

[72] Inventor **Robert M. Hughes**
Owensboro, Ky.
[21] Appl. No. **774,771**
[22] Filed **Nov. 12, 1968**
[45] Patented **Apr. 6, 1971**
[73] Assignee **General Electric Company**

[56]

References Cited

UNITED STATES PATENTS

3,334,263	8/1967	Beggs	313/348
3,238,411	3/1966	Beggs	313/348
3,297,902	1/1967	Beggs	313/348
3,196,307	7/1965	Lewis	313/348
3,050,651	8/1962	Beggs	313/15

Primary Examiner—John W. Huckert

Assistant Examiner—Barry Estrin

Attorneys—Nathan J. Cornfeld, John P. Taylor, Frank L.

Neuhauser, Oscar B. Waddell and Melvin M. Goldenberg

[54] **HIGH-FREQUENCY ELECTRON TUBE HAVING NOVEL GRID MOUNTING**
8 Claims, 3 Drawing Figs.

[52] U.S. Cl. 313/348,
313/349, 313/350, 313/265, 313/269, 313/278

[51] Int. Cl. H01j 13/46,
H01j 17/04

[50] Field of Search 313/348,
278, 349, 269, 350, 265

ABSTRACT: A high-frequency electron tube having a novel grid mount is provided to inhibit mechanical distortion of the grid at high temperature. The shape and material selection of the grid support allows the grid to expand and contract at a different rate than the envelope in which it is mounted without damaging the grid.

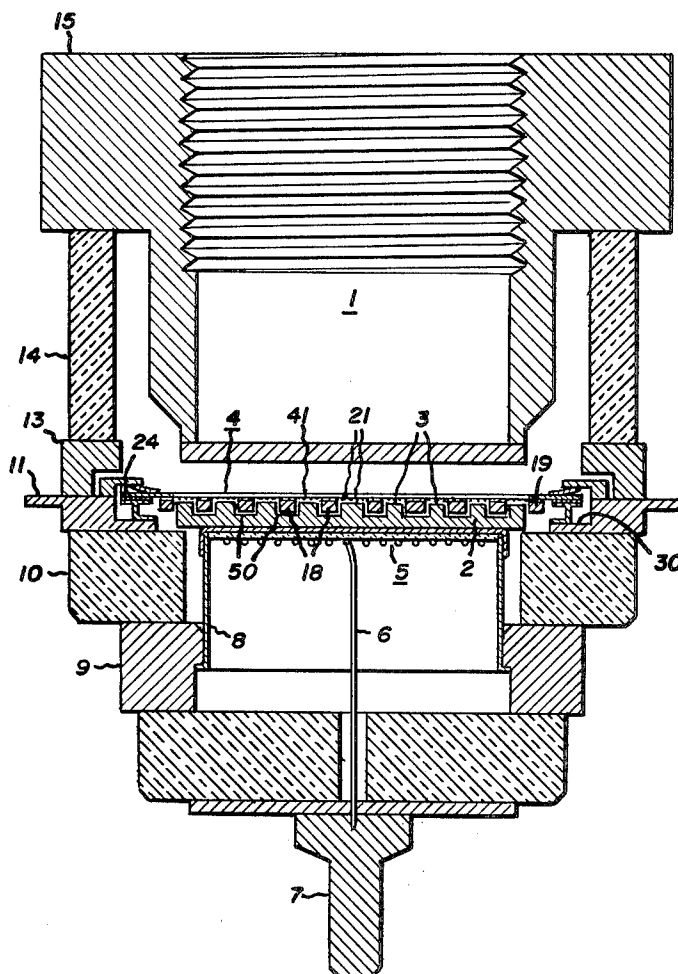


FIG. 1.

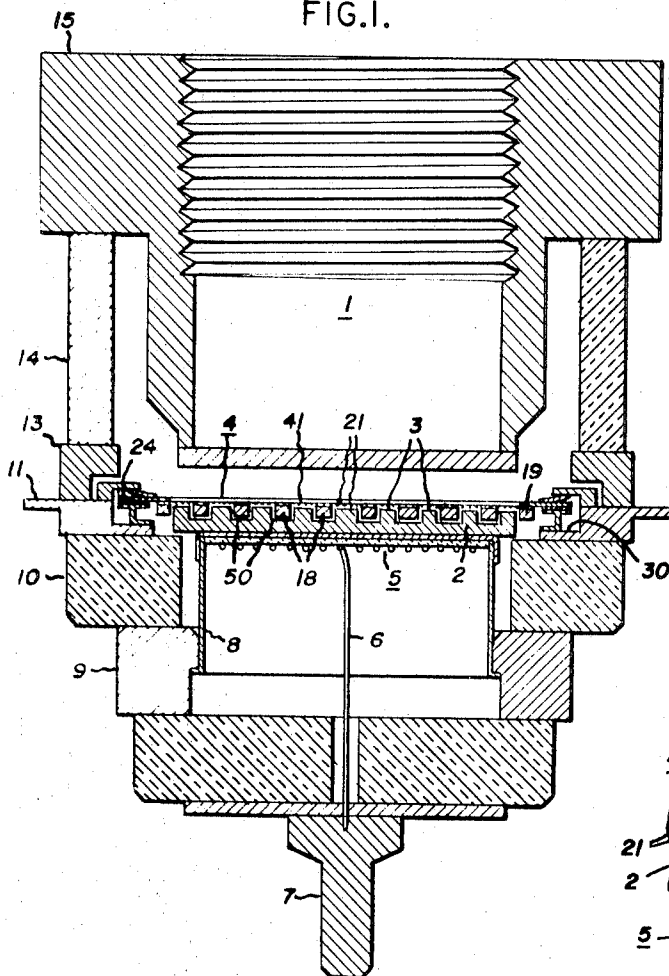


FIG. 3.

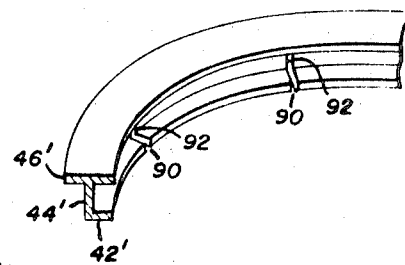


FIG. 4.

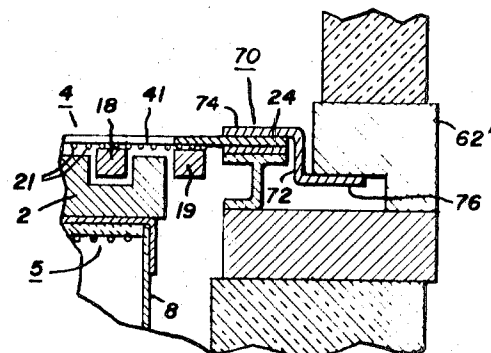
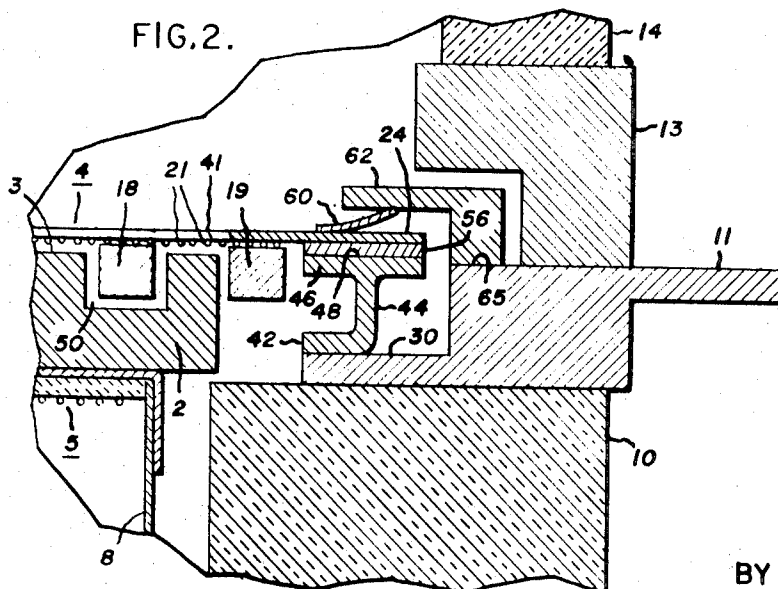


FIG. 2.



INVENTOR:
ROBERT M. HUGHES,
BY *John P. Taylor*
HIS ATTORNEY.

HIGH-FREQUENCY ELECTRONIC TUBE HAVING NOVEL GRID MOUNTING

BACKGROUND OF THE INVENTION

This invention relates to the mounting of a grid in a high-frequency electron discharge device such as disclosed and claimed in U.S. Pat. No. 3,334,263 issued Aug. 1, 1967 and assigned to the assignee of this invention. This patent, the disclosure of pertinent parts of which are herein incorporated by reference, teaches a novel configuration of the grid and the cathode to allow a discharge device to operate at high frequency, for example, 1 gigacycle per second, and high-power output without deleteriously affecting the electronic characteristics of the device. Briefly, this is accomplished by placing relatively massive supporting bars beneath the fine grid conductors to provide both mechanical support and heat conductance for the fine grid conductors. The grid supporting bars recess into corresponding grooves provided in the face of the cathode. The mating relationship of the bars and recesses enable both the cathode and anode surfaces to be physically located as close to the grid as in prior art constructions not using such reinforcement techniques. Thus, the electrical characteristics of the tube such as for example, interelectrode capacitance and high-frequency capabilities are not significantly altered despite the presence of the supporting bars.

However, under certain extreme conditions of processing and operation, I have found problems with regard to temperature expansion and contraction of the mating elements in this construction. The lateral clearances between the walls of the recesses in the cathode and the sides of the reinforcing bars are, of necessity, small to provide maximum emitting surface on the cathode. This in turn requires relatively rigid mounting of the grid within the envelope of the electronic device to provide as little lateral movement of the grid as possible relative to the cathode. As a result, mechanical distortion of the grid structure has been found to occur probably due to the difference in temperature coefficients of expansion of the grid material and the envelope.

The envelope of such devices preferably are in the form of stacked ceramic and metal parts. The metal portions are preferably titanium because of its function as a low emission material exhibiting continuous gettering properties during high-power operation and its bondability to refractories. The ceramic material functions as an insulator between the metal portions. Forsterite, because of its low dielectric constant and matching coefficient of expansion with titanium, is the preferred ceramic.

The conducting portions of the device are constructed of materials chosen for their desirable electronic characteristics, mechanical strength at high temperatures, and heat conductivity. The grid material is preferably tungsten, molybdenum, or a tungsten-molybdenum alloy. The foregoing materials are preferred in the grid for their strength at high temperatures and heat conductance characteristics. However, tungsten and molybdenum or alloys thereof do not have the same temperature coefficients of expansion and contraction as titanium and forsterite. In the temperature ranges of processing and operation of the device, tungsten and molybdenum have a temperature expansion coefficient of about 5×10^{-6} per degree centigrade while the coefficient for titanium and forsterite is about 10×10^{-6} per degree centigrade. Thus, while rigid retention of the grid is desired to prevent lateral movement of the grid relative to the cathode, such retention results in the mechanical coupling of materials having unequal coefficients of temperature expansion and contraction resulting in mechanical distortion of the weaker grid member.

Quite surprisingly, it has now been discovered that the grid can be mounted in relatively rigid fashion with respect to lateral movement with little if any danger of mechanical distortion by the novel grid mounting structure of this invention.

SUMMARY OF THE INVENTION

In accordance with the invention an electron tube having grid mounting means is provided capable of withstanding high temperatures and comprising an outer envelope having supported therein an anode electrode, a cathode electrode, and a grid structure including grid conductors closely spaced to said cathode between said anode and cathode. The grid mounting means include grid support means comprising an upright cylindrical member located between the grid structure and the envelope of the electron tube. The grid support means are constructed of a material having a coefficient of temperature expansion similar to the grid materials. The grid is held on the support means by retention means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-sectional view of one embodiment of the invention.

FIG. 2 is an enlargement of a portion of FIG. 1.

FIG. 3 is a fragmentary isometric view of an alternate embodiment of the invention.

FIG. 4 is a fragmentary enlarged cross-sectional view showing an alternate embodiment of the invention.

DETAILED DESCRIPTION

Referring now to FIG. 1, a high-power, high-frequency electron discharge device according to the present invention comprises a stud-shaped anode 1 having a circular planar surface; a cathode 2 having an active surface generally conforming to and spaced from that of the anode, the active surface of the cathode having raised planar emitting portions 3 coated with appropriate electron-emitting material; and a grid electrode 4 interposed between the anode and the cathode. The cathode 2 is conveniently heated to a high temperature by a bonded heater element 5. Connection 6 joins the aforementioned heater element 5 to terminal 7 while a thin cylindrical cathode support 8, desirably formed of a high strength, low-heat conductivity, low coefficient of expansion metal such as, for example, tantalum, completes the circuit between heater element 5 and terminal member 9.

The outer portion of the envelope of the device is formed of ceramic insulating cylindrical members bonded to metal terminal members. The ceramic insulating members are desirably forsterite because of its low dielectric constant. The metal connecting terminals and internal elements such as the cathode and anode are desirably of titanium, a low emission material exhibiting continuous gettering properties during high-power operation. The use of titanium and forsterite together is additionally preferred for their matching temperature coefficients of expansion.

Ceramic insulating cylindrical member 10 separates lower grid terminal 11 from heater terminal 9. Ceramic cylinder 14 in turn separates upper grid terminal 13 from anode terminal ring 15. The device illustrated is constructed for convenience in two parts, and in final assembly, joined together by brazing lower grid terminal 11 to upper grid terminal 13.

Grid electrode 4, which is more fully described in the aforementioned U.S. Pat., No. 3,334,263, comprises a gold-plated etched grid member 41 having closely spaced tiny grid wires 21 brazed upon its underside. The tiny grid wires are shown in the drawing out of proportion for exemplary purposes. Actual diameters of these wires may be as little as 0.0003 inch, barely visible to the naked eye. To support the grid structure and provide electrical and heat conductance to the tiny grid wires, massive grid support bars 18 are mounted to the grid member 41 as part of a relatively massive circumferential support frame or ring 19. Bars 18 are preferably parallel and extend downwardly from the grid into channels or recesses 50 in the face of cathode 2. The walls of channels 50 are spaced from bars 18 at a distance appreciably greater than the close spacing between the cathode emitting surface and the surface of the active grid which in an operative embodiment is about 1 to

3 mils. Therefore, only a negligible increase in grid-cathode capacitance is attributable to the presence of the bars 18.

Grid member 41 may be further reinforced at its periphery by brazing a washer (not shown) of approximately the same outer diameter as the upper surface of member 41. This forms a reinforced lip 24 which is used to support the grid as will presently be described.

The aforementioned electrodes are very small in diameter, approximately in the order of 1 inch or less, in order to reduce interelectrode capacitance and thereby facilitate high-frequency operation of the device. High-power output operation is then obtained by means of unusually high-emission current density from the cathode, preferably 1 ampere per square centimeter or more. Such operation requires very close spacing of the active surfaces of the electrodes requiring close tolerances. However, processing and operation of the device also results in exposure to high temperatures. Close tolerances and exposure to high temperatures can result in mechanical distortion of the electrodes, particularly the rather delicate grid due to the effects of heat expansion of materials having dissimilar temperature coefficients of expansion.

It is therefore essential that the delicate grid be firmly secured within the device to prevent lateral movement, yet secured in a manner which will compensate for the differences in temperature expansion of the grid materials and the envelope materials to which it must be secured.

In accordance with a principal feature of the invention, lower grid terminal 11 is provided on its innerside with an annular shoulder 30. Mounted to the shoulder is a circular base member 42 with an upright cylindrical sleeve 44 extending upwardly therefrom. Base member 42 and cylindrical sleeve 44 can be either formed integrally as a single piece or be of two-piece construction suitably joined together. Mounted atop sleeve 44 and joined thereto is a relatively massive rim portion 46 having a flat upper surface 48. The height of surface 48 is approximately the same height as the upper emitting surfaces 3 of the cathode.

The lower surface of lip 24 of grid 4 is placed directly on surface 48 of rim 46 or alternatively a shim 56 may be placed therebetween. The spacing must be accurate and within close tolerances to space the cathode emitting surfaces close to the tiny grid wires. The use of various thicknesses of shims may therefore be desirable for adjustment of tube characteristics.

Base 42, sleeve 44, rim 46 and shim 56, when used, form the grid support assembly. These parts are preferably constructed of the same metals as the grid, i.e., molybdenum, tungsten, or molybdenum-tungsten alloys so that the temperature coefficients of the grid and the grid support are substantially the same.

As mentioned previously, base 42 is suitably fastened to shoulder 30 and base 42, sleeve 44 and rim 46 are joined together either by being formed integrally or by suitable bonding means such as brazing. Lip 24 and, when used, shim 56 can also be bonded to the grid support, thus forming a continuous joint of grid to envelope of the device. Alternatively the lip may be securely clamped to rim 46 and the mating surfaces on lip 24 and rim 46 sufficiently roughed to minimize any sliding action. The clamping construction has been illustrated; the use of bonding means such as brazing of the lip 24 to rim 46 is easily seen without benefit of illustration. In either form of construction, the configuration of the grid support means forms a secure yet yieldable support for the grid which, by its construction, compensates for the unequal temperature expansion of grid and envelope. When the grid is expanding or contracting at a different rate from the envelope, sleeve 44 will flex outwardly or inwardly as the case may be. The flexing will be uniform, however, due to the circular shape of the sleeve, and therefore the spacing of the bars 18 in recesses 50 will not be altered as would happen in a nonuniform lateral shift of the grid in one direction perpendicular to the surface of the cathode. In this connection, it should be noted that sleeve 44 must be cylindrical and not conical. That is, the sidewalls of the sleeve must be parallel to the axis of the sleeve

and normal to the plane of the grid. Flexure of a conical shape would result in vertical as well as horizontal movement, which in turn would disrupt the vertical spacing of grid 4 between cathode 2 and anode 1.

As illustrated in FIGS. 1 and 2, lip 24 is clamped to the grid support by a concave washer 60 which is carried by retainer 62. Retainer 62 is in turn rigidly fastened to an upper shoulder 65 on grid terminal 11. The geometrical configuration of washer 60 provides minimal contact with lip 24 yet provides a tensioning effect urging lip 24 into frictional contact with the grid support means. Thus, upon expansion and contraction, the grid moves with the grid support means, due to the large frictional engagement, yet may slide relative to the line contact with washer 60.

FIG. 3 illustrates an alternate construction of the grid support. In this construction base 42' and sleeve 44' have slots 90 and 92 respectively cut therein. The slots are equally spaced radially around the base and sleeve so that the segments are of equal size. This embodiment is preferred, for example, in devices where the grid is larger than about one inch in diameter. It can, of course, be used with smaller grids as well. Rim portion 46 is not slotted however. As noted previously, in either construction rim portion 46 is relatively massive with respect to base 42 and sleeve 44 or sleeve 44'. Thus, the flexing action of the sleeve allows the grid support to compensate for the unequal coefficients of temperature expansion and the massive rim damps or inhibits transmittal of the flexing motion to the grid itself.

A preferred clamping embodiment is shown in FIG. 4 wherein washer 60 is replaced by clamping structure 70 which comprises a cylindrical sleeve 72 having an inwardly depending upper horizontal flange 74 which frictionally engages the upper surface of lip 24 on the underside of the flange. An outwardly depending lower flange 76 on sleeve 72 is engaged by retainer 62'. In this construction, the clamping means 70 are constructed of materials having similar temperature coefficients of expansion to the materials used in both the grid and the grid support. The grid then does not slide relative to the clamping structure, but, due to the frictional engagement of lip 24 with flange 74, the grid, grid support, and clamping structure expand and contract together. The sleeve 72 flexes similarly to sleeve 44 to compensate for the expansion difference of the grid and the envelope.

Thus, the invention provides novel means for securely mounting a delicate grid in precise spatial alignment with other electrodes in an electron discharge device subject to high temperatures and nonuniform expansion and contraction of materials therein having different temperature coefficients of expansion. Minor modifications of the invention will be apparent and are considered within the scope of the invention provided by the appended claims.

I claim:

1. A high-frequency electron discharge device capable of withstanding high temperature, comprising an outer envelope having therein an anode electrode, a cathode electrode and a grid structure including grid conductors closely spaced to said cathode between said anode and cathode and having a peripheral supporting lip thereon; and having grid mounting means therein including grid support means comprising an upright yieldable cylindrical member located between said grid structure and said envelope and secured at one end to said envelope, said support means being constructed of a material having a temperature coefficient of expansion substantially similar to the temperature coefficient of expansion of the material of said grid structure; and grid retention means to retain said grid structure to the opposite end of said yieldable cylindrical member to provide a grid support capable of lateral flexure with temperature changes.

2. The grid mounting means of claim 1 wherein said envelope is constructed of titanium metal and ceramic materials and the grid structure and grid mounting means are constructed of materials selected from the class consisting of tungsten, molybdenum, or tungsten-molybdenum alloys.

3. The grid mounting means of claim 1 wherein a spacing shim is placed between said lip of said grid structure and said grid support means to space said grid from said cathode.

4. The grid mounting means of claim 1 wherein said grid retention means comprises brazing said grid structure to said grid support.

5. The grid mounting means of claim 1 wherein said grid retention means comprise a concave washer resiliently biased against an upper surface to retain the grid structure non-slidably against said grid support means.

6. The grid mounting means of claim 1 wherein said grid retention means is constructed of a material having a temperature coefficient of expansion substantially similar to the temperature coefficients of expansion of said grid structure and said grid support means and comprises a cylindrical sleeve having an upper flange inwardly depending therefrom in frictional relationship with said lip on said grid, and a lower flange outwardly depending therefrom and secured to said envelope,

said grid retention means providing a resilient downward bias of said lip against said grid support means.

7. The grid mounting means of claim 1 wherein said cylindrical member comprises a slotted member having equally spaced radial slots therein to form segments of equal size.

8. In a high-frequency electron discharge device comprising an outer envelope having therein an anode, a cathode, and a grid, the improvement which comprises mounting said grid on a first end of a yieldable cylindrical member having an axis normal to the plane of the grid, said cylindrical mounting member being constructed of a material having a temperature coefficient of expansion substantially similar to the temperature coefficient of expansion of said grid, said cylindrical member being secured at an opposite end to said envelope to provide a grid support capable of uniform lateral yield with temperature change.

20

25

30

35

40

45

50

55

60

65

70

75