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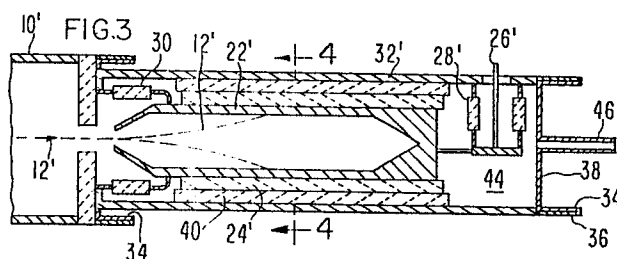
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54 **Beam collector with low electrical leakage.**

57 The collector (22) in a linear-beam electron tube is insulated from its heat sink (32) so that it can be operated at a depressed potential. The insulation comprises two bands (24,40) of dielectric sequentially in contact between the collector (22) and heat sink (32). The intervening space (44) is sealed off and preferably filled with a dielectric fluid to improve heat transfer and inhibit voltage breakdown. Gaps in one band (24) are preferably aligned with solid parts of the other to reduce electric leakage.



Description

Beam Collector With Low Electrical Leakage

The invention pertains to electron beam tubes such as traveling-wave tubes (TWT's) and klystrons which conventionally have a discrete electrode to collect the beam after it has traversed the interaction circuit which is usually at ground potential. Conversion efficiency of these tubes, particularly TWT's is often improved by biasing negative to ground ("depressed collector") so that the electrons give up kinetic energy before dissipating the remainder on the collector surface. Depression is particularly helpful in millimeter-wave tubes where the inherent interaction efficiency is low due to the high-impedance beams necessary for beam focusing through the tiny circuit, the resultant poor coupling between beam and circuit and the relatively high circuit losses.

The use of high-voltage, low-current beams makes any electrical leakage from collector to ground a serious fractional loss of power and also masks the measurement of beam current interception on the circuit, which must be minimized to reduce heating of the delicate circuit and maintain the conversion efficiency.

When the collector is depressed, the heat generated in it must be transferred through an electrically insulating path to a ground-potential heat sink. In large tubes the sink has often been just the air, using cooling fins on the collector in a stream of forced air. In tiny millimeter-wave tubes the insulation between collector and grounded tube body becomes a problem with high, exposed voltages and short leakage paths.

A self-contained depressed-collector design of the prior art is shown in FIGS. 1 and 2. The TWT is enclosed in a metallic vacuum envelope 10 as of copper. An electron beam 12 from a gun (not shown) traverses an interaction circuit, as a helix of tungsten wire 14 supported by a number of dielectric rods 16 as of sapphire inside a copper casing 32 which is part of envelope 10. The terminal end of helix 14 extends out conductor 18 through envelope 10 via an insulating vacuum seal 20. Beam 12, after passage through circuit 14 wherein it is confined to a small cylinder by an axial magnetic field (not shown), expands into hollow collector electrode 22, as of copper. Between collector electrode 22 and envelope 10 are shrink-fitted a plurality of dielectric rods 24 as a beryllium oxide ceramic which provide mechanical support, electrical insulation and thermal conductivity to envelope 10 which is cooled by a grounded heat sink (not shown) such as air fins, liquid channels or a conductive path. Current is supplied to collector 22 by a lead 26 through an insulating vacuum seal 28.

The prior-art collector of FIGS. 1, 2 has some inherent problems. Since the insulating structure is in a high vacuum, thermal conductivity is poor through the small-area contacts to the rods 24. (In vacuum, only radiative transfer is possible except for the tiny areas of atomic-scale physical contact.)

Another problem arising in low-current high-volt-

age applications such as millimeter-wave tubes is that, in the vacuum, conductive coatings get deposited on the insulating rods. Some metal is evaporated from hot parts, and some sputtering occurs from residual gas in the high electric field. The current leakage across these coatings is increased by the fact that during repeated heating and cooling cycles the compression on the rods may be relieved so that they rotate, exposing fresh faces to the coating processes. Nevertheless, cylindrical rods are widely used because they are easily and cheaply manufactured.

In some prior-art tubes, an attempt was made to reduce leakage by filling the vacant spaces between collector and casing with a dielectric fluid. As described below under embodiments of the present invention, this reduced high-vacuum discharges as causes of conductive layer build-up. However, considerable electrical leakage persisted.

The invention provides a collector assembly for an electron beam tube as set out in Claim 1.

Examples of the prior art and of the invention will now be described with reference to the accompanying drawings:-

FIG. 1 is a schematic axial cross section of a prior-art insulated collector.

FIG. 2 is a schematic cross section perpendicular to the axis of the collector of FIG. 1.

FIG. 3 is a schematic axial section of a collector embodying the invention.

FIG. 4 is a section perpendicular to the axis of the collector of FIG. 3.

FIG. 5 is a schematic section perpendicular to the axis of a different embodiment.

FIG. 6 is a schematic section of another embodiment.

FIG. 3 is a schematic section of a collector embodying the invention. Electron beam 12', after passing through the interaction structure (not shown) of a TWT encased in a vacuum envelope 10', enters a hollow beam collector electrode 22', where it expands and is intercepted on the inner wall. Collector 22' is preferably formed with inner and outer surfaces shaped as right circular cylinders, for ease of manufacture and easy cooling. Collector 22' is mounted and sealed off as part of the tube's vacuum envelope 10' by an insulating, hollow, dielectric cylinder 30 as of high-alumina ceramic. The heat generated in collector 22' is carried radially outward to a surrounding casing 32' as of copper. Casing 32' is eventually sealed off by welding lip 34 of an end closure 38 to lip 36 of casing 32'.

The space 44 between collector 22' and enclosure 32' is largely filled by two concentric bands of solid dielectric material 24', 40 such as beryllia ceramic which has high thermal conductivity. In the preferred embodiment the inner band is a layer of closely-packed dielectric rods 24', and the outer band is a hollow dielectric cylinder 40. Dielectrics 24', 40 fit tightly to optimize thermal conduction.

Electrical connection to collector 22' is brought

out by a wire 26' passing through casing 32' via an insulating seal 28'.

Insulating bands 24', 40 are preferably inserted after the vacuum processing of the tube to avoid contamination during bakeout by volatile materials. Casing 32' is then sealed shut by installing end closure 38. In a succeeding manufacturing step the space 44 between collector 22' and casing 40 is filled via a tubulation 46 with a dielectric fluid such as nitrous oxide which has good thermal conductivity and voltage breakdown, or a halogenated organic gas which has excellent voltage-breakdown characteristics. In applications where breakdown is not a limiting factor, improved thermal transfer may be obtained with a gas of low molecular weight such as hydrogen or helium. Alternatively, a liquid dielectric may be used, but this would be more critical of filling and would present thermal expansion problems. For applications having lower breakdown requirements an air filling may suffice. In any case the dielectric fluid improves heat transfer by adding convection between the close-fitting parts. In the prior-art schemes heat transfer occurred only by radiation across the vacuum except through the small areas of actual molecular contact. After filling, space 44 is sealed off by closing tubulation 46.

As discussed under "prior-art", an insulating band 24 can become electrically leaking by being coated with metal from its contact with a metal part 22. As the tube is heated and cooled by intermittent operation, rods such as 24 can become free and rotate during the thermal expansion cycles, making the entire surface somewhat conducting. In the present invention such rods do not contact a second metallic electrode on the side opposite the first, but a second insulator. The formation of a leakage path across the electrically series bridge is inhibited. Preferably the second dielectric band is formed, as by the described cylinder 40, so that if any radial gap surfaces exist, as by accidental thermal cracking of the cylinder, there is only a very small probability that they align with the leakage paths of the first band 24'.

FIG. 5 is a schematic axial section of an alternative embodiment in which the outer dielectric band is cut into segments 42 to alleviate cracking by thermal stresses. The segments are shaped so as not to rotate during cycling, so radial paths can not be coated by contact and there is small chance of the radial cracks aligning with gaps between inner band cylinders 24''.

FIG. 6 is a schematic axial section of another embodiment. Where thermal transfer is not all-important, the second band may be composed of a second layer of cylindrical rods 44. As described above, these rods are cheap and readily obtainable. The outward leakage paths are broken by the discontinuities between rods, and their gaps are generally not aligned.

It will be obvious to those skilled in the art that many different embodiments can be made within the scope of the invention in addition to the exemplary ones described. The forms of the dielectric elements can be quite diverse. The cylindrical rods 24' are cheap and easily obtainable. For the second band 40 a vast number of shapes may be used. It is only

desirable that these elements not be rotatable. It is not completely essential that the insulating space be filled by a dielectric fluid, although this is desirable.

Claims

1. A collector means for a linear-beam electron tube comprising:

a conductive inner collector electrode with a cylindrical outer surface,

a conductive casing surrounding said collector electrode,

an inner band of thermally conductive dielectric surrounding and in contact with said collector electrode, and

an outer band of thermally conductive dielectric between and in contact with said inner band and said casing.

2. The collector means of claim 1 wherein said bands are configured such that gaps or discontinuities extending outward through one band are generally aligned with solid parts of the other band.

3. The collector means of claim 2 wherein at least one of said bands is a largely complete hollow cylinder.

4. The collector means of claim 1 wherein said hollow cylinder is composed of a plurality of adjoining segments.

5. The collector means of claim 4 wherein said segments are divided peripherally of said cylinder.

6. The collector means of claim 4 wherein said segments are divided by strain cracks.

7. The collector means of claim 1 wherein at least one of said bands comprises a layer of parallel rods shaped as right circular cylinders.

8. The collector means of claim 7 wherein the other of said bands does not consist of right circular cylinders.

9. The collector means of claim 7 wherein the other of said bands comprises a second layer of right circular cylinders.

10. Collector means as claimed in any one of claims 1 to 9 wherein said casing is closed gas-tight.

11. The collector means of claim 10 wherein the open space between said casing and said collector is filled with a dielectric fluid.

12. The collector means of claim 11 wherein said fluid is a gas.

13. The collector means of claim 11 wherein said fluid is a halogenated organic compound.

14. The collector means of claim 12 wherein said gas is a member of the class consisting of hydrogen and helium.

15. The collector means of claim 12 wherein said gas is nitrous oxide.

16. A linear beam electron tube comprising a vacuum envelope and a collector means as claimed in claim 10 wherein said casing is part of the vacuum envelope of said tube.

17. A linear beam electron tube comprising a

vacuum envelope and a collector means as claimed in claim 10 wherein said casing is sealed off from the vacuum envelope of said tube and is conformed to permit placement of said dielectric bands after vacuum-processing of said tube and before said casing is closed gas-tight.

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FIG. 1
PRIOR ART

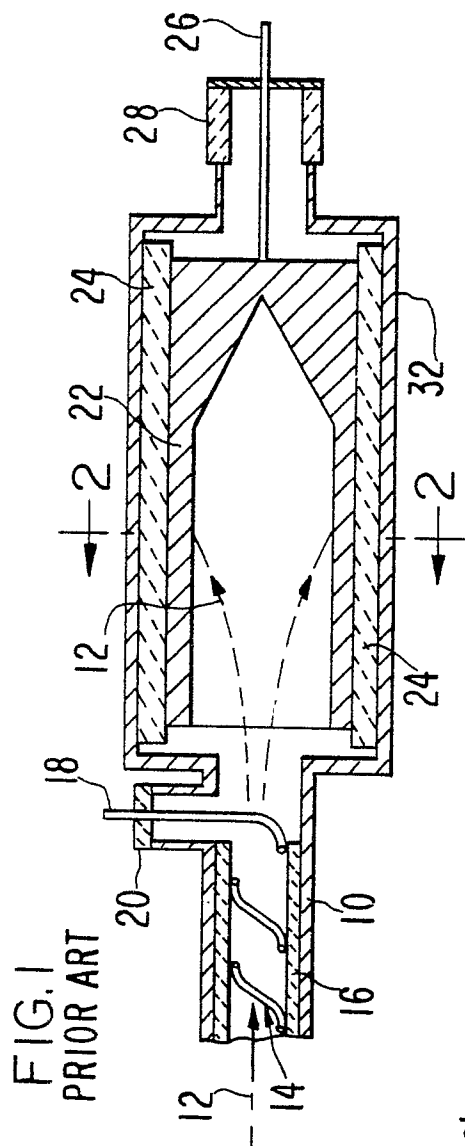


FIG. 2
PRIOR ART

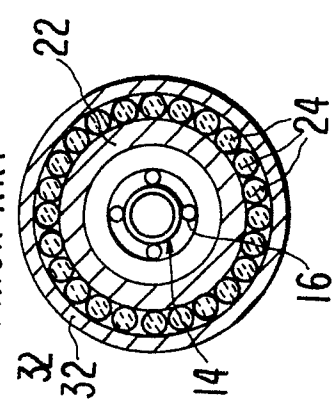


FIG. 3

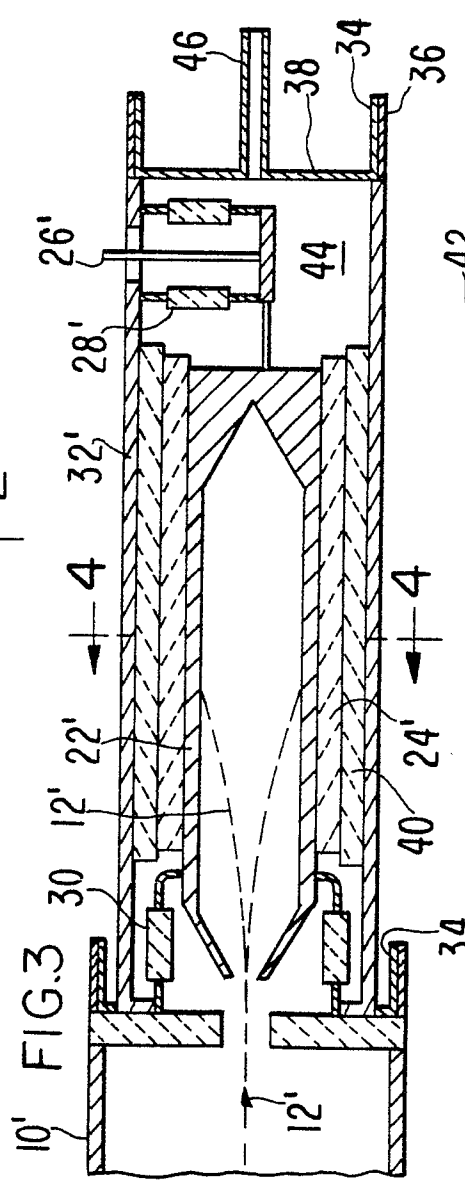


FIG. 4

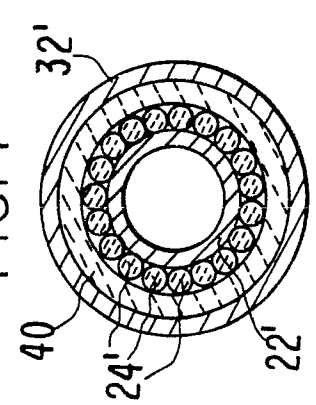


FIG. 5

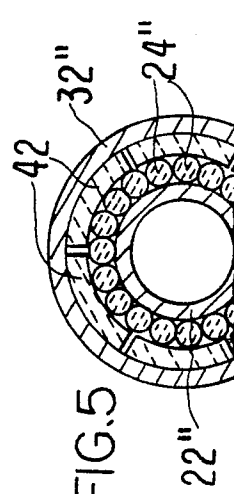
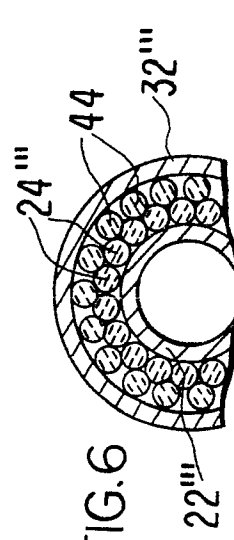


FIG. 6





DOCUMENTS CONSIDERED TO BE RELEVANT			EP 88300336.0
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
Y	GB - A 1 238 822 (THOMSON-CSF) * Page 1, line 86 - page 2, line 51; fig. 3,3a * --	1,2,7, 10,11, 13,16	H 01 J 23/033
Y	US - A - 3 749 962 (SMITH et al.) * Column 2, line 29 - column 3, line 13; fig. 1,2 * --	1,2,7, 10,11 13,16	
A	DE - A1 - 2 906 657 (LICENTIA) * Page 6, lines 4-30; fig. 1,2 * -----	1,3,4	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 4)
			H 01 J
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 13-04-1988	Examiner KUTZELNIGG
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	