United States Patent

Jackson

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[54] DEPRESSABLE BEAM COLLECTOR STRUCTURE FOR ELECTRON TUBES

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[52] **U.S. Cl.**.....**313/39,** 313/30, 313/46, 313/309, 313/351

[51] **Int. Cl.**.....**H01j 19/36**

[58] **Field of Search**.....313/30, 39, 46, 309, 351

[56] **References Cited**

UNITED STATES PATENTS

3,098,165	7/1963	Zitelli	313/39
3,359,451	12/1967	Zitelli et al	313/30

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[57] **ABSTRACT**

A depressible beam collector structure for electron beam tubes is disclosed. The beam collector structure includes a metallic beam collector electrode for collecting and dissipating energy of the beam. An electrically insulative ceramic sleeve surrounds the beam collector electrode for electrically insulating the collector electrode relative to the surrounds of the insulator body. An array of yieldable metallic thermally conductive cantilever fins are interposed between and interconnect the beam collector electrode with the surrounding insulative sleeve for providing a thermally conductive path therebetween. The yieldable cantilever fins conduct heat from the collector to the insulator and thence to the surrounds while preventing transmission of stress due to differential thermal expansion to the brittle insulator.

9 Claims, 4 Drawing Figures

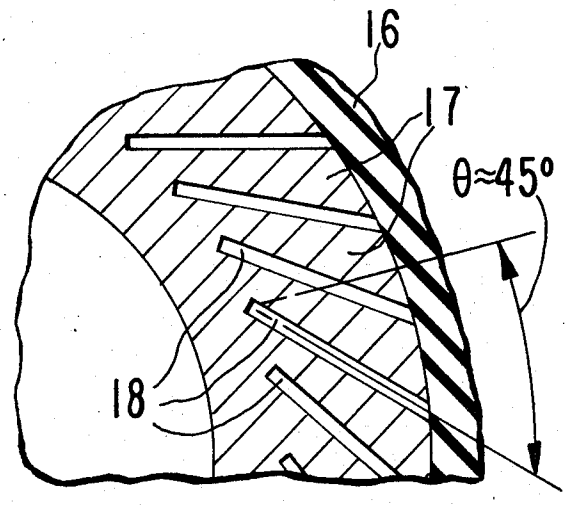


FIG.1

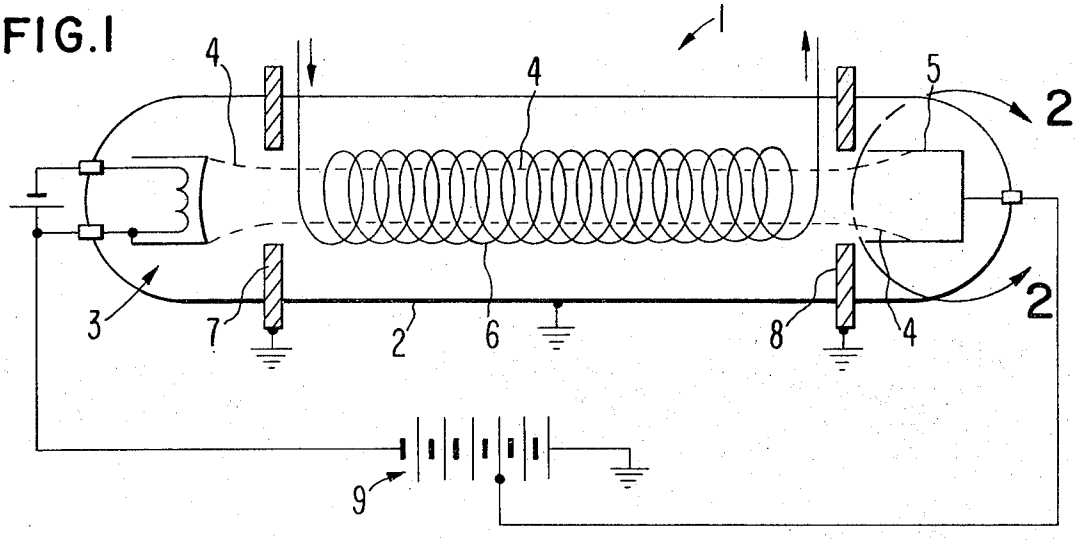


FIG.2

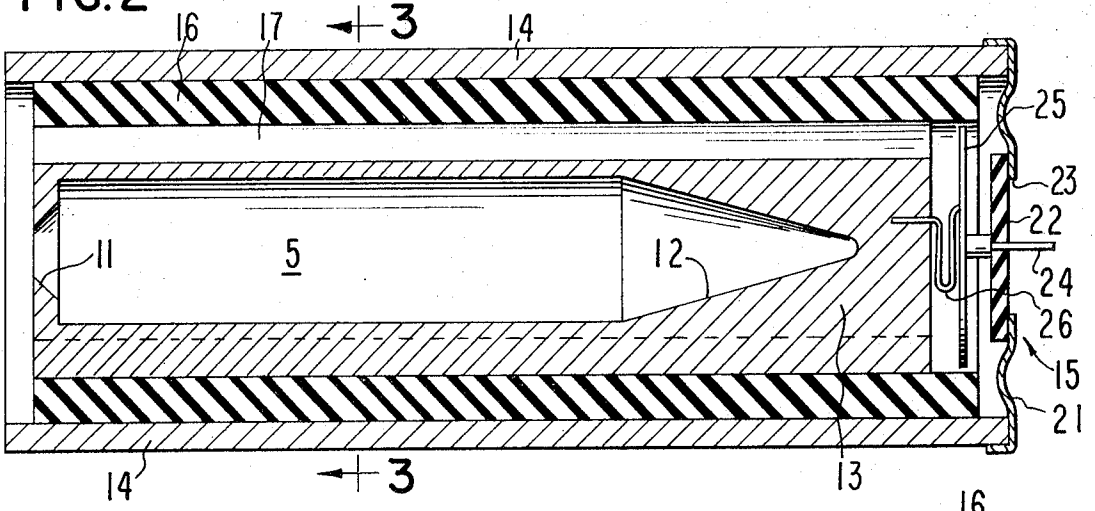


FIG.3

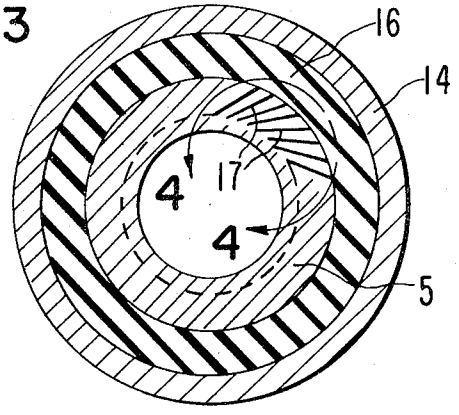
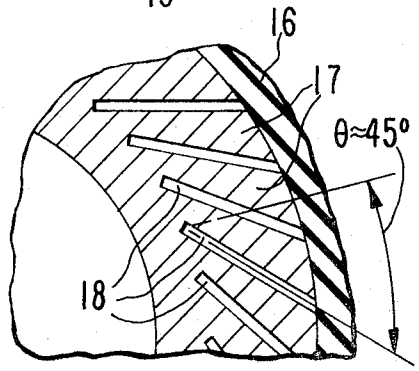


FIG.4



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DEPRESSABLE BEAM COLLECTOR STRUCTURE FOR ELECTRON TUBES

GOVERNMENT CONTRACT

The invention herein described was made in the course of or under a contract or subcontract thereunder with the U.S Department of Defense.

DESCRIPTION OF THE PRIOR ART

Heretofore, beam collectors for traveling wave tubes and the like have been made wherein the beam collector electrode was bonded to a surrounding ceramic insulative sleeve via the intermediary of a multitude of waffle-like copper projections extending from the outer surface of the collector electrode to the ceramic sleeve. The ceramic sleeve, in-turn, was bonded to a surrounding metallic sleeve forming a portion of the vacuum envelope of the tube. A feedthrough insulator permitted an independent potential to be applied to the collector electrode relative to the grounded envelope of the tube for depressed collector operation. In principle, the thermal energy generated in the collector electrode was to be conducted through the waffle-like projections to the insulative sleeve and thence through the surrounding metallic envelope to the surrounds of the tube.

The problem was that the waffle-like projections, which served as the thermal bridge between the collector electrode and the surrounding ceramic sleeve, provided insufficient yield under thermally produced stress resulting in transmission of the stress to the ceramic producing fracture of the ceramic. When the ceramic sleeve fractured, gas was released into the tube which produced ion focusing of the electron beam in the collector with subsequent burn out of the collector electrode, rendering the tube inoperative.

SUMMARY OF THE PRESENT INVENTION

The principle object of the present invention is the provision of an improved depressible beam collector structure for electron beam tubes.

One feature of the present invention is the provision, in a depressible beam collector structure, of yieldable metallic thermally conductive cantilever means interposed between the beam collector electrode structure and a surrounding insulative member to provide a thermally conductive path therebetween, such cantilever means flexing under stress to reduce transmission of thermally produced stress from the metallic beam collector to the surrounding insulative member thus preventing fracture of the insulative member while allowing thermal conduction therebetween.

Another feature of the present invention is the same as the preceding feature wherein the cantilever means comprises an array of metallic fins extending longitudinally of the beam collector structure with the fins being spaced apart around the circumference of the beam collector structure.

Another feature of the present invention is the same as any one or more of the preceding features wherein the cantilever means are formed by the land regions between adjacent slots of an array of slots formed in the outer surface of the beam collector structure.

Another feature of the present invention is the same as any one or more of the preceding features wherein the cantilever means comprise fins projecting outwardly from the outer surface of the beam collector structure, such fins having a thickness greater than the spacing between adjacent fins whereby the fins form a relatively high thermal conductivity and yieldable bridge between the beam collector structure and the surrounding insulator member.

Another feature of the present invention is the same as any one or more of the preceding features wherein the insulative member is bonded to a surrounding metallic sleeve forming a portion of the vacuum envelope of the tube.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

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

FIG. 3 is a sectional view of the structure of FIG. 2 taken along line 3—3 in the direction of the arrows, and

FIG. 4 is an enlarged detail view of that portion of the structure of FIG. 3 delineated by line 4—4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring no to FIG. 1, there is shown an electron beam tube 1 of the general type to employ a depressed beam collector structure of the present invention. More particularly, the electron beam tube 1 includes an elongated evacuated envelope structure 2, as of copper, having an electron gum assembly 3, disposed at one end thereof, for forming and projecting a beam of electrons 4, as of 0.4 Amps, over an elongated beam path to a beam collector electrode 5 disposed at the opposite end 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 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 envelope 2, slow wave circuit 6, anode pole piece 7, and collector pole piece 8 are typically operated at ground potential, whereas the cathode of the electron gun 3 is operated at a minus potential, as of −4,400V, relative to ground, as supplied from a power source 9. The collector electrode 5 is operated at a depressed potential, as of −1,600V, relative to the grounded anode potential. The depressed collector potential is derived from a tap on the power supply 9.

Referring now to FIGS. 2 and 3, 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 sleeve 14, as of copper, forms a portion of the vacuum envelope 2 and is closed at its outer end via a disc-shaped end closing wall structure 15.

A hollow cylindrical insulative sleeve 16, as of alumina or beryllia ceramic, is sandwiched in the annular space between the collector electrode 5 and inside of the envelope sleeve 14. The insulator 16 supports the collector 5 in insulative relation to the grounded envelope sleeve 14 while providing a thermally conductive path from the collector 5 to the envelope 14 and its surrounds for cooling the collector electrode 5 in use.

The ceramic sleeve 16 is metallized on its inside and outside and brazed on its outside to the inside surface of the sleeve 14 and brazed on its inside surface to the outer surface of the collector electrode 5.

The outer surface of the collector electrode 5, which is bonded to the inner surface of the ceramic insulator 16, is provided with an array of longitudinally directed cantilever fins or fingers 17 brazed at their outer extremities to the inside surface of the ceramic insulator 16. In a preferred embodiment, the cantilever fins 17 are formed by slotting the outer surface of the collector electrode 5 with an array of inwardly and longitudinally directed slots 18 which are inwardly inclined to the radial direction at a substantial angle such as 45°. The land re-

gion 17 remaining between adjacent slots 18 forms the fin 17 which projects from the collector 5 to the insulator 16. Each fin 17 is bonded to the insulator 16 via a brazed joint at the extremity of the fin 17. In a preferred embodiment, the fins 17 have a thickness in the circumferential direction which is much larger than the width of the slots 18, in the circumferential direction, such that the thermal conductivity through the fins 17 to the insulator 16 is not substantially impaired.

The fins 17 form yieldable cantilever members which are directed substantially in the same direction as the slots 18, such that the fins 17 will flex. In this manner, the thermally produced stresses, caused by differences in thermal expansion between the collector 5 and the insulator 16, which are directed in the radial direction, are relieved by the cantilever fins 17, since the fins 17 are permitted to flex in the radial direction. Thus the fins relieve the stress and prevent the stress from being transmitted through the fins 17 to the insulator 16, while at the same time not substantially impeding the flow of heat from the collector 5 to the insulator 16 and hence to the sleeve 14 and its surrounds.

In a typical example, the collector electrode 5 is 2.725 inches long and 0.882 inch in outside diameter. The slots 18 are 0.185 inch wide and 0.93 inch deep with 36 slots 18 being provided at equal spacing about the perimeter of the collector 5. The collector is designed to dissipate approximately 1,100 watts cw and to operate at 300° C. with the outer sleeve 14 operating at approximately 200° C.

The depressed operating potential is applied to the collector electrode 5 via a feed through insulator assembly 1 disposed in the end closing wall 15 of the collector. More particularly, the end closing wall 15 includes an annular corrugated metallic frame 21, as of Kovar sealed at its outer periphery to the outer periphery of the sleeve 14, as by brazing. A ceramic disc 22 is sealed over the central aperture 23 in the frame 21. An electrically conductive lead 24 is hermetically sealed to the insulator 22 and passes therethrough into the vacuum envelope of the tube 2. A disc-shaped sputter shield 25, as of Kovar, is carried from the lead 24 and a flexible lead 26 interconnects the shield 25 and the collector electrode 5 for applying the operating potential to the collector 5 relative to the potential of the envelope 2.

In one embodiment of the present invention, the sleeve 14 is clamped into a thermally conductive body, as of aluminum, having an array of heat conductive fins affixed thereto for dissipating the heat conducted through the sleeve 14 to the finned aluminum body.

Although in the embodiment of the invention, as shown in FIGS. 2 – 4, the conductive sleeve 14 is disposed around the outside of the insulator 16 to form a portion of the vacuum envelope, it is not a requirement that the vacuum envelope be formed by the electrically conductive sleeve 14. In an alternative embodiment, not shown, the insulator 16 forms the envelope of the tube and it is brazed, in a vacuum tight manner, to the remaining conductive portion of the body of the tube and the end closing wall structure 15 is brazed over the open end of the insulator 16.

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 on the accompanying drawings shall be interpretered as illustrative and not in a limiting sense.

WHAT IS CLAIMED IS:

1. In an electron beam tube, means for projecting a beam of electrons over an elongated beam path, beam collector means at the terminal end of the beam path for collecting and dissipating energy of the beam, said collector means including a hollow metallic beam collector structure, an electrically insulative member disposed surrounding said metallic beam collector structure for electrically insulating said collector from the surrounds, yieldable metallic thermally conductive cantilever means interposed between and interconnecting said metallic beam collector structure and said surrounding insulative member for providing a thermally conductive path from said metallic collector structure to said surrounding insulative member, and said cantilever means extending outwardly from said collector structure to said insulative member in a direction inclined at an angle to a line along the shortest distance between said collector structure and said insulative member, whereby said cantilever means are made to flex under differential thermal expansion between said collector and said insulator to reduce transmission of thermally produced stress from said metallic collector to said surrounding insulating member to prevent fracture of said insulative member while allowing thermal conduction thereto.

2. The apparatus of claim 1 wherein said cantilever means comprises an array of fins extending longitudinally of said hollow beam collector structure and said fins of said array being spaced apart around the circumference of said beam collector structure.

3. The apparatus of claim 2 wherein said fins extend outwardly from said beam collector structure in a direction which is approximately inclined at a angle of 45° to a radial from said beam collector structure to said surrounding insulative member.

4. The apparatus of claim 2 wherein said fins are defined by the land portions remaining between adjacent slots of said array of slots formed in the outer surface of said beam collector structure, said slots of said array of slots being directed generally longitudinally along said beam collector structure.

5. The apparatus of claim 1 wherein said cantilever means comprises an array of fins projecting outwardly from the outer surface of said beam collector structure, and means for bonding the outer extremities of said fins to the inside surrounding surface of said insulative member to provide a thermally conductive joint therebetween.

6. The apparatus of claim 2 wherein said fins have a thickness greater than the spacing between adjacent fins, whereby the array of fins provides a relatively high thermally conductive yieldable bridge between said beam collector structure and said surrounding insulator member.

7. The apparatus of claim 1 including a metallic sleeve disposed surrounding said insulative member and forming a portion of the vacuum envelope of said tube, and means for bonding the outer surface of said insulative member to the inner surface of said surrounding metallic sleeve.

8. The apparatus of claim 3 wherein said surrounding insulative member is ceramic, and means for bonding the outer extremities of said fins to the inside surrounding surface of said ceramic insulative member to provide a thermally conductive joint therebetween.

9. An apparatus of claim 4 wherein said surrounding insulative member is ceramic, and means for bonding the outer extremities of said fins to the inside surrounding surface of said ceramic insulative member to provide a thermally conductive joint therebetween.

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