged mounting assembly of the multiple electrodes in which the space relation of the cathode and control electrode is maintained constant so that the transconductance characteristic is stabilized to insure positive and constant operation in the band of frequencies for which the specific cooperating electrode assembly is desired to be employed. The mounting assembly of the cathode in combination with the frame grid construction maintains constant parallelism between these electrodes regardless of mechanical vibrations. Furthermore, the capacitance effects of the bracing straps of the control grid frame are neutralized by the shielding portions of the surrounding grid assembly so that the spurious fields in the vicinity of the straps of the grid frame are prevented from reaching the anode.

While the invention has been disclosed in a particular embodiment, it is, of course, understood that various modifications may be made in the detailed assembly and structure to achieve the results of this invention and such modifications are deemed to be within the scope of the appended claims.

What is claimed is:

1. An electronic discharge device comprising an

enclosing vessel, a unitary mount within said vessel including a tubular cathode, an anode surrounding said cathode, a grid adjacent the cathode having a frame type structure with bracing straps at opposite ends between the cathode and anode surfaces, and another grid located in a direction toward said anode having a winding of widely spaced turns over a portion within the compass of said frame grid winding and shielding portions intermediate said bracing straps and said anode.

2. An electronic discharge device comprising an enclosing vessel, a mount within said vessel including a tubular cathode, an anode surrounding the same, and a plurality of grid electrodes therebetween, one of said grids being a control grid adjacent the cathode and having a frame type structure with bracing straps at opposite ends parallel to said cathode and anode surfaces, and another of said grids surrounding said control grid and having means at opposite ends thereof for neutralizing the capacitance effects of said bracing straps on said frame structure.

3. An electronic discharge device comprising an enclosing vessel, a unitary mount within said vessel including a tubular cathode, an anode surrounding the same, and a plurality of grid electrodes between said cathode and anode, one of said grid electrodes adjacent the cathode having a frame type structure with bracing straps at opposite ends parallel to said cathode and anode surfaces, the next adjacent grid located in a direction toward the anode having a winding of widely spaced turns over a portion within the compass of said frame grid winding and closely spaced turns of winding at opposite ends equivalent to the expanse of said straps on said frame structure.

4. An electronic discharge device comprising an enclosing vessel, a unitary mount within said vessel including a tubular cathode, an anode surrounding the same, and a plurality of grid electrodes between said cathode and anode, the grid adjacent the cathode being a control grid having a frame type structure with bracing straps at opposite ends between said cathode and anode surfaces, and another of said grids surrounding said control grid and having shielding portions at opposite ends in longitudinal extent equivalent to said bracing straps.

5. An electronic discharge device comprising an enclosing vessel, a unitary mount within said vessel, said mount including a plurality of closely spaced cooperating electrodes and spacing insulators at opposite ends, one of said electrodes being a control grid relatively close to the cathode surface and formed of a closely wound helical wire insufficient in itself to be self-supporting to maintain the laterals in parallel relation, a metallic frame structure supporting said wire laterals and having bracing straps at each end, another helically wound wire grid surrounding said control grid, said latter grid having uniformly spaced laterals of wider pitch over the length corresponding to the closely pitched turns of said control grid, and closely spaced turns at each end of said latter grid collateral to and coextensive with said bracing straps of said frame structure.

6. A cathode mounting comprising a rectangular cathode, a plurality of electrodes surrounding said cathode, insulating spacer members at opposite ends of said electrodes and cathode, said members having openings through which said

cathode extends, and broad flat contact friction fingers projecting inwardly from said members, engaging said cathode and holding it centrally within said electrodes.

7. An electronic discharge device comprising an enclosing vessel, a unitary electrode mount supported therein including a rectangular tubular cathode and at least one closely spaced electrode surrounding said cathode, spacing insulators at opposite ends of said mount having apertures therein for the support and spacing of said cathode and electrode in precise collateral relation, and equally spaced broad flat contact friction portions on said insulators engaging the long dimension surface of said cathode to insure constant spacial relation with respect to said closely adjacent electrode.

8. An electronic discharge device comprising an enclosing vessel, a unitary electrode mount supported therein including a rectangular tubular cathode and at least one closely spaced electrode surrounding said cathode, spacing insulators at opposite ends of said mount having apertures therein for the support and spacing of said cathode and electrode in precise collateral relation, and spaced friction portions having parallel edges in contact with opposite long sides of the cathode in said insulators, the distance between opposed portions being equivalent to the outer minor dimension of said cathode.

9. An electronic discharge device comprising an enclosing vessel, a unitary electrode mount supported therein including a rectangular tubular cathode and at least one closely spaced electrode surrounding said cathode, spacing insulators at opposite ends of said mount having precision slots and apertures therein for the mounting of said cathode and electrode, the central slot for said cathode being greater in dimension than the minor axis thereof, and a plurality of integral blunt edge tab projections extending from said central slot on each side in opposed planar relation and matching the minor axis of said cathode and rigidly mounting the cathode free from lateral movement.

10. An electronic discharge device comprising an enclosing vessel, a unitary electrode mount supported therein including a tubular central cathode and a frame type control electrode surrounding said cathode, the uprights of said frame having a hollow semicircular configuration and said frame supporting a closely spaced lateral winding of fine wire, mica spacers at opposite ends of said mount having pairs of semicircular slots to accommodate said uprights and a central elongated slot for said cathode, the distance between the lateral winding and the surface of said cathode in collateral relation being approximately $2\frac{1}{2}$ mils, and pairs of blunt integral extensions in said cathode slot engaging opposite sides of said cathode to maintain said relation constant.

RICHARD C. GEE.
WARREN GRONROS.

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