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ELECTRON DISCHARGE DEVICE WITH GRID WIRE TENSIONING MEANS AND METHOD

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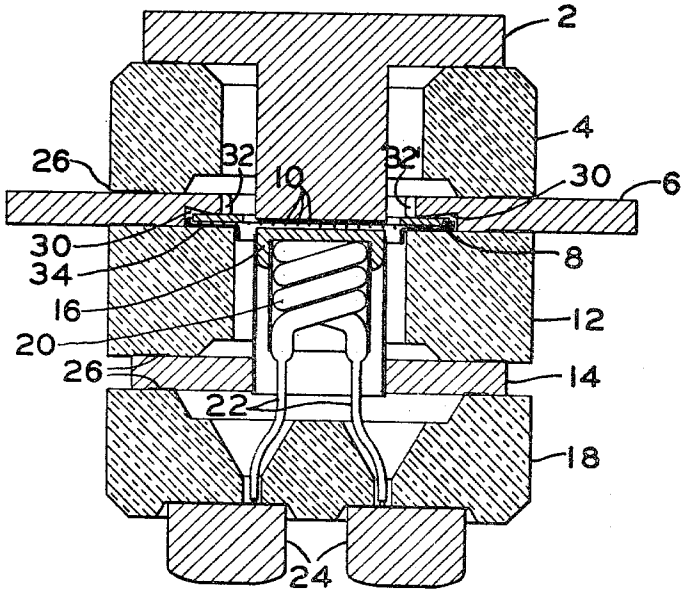


FIG. 1

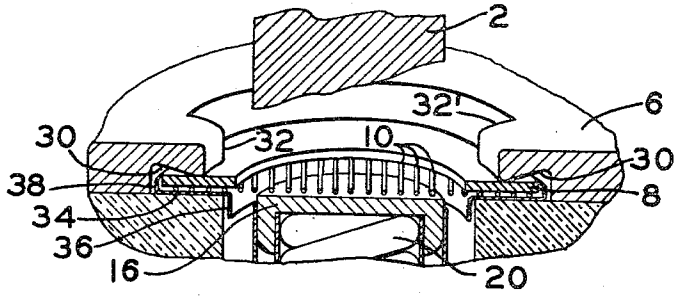


FIG. 2

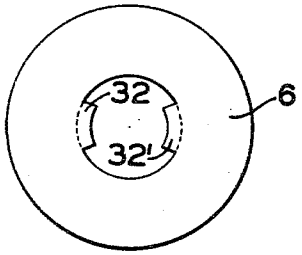


FIG. 3

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ELECTRON DISCHARGE DEVICE WITH GRID WIRE TENSIONING MEANS AND METHOD

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This invention relates to electron discharge devices, and more particularly, to devices of the stacked, ceramic and metal type having, in adjacent relation, metallic parts whose contiguous surfaces may adhere or fuse together under elevated temperature conditions experienced during manufacture or use of the discharge device.

One advantageous form of electron discharge device includes a stack of alternate ceramic and metal components of generally annular shape sealed together to form a generally cylindrical envelope. The ceramic components serve as insulating spacers, and the metal components serve as supports for, and connections or terminals to, the electrodes of the device which are disposed within the envelope. In the manufacture of such devices, heat and pressure are conveniently used to facilitate joining the ceramic and metal parts in an operation which both outgasses and seals the device.

One difficulty in the construction of this type of device arises from the fact that certain of the metal components of the envelope have thermal coefficients of expansion which generally differ substantially from the coefficient of expansion of other metals, such as tungsten, whose refractory and other mechanical and electrical properties make them desirable to use within the device as electrodes or supports for electrodes. Moreover, in the arrangement of parts in such devices, such an envelope member may not infrequently be disposed in contact with a refractory electrode. Under such circumstances the envelope member has a distinct tendency to adhere to or fuse with the electrode under the elevated temperature conditions encountered in device manufacture or use, particularly where the envelope member may consist of one of the more chemically active metals such as titanium or other metal possessing gas gettering properties. The result of such adherence, in view of the difference in thermal coefficients of expansion of the two elements is that, upon cooling of the parts, the differential contraction produces undue stresses, and may cause distortion of the parts which, even though minute in an absolute sense, is highly objectionable from the standpoint of its effect on the preservation of critical dimensions within the device.

In U.S. Patent 2,923,847 to C. G. Childs and J. M. Connelly, patented February 2, 1960 and assigned to the assignee of this application, a grid assembly for ceramic and metal electron discharge devices is described and claimed that successfully overcomes the just-described objectionable feature by the interposition, between the adjacent metallic members of a separator or shim element of such material that resists fusion or adherence with one of the adhering members, thereby to permit differential thermal expansion and contraction without undue stressing or distortion of either.

In accordance with the present invention a novel grid assembly for such electron discharge devices is provided wherein the fusion or adherence of the dissimilar adjacent members is actually beneficially utilized to enhance the characteristics thereof. Thus, not only are additional elements not required to compensate for unwanted fusion or adherence of adjacent metallic elements of the grid assembly, but controlled and selective fusion or adherence of these elements is positively utilized to provide improved tensioning of grid wires that are attached to one of the members.

Accordingly, a principal object of the present invention is to provide a new and improved grid assembly for use in electric discharge devices.

Another object is to provide an improved electron discharge device of the alternate stacked ceramic and metal type in which controlled and selective dissimilar thermal expansion of its metal parts is employed to provide improved characteristics of the wire grid elements thereof.

These and other objects of the invention fill be apparent from the following description, and the scope of the invention will be defined in the appended claims.

Briefly, in accordance with the invention herein described, the electrode or other refractory metal element and the other element which has a tendency to adhere to the refractory metal, are constructed and arranged to provide controlled adherence of the electrode to the other element over a limited extent of the periphery of the electrode so that, on contraction of these parts during cooling of the device, tensioning of the wires of the electrode is accomplished.

In the drawings:

FIG. 1 is a longitudinal cross-sectional view of an electron discharge device of a type to which the present invention is particularly applicable;

FIG. 2 is an isometric view of a portion of the device shown in FIG. 1 drawn to an enlarged scale; and

FIG. 3 is a plan view of a grid terminal member in accordance with the invention.

The device shown in the drawings comprises a stacked array including an anode member and terminal **2**, an annular grid insulator **4**, a metal grid support and terminal ring **6**, a grid electrode including a support washer **8** across which are tightly strung a plurality of fine grid wires **10**, a cathode insulator **12**, a metal cathode support ring and terminal **14**, a cathode **16**, and a heater insulator **18**. The cathode is heated by a heater **20** from which the heater leads **22** extend through openings in the heater insulator **18** to heater terminals **24** in the bottom of the heater insulator.

The grid wires **10** and the grid support washer **8** may be of tungsten or other metal of refractory properties suitable to the environment, the wires **10** being fastened, at the ends thereof, to the washer **8** as by copper brazing to provide a planar array of tightly strung parallel wires which in an operative embodiment comprise a total of 143 wires spaced so minutely from each other as to yield a wire density of about 736 per inch. It will thus be apparent that proper tensioning of the grid wires to minimize unwanted vibration thereof is of critical importance in the fabrication and operation of the device.

The grid insulator **4**, cathode insulator **12**, and heater insulator **18** are generally of a suitable ceramic, for example, forsterite, and the anode **2**, grid ring **6**, cathode ring **14**, and heater terminal **24** of a metal such as, for example, titanium, having suitable gas-gettering properties and a thermal coefficient of expansion compatible with that of the ceramic. All the titanium parts are sealed to the ceramic parts by suitable seals **26** to form a vacuum-tight envelope.

The lower surface of the grid terminal ring **6** is formed to provide a pair of diametrally opposed recesses **30** extending arcuately about its inner periphery for approximately 60° each. The recesses are defined by arcuate flanges **32**, **32'**, which, as more clearly shown in FIG. 3, can be diametrally opposed to each other and are adapted to bear on the abutting portions of the grid washer **8**. In assembly of the device, the grid washer **8** is oriented relative to the ring **6** so that the midpoints of flanges **32**, **32'** lie on a diameter that is substantially perpendicular to the direction of wires **10**. It will be noted that the

grid washer 8 and attached wires 10 are mounted with the latter in next adjacent and closely spaced relation to the planar active surface of the cathode 16, precision spacing between the grid wires 10 and cathode 16 being ensured by the interposition of a spacer cap 34, the axial thickness of which is accurately determined to provide such spacing with the wires 10 maintained at requisite planarity and linear tension. Spacer 34 is preferably of molybdenum or tantalum or other suitable material that resists fusion to tungsten at the elevated temperatures of fabrication and operation of the device. The spacer is formed with a down-turned inner peripheral flange 36 and an up-turned outer peripheral flange 38 to facilitate assembly of the grid subassembly, which includes the washer 8 and attached wires 10. The outer diameter of the grid washer 8 is dimensioned to be slightly less than the inner diameter of the grid ring 6 so that the upturned flange 38 of the spacer 34 is positioned between the outer edge of the washer 8 and the inner wall portion of the ring 6. This relationship of dimensions is desired so that the portions of the washer 10 not contacted by the flanges 32, 32' are free to expand slightly, under tension, as will appear.

The grid support washer 8 and attached wires 10 are adapted to be clamped tightly between flanges 32 and 32' and the opposing surface portions of spacer 34, which, in turn, is tightly clamped to the cathode insulator so as to hold the grid rigidly in place both axially and transversely of the device after the envelope is assembled and sealed.

In the manufacture of the device, the parts are assembled as shown in the drawing, axial pressure being applied to the parts by placement thereof in a suitable jig (not shown) and the assembly is both evacuated and raised to an elevated temperature, in the range for example, of 800°–1100° C., for a sufficient period to thoroughly outgas the parts, exhaust the envelope, and fuse the seals 26. Because the thermal coefficient of expansion of titanium is approximately three times as great as that of tungsten, for example, the grid ring 6 expands radially a correspondingly larger amount than the grid support washer 8. Moreover, due to the chemically active nature of titanium and its tendency to adhere to or fuse with other metals with which it is in contact at elevated temperatures in the range above-mentioned, the flanges 32 and 32' of the grid ring have a pronounced tendency to become joined to the surfaces of the grid support washer 8 with which they are in direct contact. In such event, as the assembly is allowed to cool, the radial contraction of the grid ring 6 is some three times as great as the grid support washer 8, and since relative movement between the grid ring 6 and grid support washer 8 is prevented by the adherence of surfaces 32 and 32' to the abutting parts of the washer, the grid support washer 8 is radially compressed in a direction perpendicular to the direction of the wires 10. Inasmuch as the flanges 32, 32' do not extend completely about the inner periphery of the ring 6, the radial compression experienced on cooling is accompanied by a transverse radial extension in the direction parallel to the wires 10 tending to maintain the wires under tension, thus preventing distortion of the grid support washer or any slackening and sagging of the grid wires 10.

Thus, it is seen that in accordance with the present invention, unwanted distortion of the grid support washer 8 or slackening of the wires 10 is prevented and improved tensioning of the wires is accomplished without necessitating the insertion between the opposing surfaces of the grid ring 6 and grid support washer 8, as heretofore proposed, of a separator or shim of a material which would have resistance to adhering to or fusing with either the grid support washer or the grid ring in the temperature range to which the parts are subject during manufacture or later operation of the tube.

This desirable result, it will be noted, is made possible by the simple expedient of controlling and limiting the adherence or fusion of the grid ring flanges 32, 32' to only preselected portions of the grid washer to effect slight radial compression of the washer 8 normal to the wires 10 and to permit correspondingly slight radial extension parallel to the wires 10.

Another substantial advantage is available in the construction of the present invention in that the limitation of the extent of the flanges 32, 32' to restricted parts of the ring 6 remote from the brazed connection of the wires 10 to the washer 8 serves to reduce the flow of heat from the heat source during the outgassing operation. In this manner the tendency of the brazed connections to be softened and consequent loosening of the wires is minimized.

It will be appreciated by those skilled in the art that the invention may be carried out in various ways and may take various forms and embodiments other than those illustrative embodiments heretofore described. It is to be understood that the scope of the invention is not limited by the details of the foregoing description, but will be defined in the following claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A grid electrode assembly for electron discharge devices, comprising a support, a plurality of grid wires disposed in parallel array on said support, an annular terminal member having a pair of projections adapted to engage said support over a predetermined small portion thereof, the remaining portion of said support being disposed in spaced relation to said terminal member, said projections and said support being of dissimilar materials having unequal coefficients of thermal expansion, the coefficient of expansion of said terminal member being high relative to the coefficient of expansion of said support and adapted to fuse together at elevated temperatures of fabrication of the devices, whereby, upon cooling of said assembly from said elevated temperature, linear contraction of said support occurs along a line joining said predetermined small portions of said support and linear elongation occurs in a direction perpendicular thereto.

2. An electron discharge device comprising an evacuated envelope, a grid electrode assembly mounted in said envelope, said assembly comprising a support, a plurality of grid wires affixed to said support and disposed in parallel array thereon, a terminal member forming part of said envelope and including means for engaging said support over predetermined small opposed portions thereof, the remaining portions of said support having the ends of said wires affixed thereto and disposed in spaced relation to said terminal member, said terminal member and said support being of dissimilar materials having unequal coefficients of thermal expansion, the coefficient of expansion of said terminal member being high relative to the coefficient of expansion of said support and adapted to become fused together at elevated temperatures of fabrication of the device whereby, upon heating of said terminal member conduction of heat energy to said remaining portion is minimized and upon cooling of said assembly from said elevated temperature, contraction of said assembly occurs along a line joining said predetermined small portions of said support and expansion occurs in a direction perpendicular thereto.

3. A grid electrode assembly for electron discharge devices comprising a support, a plurality of grid wires disposed in parallel array on said support, a terminal member, the coefficient of expansion of said terminal member being high relative to the coefficient of expansion of said support, and projection means cooperatively associated with said terminal member and said support for providing an increased tension in said grid wire at a first predetermined temperature relative to a second higher predetermined temperature, said second temperature corresponding substantially to the temperature of fabrication of said

electrode, and said first temperature corresponding substantially to the temperature of operation of said grid electrode.

4. In the method of making electron discharge devices in which a planar grid electrode having a relatively low coefficient of expansion is secured between a grid terminal having a relatively high thermal coefficient of expansion and an insulative spacer, said electrode and said terminal being of materials adapted to fuse together at the high temperature of fabrication of said device, comprising the steps of assembling said electrode terminal and spacer in a predetermined relationship, heating the device to cause said terminal to expand relative to said electrode, controlling and limiting the fusion of the said grid electrode to the said terminal to preselected portions of said electrode, and cooling said device to effect contraction of the said terminal along a line joining said preselected portions, expansion of said electrode in a direction perpendicular thereto, and hence tensioning of grid wires secured thereto.

5. In the method of making electron discharge devices in which a planar grid electrode having a relatively low

coefficient of expansion is secured between a grid terminal having a relatively high thermal coefficient of expansion and an insulative spacer, said electrode and said terminal being of materials adapted to fuse together at the high temperature of fabrication of said device, comprising the steps of assembling said electrode, terminal and spacer in a predetermined relationship; heating the device to cause said terminal to expand relative to said electrode; and controlling and limiting the fusion of the said grid electrode to the said terminal to preselected portions of said electrode.

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