

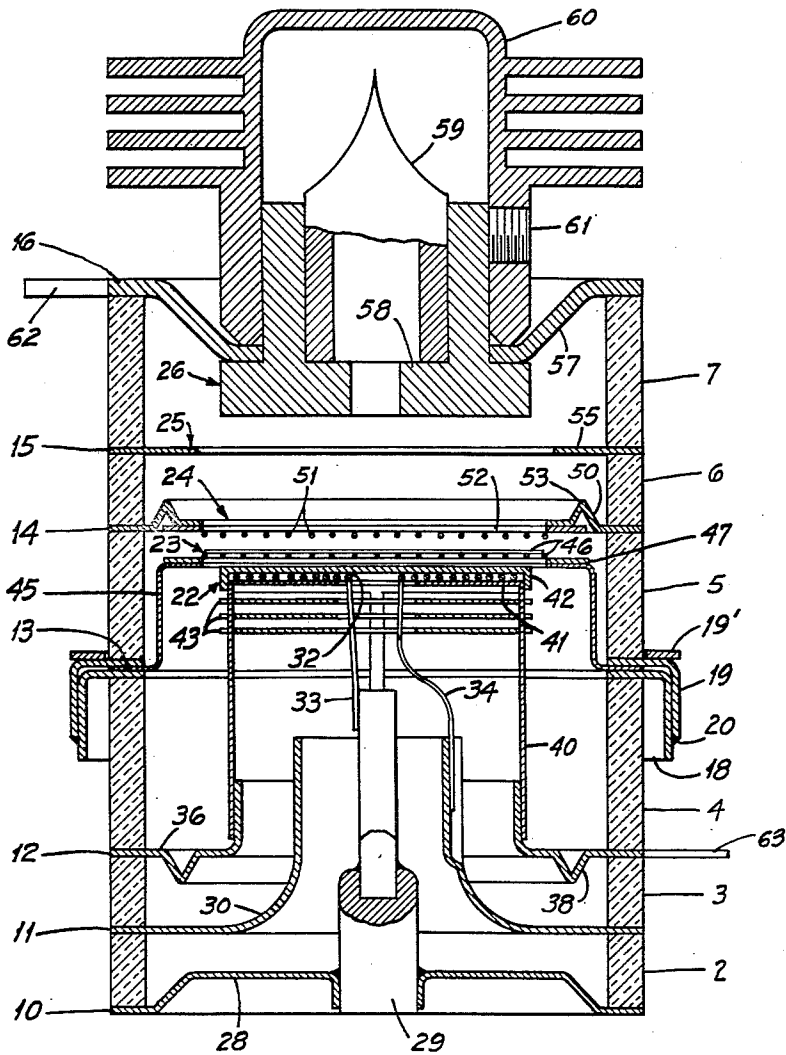
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TUBE HAVING PLANAR ELECTRODES

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TUBE HAVING PLANAR ELECTRODES

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This invention relates to electron tubes and more particularly to electron tubes of the type having planar electrodes.

The purpose of the invention is to provide a planar electrode tube which will be operable with good efficiency at anode voltages comparable to screen voltage and at the same time one which will have low output capacitance. Further, the purpose of the invention is to provide a planar electrode tube having a very efficient heater-cathode structure, and in addition, a planar tube which can be operated at unusually high ambient temperatures.

In addition, the purpose of the invention is to provide a miniaturized, ruggedized tube capable of assembly by automation equipment.

The required electrical capabilities have been achieved by using in their normal arrangement a cathode, control grid and screen grid, and adding a ring-shaped electrode between the screen grid and the anode. The ring electrode can be operated at cathode potential so that secondary electrons released at the anode will be prevented from traveling to the screen grid even if the voltage on the screen is as high as the anode voltage. Thus, the ring electrode serves a purpose similar to that of the conventional suppressor grid. However, the ring electrode of the invention is devoid of grid bars and thus minimizes the output capacitance.

The required ability to operate in a high temperature environment presents a considerable problem in maintaining the proper spacings between the electrodes, and, of course, the insulating material used in the tube envelope must be capable of withstanding high temperatures. The means which the invention teaches for permitting high temperature operation comprises in combination with a ceramic envelope an arrangement preventing detrimental movement of the electrodes toward and away from each other due to the different coefficients of expansion of the ceramic in the envelope and of the metal elements which support the electrodes on the envelope.

The manner in which all of the required features have been obtained in a planar tube will now be described in detail with reference to the single figure of the drawing, which figure shows the tube in cross section.

Referring to the drawing it will be seen that the tube embodying the invention comprises a generally cylindrical envelope made up of alternate ceramic and metal rings joined together. There are six ceramic rings, preferably of the high alumina type, designated by the reference numerals 2-7 consecutively. There are seven metal rings designated by the numerals 10-16 consecutively. All of the metal rings are of Kovar except for ring 16 which is preferably copper. The ends of the ceramic rings are metallized by any suitable procedure as, for example, the moly-manganese powder sintering process. The metallized ends of the ceramic rings are then brazed directly to the metal rings except in the case of metal ring 13. A final sealing is provided in the area of metal ring 13 by means of two sealing rings 18 and 19, the

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inner portions of which are brazed respectively to the ceramic rings 4 and 5 and the outer portions of which are joined by a final weld or braze 20. A terminal ring 19' is attached to the sealing ring 19 and carries one or more radially extending terminal tabs (not shown). Metal ring 13 is spot welded to sealing ring 19 to fix its position in the tube, as will be more fully described hereinafter.

The tube comprises a plurality of planar electrodes consisting of a cathode 22, a control grid 23, a screen grid 24, a suppressor electrode 25, and an anode 26. The electrode 25 instead of being a grid-like structure such as grids 23 and 24 is a ring-shaped member providing an unobstructed central aperture; it will be noted from the drawing that this aperture is of larger area than the area of the cathode and does not perform any beam forming function.

The metal envelope rings 10-16 form lead-ins for the various electrodes and are extended inwardly of the envelope to provide supports and electrical leads for the electrodes. For example, the metal ring 10 is extended inwardly at 28 to form a closure for the bottom of the tube and a support for a two-piece heater pin 29 which is brazed within a central aperture in the end closure. Metal ring 11 is extended inwardly at 30 to form a second lead for the heater, the heater itself being a flat coil 32 of wire coated with an insulating material such as an aluminum oxide. The heater 32 has its ends 33 and 34 attached respectively to the leads 29 and 30 by means of spot welds.

Metal ring 12 is extended inwardly at 36 to provide a support for the cathode 22. It will be noted that the spacing between cathode 22 and grid 23 is extremely small so that even a very slight change in this spacing will have a substantial detrimental effect. Again stating that the tube is designed for operation at extremely high ambient temperatures, for example, 500 degrees centigrade, it will be understood that problems are encountered in avoiding change in grid to cathode spacing due to the different coefficient of expansion of the various materials employed in the tube. The main problem which has heretofore plagued the industry in this regard is that the radially extending metal electrode supports, such as cathode ring 36, have a different coefficient of expansion than the ceramic rings between which they are held against radial movement. Thus, as metal ring 36 tends to expand more than ceramic rings 3 and 4 the cathode support tends to accommodate its radial expansion by the detrimental action known in the art as "oil canning." In other words, when a disk or flat ring is heated and thus tries to expand, it will, if this expansion is prevented, tend to bow up or down at its center. According to the invention this detrimental oil canning action has been avoided by placing a V-shaped corrugation 38 in support ring 36. Thus radial movement of support 36 due to temperature change is accommodated by opening and closing of the V-shaped corrugation, thereby avoiding the oil canning action.

The cathode heater structure is supported on four legs 40 which are spot-welded at their lower ends to support ring 36 and integrally connected at their upper ends to a centrally apertured support disk 41. The cathode per se comprises a rimmed disk 42 which is spot-welded to the legs 40 so as to clamp the heater coil 32 between the support disk 41 and the cathode disk 42. The upper surface of the cathode disk is, of course, preferably coated with an oxide type emissive material. Three metal heat shields 43 in the form of centrally apertured disks are spot-welded to the support legs 40.

The metal envelope ring 13 is extended inwardly of the tube to form a cylindrical support 45 for the control grid 23, the grid itself comprising a number of tungsten

wires 46 brazed to a tungsten washer 47 which is in turn brazed to the cylindrical Kovar support 45. The wires 46 and the washer could also be molybdenum, one of the essential things being that both the wires and the washer be of material having the same coefficient of expansion. If the coefficients of expansion are not the same and the washer expands more it will stretch the wires upon heating, and the wires will then sag when cooled. If the washer expands less than the wires, then the wires will bow or sag when heated. The grid support 45 is of Kovar which has a different coefficient of expansion than the tungsten or molybdenum washer. Accordingly, it is necessary that support 45 be weakened in the radial direction so as not to overpower the washer 47. This weakening has been accomplished by making support 45 cylindrical instead of conical and by making it of substantial length. The 90° bends at the ends of cylinder 45 are easily flexed to accommodate movement due to radial forces. The bends in a conical support are greater than 90° and thus would offer more resistance to movement caused by radial forces. Support 45 will not be subject to detrimental oil canning action because the 90° bends at the upper and lower ends of the support will accommodate the deformation caused by the fact that ring 13 is held by the ceramic envelope. It will be recalled that ring 13 is spot welded to sealing ring 19, and it will be understood that when the tube is evacuated a cold weld will very likely occur between rings 13 and 20.

Metal envelope ring 14 is extended inwardly at 50 to form a support for the screen-grid 24 which consists of a number of tungsten or molybdenum wires 51 spot-welded to a tungsten or molybdenum washer 52 which is in turn spot-welded to the support 50. Support 50 is provided with a V-shaped corrugation 53 for the dual purpose of preventing oil canning (as explained in connection with cathode support 36) and also preventing the Kovar support 50 from overpowering the tungsten or molybdenum washer 52 (as explained in connection with control grid support 45). It will be seen from the drawing that the screen grid wires 51 are aligned directly above the control grid wires 46 and it should be understood that these wires are parallel to each other so that the control grid wires tend to shield the screen grid wires and prevent the latter from being struck by electrons passing from the cathode to the anode.

Metal envelope ring 15 is extended inwardly at 55 to form a support for the suppressor electrode 25. Since the suppressor electrode does not include grid wires, the support 55 is also the electrode, or at least it is not possible to say where one starts and the other ends. The spacing between electrode 25 and the adjacent electrodes is not so critical as to require a V-shaped groove in support 55.

The metal envelope ring 16 is extended inwardly at 57 to form a support for the anode 26. The anode comprises a copper plug 58 which is brazed to support 57. The anode plug has a central exhaust passage in which an exhaust tube 59 is brazed. A cooler 60 is attached to the anode by a screw 61. Metal ring 16 carries a terminal tab 62. As a matter of fact each of the metal rings 10, 11, 12, 14, 15 and 19 carry terminal tabs. The tabs are spaced around the periphery of the tube so that only the tab 62 for the anode and a tab 63 for the cathode are visible in the drawing.

The design of the tube is such that it is particularly adapted to be made with automation equipment. For example, the ceramic rings 2, 3 and 4 and the metal rings 10, 11, 12 and 18 can all be loaded into a simple cylindrical jig by automatic equipment. Similarly, the ceramic rings 5, 6 and 7 and the metal rings 14, 15, 16 and 19 can be loaded by automatic equipment into a simple cylindrical jig. The loaded jigs can be passed on conveyer lines through a brazing furnace to join the

ceramic and metal envelope rings. The subassemblies of the electrodes and their supports are of course fabricated prior to loading the jigs. For example, heater pin 29 is attached to support 28 by a very high temperature braze, and cathode legs 40 are spot welded to support 36. The cathode-heater structure is of course first made as a unit consisting of cathode disk 42, heater coil 32, support disk 41 and heat shields 43. It should be noted that since the cathode is supported on legs rather than on the usual cylinder of metal foil it is possible to spot weld heater ends 33 and 34 to the heater leads 29 and 34 after the metal rings 10, 11, 12 and 18 have been brazed to the ceramic rings 2, 3 and 4. After the lower and upper sections of the tube have been brazed as previously described, the cathode disk 42 is coated with electron emissive material, and metal ring 13 is spot welded to sealing ring 19, after first aligning the control grid wires 46 with the screen grid wires 51. Lastly the upper and lower sections are joined together and a final seal is made at 20.

Having thus described the invention, what is claimed as new and described to be secured by Letters Patent is:

1. An electron tube comprising an envelope having alternate ceramic and metal rings joined together, planar electrodes in said envelope, said electrodes comprising a cathode, a control grid, a screen grid, an anode and a suppressor electrode interposed between said screen grid and said anode, said cathode comprising a disk having an electron emissive surface and supported on legs extending longitudinally of the tube, one of said metal rings being extended inwardly of the envelope to form a support ring for said cathode, said cathode legs being attached to said support ring, an annular V-shaped corrugation in said support ring, a heater comprising a flat coil of insulated wire abutting the cathode disk, a centrally apertured support plate attached to said legs and holding said heater coil against said cathode disk, a centrally apertured heat shield disk attached to said legs, separate heater leads connected to two of said metal envelope rings, said heater coil having two end wires passing through the apertures in the support plate and heat shield, and spot welds attaching said end wires to said heater leads.

2. An electron tube comprising an envelope having alternate ceramic and metal rings joined together, a plurality of planar electrodes including a cathode, a control grid and a screen grid, an anode, and a suppressor electrode interposed between said screen grid and said anode, a flat heater coil for said cathode, starting at one end of said tube the first said metal ring forms an end closure for the tube and also forms a lead-in for said heater, the second metal ring forms a second lead-in for said heater, the third metal ring forms a lead-in for said cathode, the fourth metal ring forms a lead-in for said control grid, the fifth metal ring forms a lead-in for said screen grid, the sixth metal ring forms both the suppressor electrode and the lead-in therefor, and the last metal ring forms a closure for the other end of the tube and a lead-in for said anode, said cathode lead-in ring being extended internally of the envelope to form a support ring for said cathode, a plurality of support legs mounting said cathode on said support ring, a V-shaped annular corrugation in said support ring between said legs and the inside of the envelope wall, means including spot welds attaching the ends of said heater coil to said heater lead-ins, a cylindrical support for said control grid joined at one end to the control grid and at the other end of said control grid lead-in ring, said cylindrical support being positioned around the cathode end of said support legs, said screen grid lead-in ring being extended internally of the envelope to form a support ring for said screen-grid, and a V-shaped annular corrugation in said screen grid support ring.

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