United States Patent

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[54] **THERMALLY CONDUCTIVE ELECTRICAL INSULATOR FOR ELECTRON BEAM COLLECTORS**
7 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **313/30,** 315/5.38, 313/18, 313/30, 313/46, 315/3.5, 313/89
[51] **Int. Cl.** **H01j 25/34**
[50] **Field of Search** ..... 315/3.5 X, 5.38; 313/18, 30, 46

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ABSTRACT: A beam collector for an electron beam tube includes a hollow metallic beam collector surrounded by a metallic sheath forming a portion of the vacuum envelope of the tube. An electrical insulator structure is disposed in the annular space intermediate the beam collector and the surrounding sheath. The insulator structure includes an array of electrical insulator members with a first array of flexible metallic frame structures joined to said sheath and projecting inwardly to the insulator members. A second array of flexible metallic frame structures are joined to the collector and project outwardly therefrom to the insulators. The flexible frame structures are joined to the insulator members in electrical insulative relation with respect to each other and provide parallel thermally conductive paths for conduction of thermal energy from the collector to the sheath, while allowing for thermal expansion and contraction of the collector.

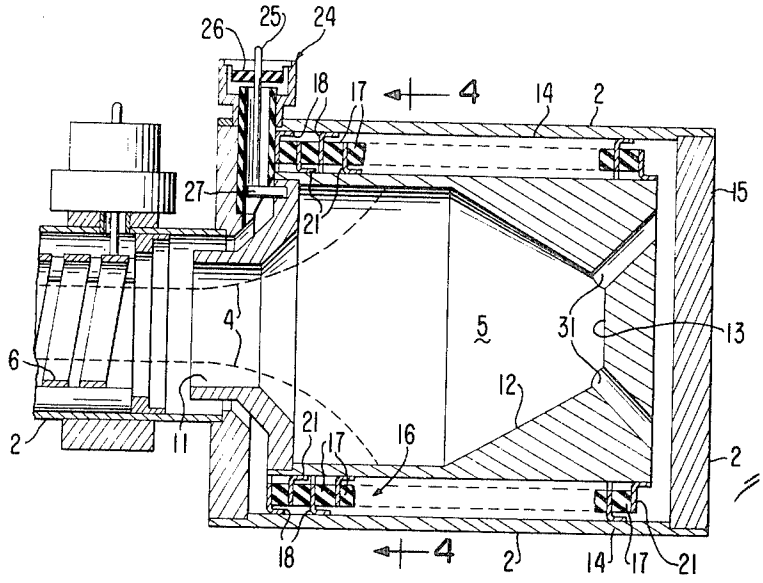


FIG. 1

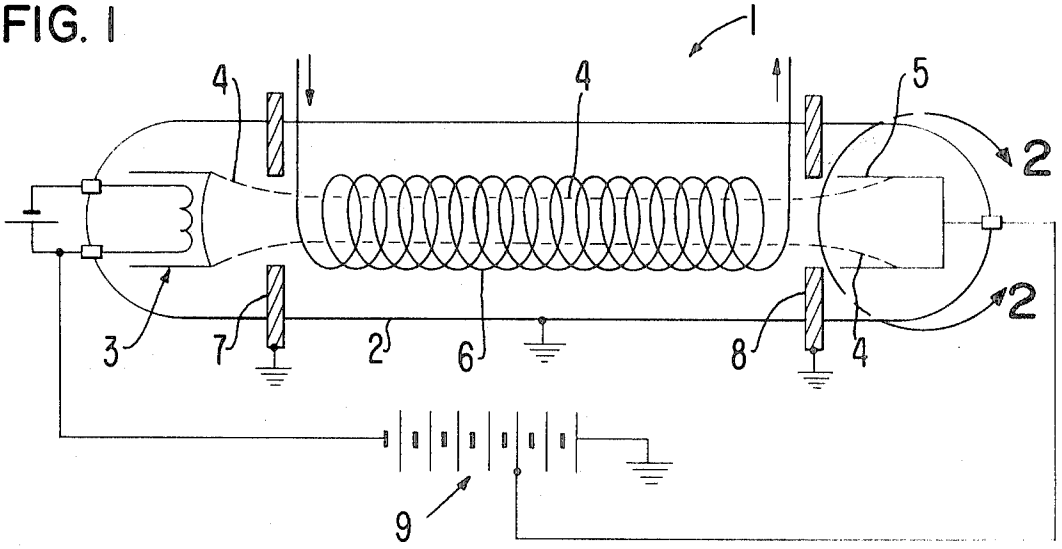
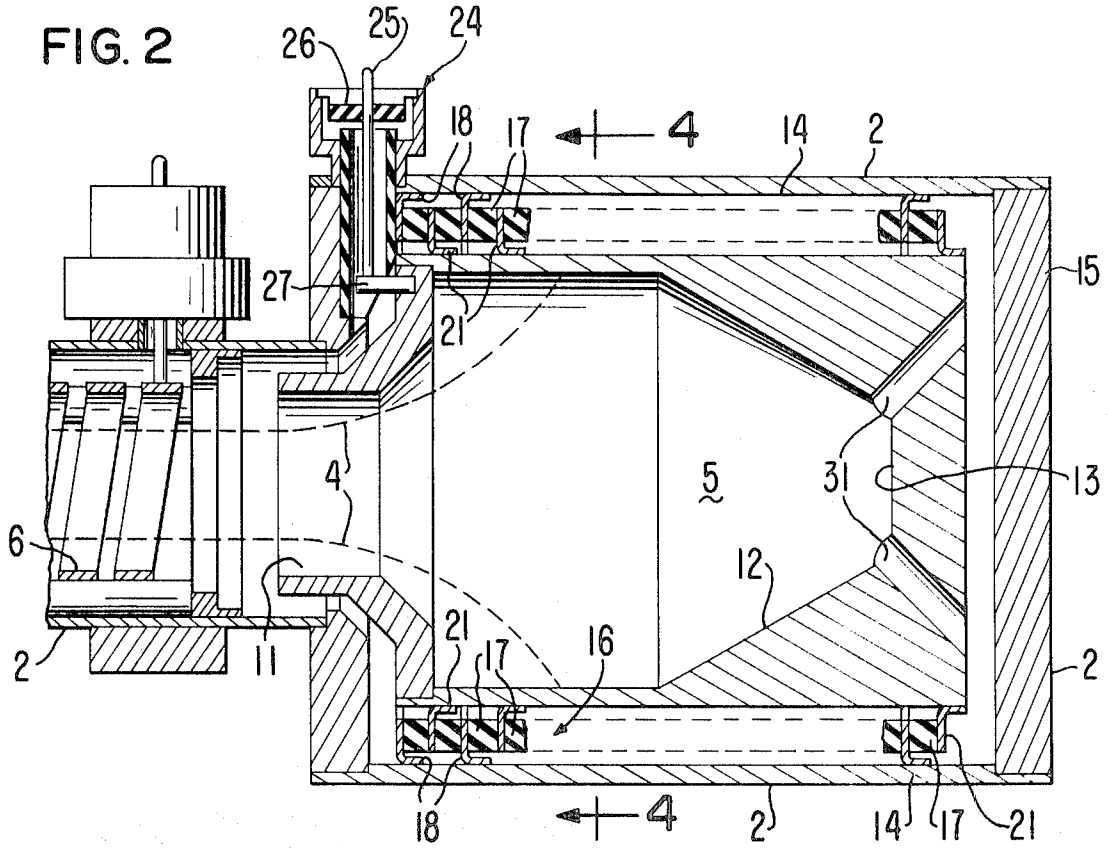


FIG. 2



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FIG. 3

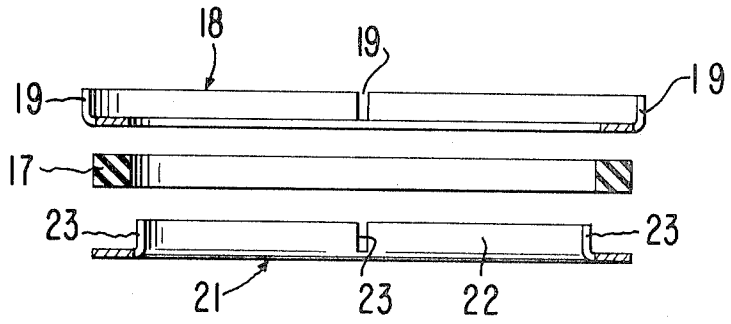


FIG. 4

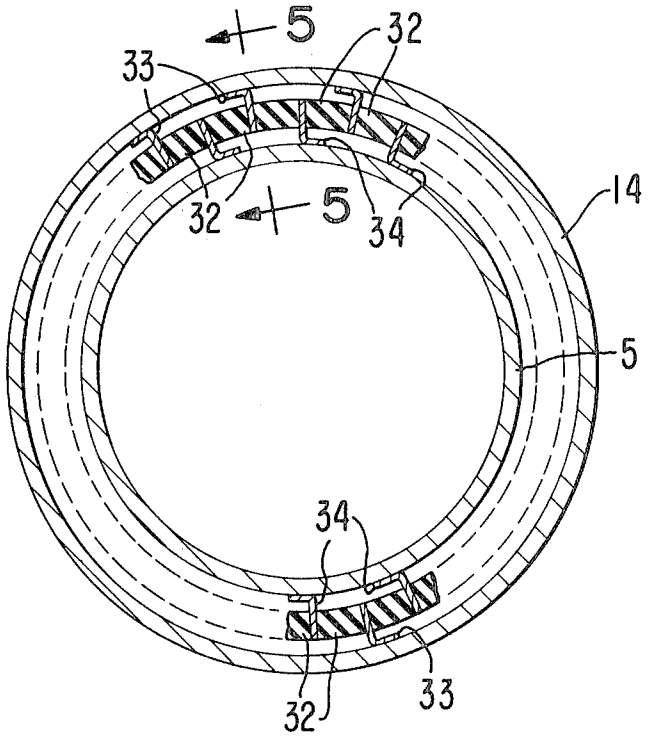
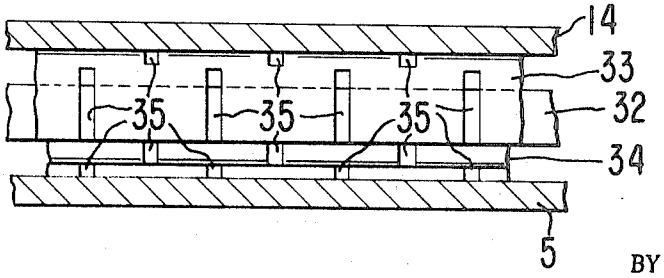


FIG. 5



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THERMALLY CONDUCTIVE ELECTRICAL INSULATOR FOR ELECTRON BEAM COLLECTORS

DESCRIPTION OF THE PRIOR ART

Heretofore, beam tubes have employed beam collector structures wherein a hollow metallic beam collector was supported in insulative relation with respect to a surrounding metallic sheath, forming a portion of the vacuum envelope, via the intermediary of a hollow cylindrical insulator interposed in the annular space between the collector and the sheath. The insulator was brazed on one side to the collector and brazed on the other side to the sheath. The problem with this prior collector insulator was that it has a substantially different coefficient of thermal expansion than the metallic collector and sheath, resulting in thermally produced stress in use. The stress often caused fracture of the insulator releasing gas into the evacuated tube. The released gas was ionized by the beam and produced ion-focusing of the beam in the collector, resulting in a burnout of the collector. It would be desirable to provide a beam collector insulator structure which would have substantial thermal conductivity, to provide a good thermally conductive path from the collector to the surrounding sheath, while allowing for differences in the thermal expansion between the collector, insulator, and the surrounding sheath.

SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of an improved thermally conductive collector electrical insulator structure for electron beam tubes.

One feature of the present invention is the provision, in an electron beam tube, of a beam collector structure having a metallic collector member supported from a conductive surrounding sheath via the intermediary of an array of insulative members, such members being joined to the collector and sheath via the intermediary of a first and second array respectively, of yieldable metallic frame members for supporting and electrically insulting the collector relative to the sheath while providing parallel thermally conductive paths for conduction of thermal energy from the collector to the sheath.

Another feature of the present invention is the same as the preceding feature wherein the insulative members are annular ceramic members coaxially aligned with the collector and sheath, and the first ans second metallic frame members are annular and coaxially aligned with the collector and sheath.

Another feature of the present invention is the same as the first feature wherein the insulator and metallic frame members are elongated and extend longitudinally of the collector.

Other features and advantages of the present invention will become apparent upon the perusal of the following specification taken in connection with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal schematic line diagram of an electron beam tube of the type to incorporate the collector structure of the present invention,

FIG. 2 is a longitudinal sectional view of a physical realization of the beam collector portion of the structure of FIG. 1 delineated by line 2—2 and depicting the insulator structure of the present invention,

FIG. 3 is an exploded sectional view of a portion of the insulator structure of the present invention,

FIG. 4 is a transverse sectional view of the collector structure of FIG. 2 taken along line 4—4 in the direction of the arrows and depicting an alternative insulator embodiment of the present invention, and

FIG. 5 is a sectional view of the structure of FIG. 4 taken along line 5—5 in the direction of the arrows.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there is shown an electron beam tube 1 of the general type to employ a collector insulator

structure of the present invention. More particularly, the electron beam tube 1 includes an elongated evacuated envelope structure 2 having an electron gun assembly 3, disposed at one end thereof, for forming and projecting a beam of electrons 4 over an elongated beam path to a beam collector electrode 5 disposed at the opposite and of the envelope 2. A slow wave circuit 6, such as a helix, is disposed along the beam path intermediate the gun 3 and beam collector 5 for electromagnetic interaction with the beam to produce amplified output microwave energy in accordance with the conventional traveling wave tube mode of operation. A beam focus solenoid, not shown, is typically coaxially disposed of the envelope 2 for producing an axially directed beam-focusing magnetic field for focusing the beam 4 through the slow wave circuit 6 to the collector 5. Anode and cathode magnetic pole pieces 7 and 8, respectively, are disposed at opposite ends of the slow wave circuit 6 to insure that the beam focus magnetic field is concentrated into the beam path and is uniform over the beam path. The slow wave circuit 6, anode pole piece 7, and collector pole piece 8 are typically operated at a depressed potential relative to the anode potential and the depressed collector potential is derived from a tap on the power supply 9.

Referring now to FIG. 2, there is shown a beam collector structure incorporating features of the present invention. The beam collector structure includes a hollow cylindrical beam collector electrode 5, as of copper, having a constricted beam entrance port 11 and an inwardly tapered end portion 12 closed at its end via an end-closing wall portion 13. A hollow cylindrical metallic sheath 14, as of copper, forms a portion of the vacuum envelope 2 and is closed at its outer end via a disk-shaped end-closing wall 15. The sheath 14 surrounds the collector electrode 5 in spaced relation therefrom.

A thermally conductive collector insulator structure 16 is interposed in the annular space between the collector electrode 5 and the surrounding sheath 14. The collector insulator structure 16 includes an array of ring-shaped ceramic insulator members 17, as of alumina or beryllia. The insulator rings 17 are coaxially aligned with each other and with the collectors 5 and 14. In a typical example, the insulator rings 17 have an outside diameter of 1.875 inches, a radial thickness of 0.125 inches, and an axial length of 0.080 inches. The rings 17 are metallized on both ends and brazed to a first array of metallic frame structures 18 joined to the sheath 14, as by brazing, and projecting inwardly therefrom to the insulative structures 17. The first metallic frame members 18 (see FIG. 3) have a generally cup-shaped configuration with a relatively large central aperture. They are made of a ductile material, such as copper, and are provided with gas access and stress relief notches 19 passing through the side of the cup and positioned at approximately 90° intervals around the periphery of the cup 18. In a typical example, the cups 18 have an inside diameter of 1.625 inches and an outside diameter of 1.980 inches and a wall thickness of 0.020 inches with an overall height of the cup in the axial direction being 0.080 inches.

A second array of metallic frame members 21 are joined to the collector electrode 5, as by brazing, and project outwardly to the insulative ring structures 17. The second metallic frame members 21 have an eyelet-shaped configuration with an inner flanged lip portion 22 which is provided with gas access and stress relief notches 23 at 900° intervals around the periphery of the inner lip 22. In a typical example, the eyelet frame member 22 has an inside diameter of 1.532 inches, an outside diameter of 1.875 inches, is made of copper having a wall thickness of 0.020 inch, and the flange inner lip portion has an axial length of 0.080 inch.

The first and second arrays of metallic frame members 18 and 21, respectively, are brazed into the stack of insulator rings 17 in interdigital fashion with an insulator ring 17 disposed between adjacent frames of the first and second arrays, respectively, such that the arrays of frame members are insulated from each other via the intermediary of the insulative rings 17 to permit an independent operating potential to be applied to the collector electrode 5 relative to the

grounded sheath 14 via a suitable electrical feedthrough assembly 24. The feedthrough contains an insulated lead 25 passing through a vacuumtight insulator 26, such lead 25 being connected to the collector electrode 5 at a terminal 27. The collector insulator structure 16 extends axially of the collector electrode 5 over a preponderance of its length, preferably over its entire length, to facilitate cooling of the collector electrode via thermal conduction through the parallel thermal paths provided by the metallic frame members 18 and 21 and their intermediate insulative rings 17.

A plurality of inclined bores 31 pass through the end wall portion 13 of the collector electrode to provide gas communication passageways linking the interior of the collector 5 with the region between the collector 5 and the surrounding sheath 14 to insure that the insulative structures 16 are properly evacuated. The gas access notches 19 and 23 assure evacuation of the insulator structures 16.

In operation, the electron beam passes through the slow wave circuit 6 and into the collector electrode 5 via beam entrance port 11. Upon passing through the entrance port 11, the beam 4 spreads due to space charge repulsive forces and due to a diverging beam focusing magnetic field to impinge uniformly upon the inner surfaces of the collector electrode 5. In a typical example, the beam power is approximately 1 kilowatt CW power. The beam power is converted into thermal energy at the collector 5 and conducted via the frame members 18 and 21 together with insulative rings 17 to the outer sheath 14. The relatively ductile and flexible frame members 18 and 21 allow for differential thermal expansion between the collector 5 and the surrounding sheath 14 without producing fracture of the insulative rings 17, and while providing rigid support for the collector 5 relative to the sheath 14. The generally L-shaped cross section for the frame members 21 ans 18 insures a relatively large area of the frame members in thermal contact with the collector 5 and sheath 14 to facilitate conduction of thermal energy between the collector 5 and sheath 14 via the frame members 18 and 21.

Referring to FIGS. 4 and 5, there is shown an alternative embodiment of the present invention. In this embodiment, the structure is substantially the same as that of FIG. 2 with the exception that the collector insulator structure between the collector 5 and the sheath 14 comprises an array of elongated insulative bars 32 extending longitudinally of the collector 5 and formed, for example, by slicing a hollow cylindrical insulator, as of alumina or beryllia, to a plurality of longitudinal elements. The insulative bars 32 are metallized on opposite side edges and brazed to first and second arrays of elongated metallic frame members 33 and 34, respectively, of generally L-shaped cross section. Frame members 33 are brazed to the outer sheath 14 and project radially inwardly therefrom to the insulator bars 32. Metallic frame members 34 are brazed to the collector electrode 5 and extend radially outward therefrom to the insulators 32. The frame members 33 and 34 are notched at 35 for stress relief. Frame members 33 are interdigitated with frame members 34 with an insulator 32 being provided between adjacent frames 33 and 34 to provide electrical insulation between the collector electrode 5 and the sheath 14, while permitting a plurality of parallel thermal paths for conduction of thermal energy from the collector 5, via the frame members 34 intermediate insulator structures 32, and frame members 33, to the sheath 14.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In an electron beam tube, means for forming and projecting a beam of electrons over an elongated beam path, means at the terminal end of the beam path for collecting and dissipating the energy of the beam, said collector means including a hollow metallic beam collector structure, a conductive sheath surrounding said collector structure, electrically insulative structure interposed between said collector structure and said surrounding conductive sheath for supporting said collector structure from said sheath in insulative relation to permit independent potentials to be applied to said sheath and collector structures, THE IMPROVEMENT WHEREIN, said insulative structure includes an array of insulative members disposed between said collector and sheath, a first array of metallic frame members joined to said sheath and projecting inwardly therefrom to said insulative members, a second array of metallic frame members joined to said collector structure and projecting outwardly therefrom to said insulative members, and said first and second array of frame members being joined to said insulative members in electrically insulative relation with respect to each other; whereby said insulative members provide electrical insulation between said sheath and collector while said first and second metallic frame members and said insulator members provide parallel thermal conductive paths for conduction of thermal energy from said collector to said sheath.

2. The apparatus of claim 1 wherein said insulative members are annular ceramic members coaxially aligned with said collector and sheath, and said first and second metallic frame members are annular and coaxially aligned with said collector and sheath.

3. The apparatus of claim 1 wherein said metallic frame members are of L-shaped cross section.

4. The apparatus of claim 2 wherein said first array of metallic frame members are centrally apertured cups and said second array of metallic frame members are eyelets.

5. The apparatus of claim 1 wherein said arrays of insulative and frame members extend over a preponderance of the length of said collector.

6. The apparatus of claim 1 wherein insulative and metallic frame members are elongated and extend longitudinally of said collector.

7. The apparatus of claim 1 including means defining an evacuated envelope structure and wherein said arrays of insulative and metallic frame members are disposed within said evacuated envelope structure.

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