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VIBRATION RESISTANT ELECTRON TUBE

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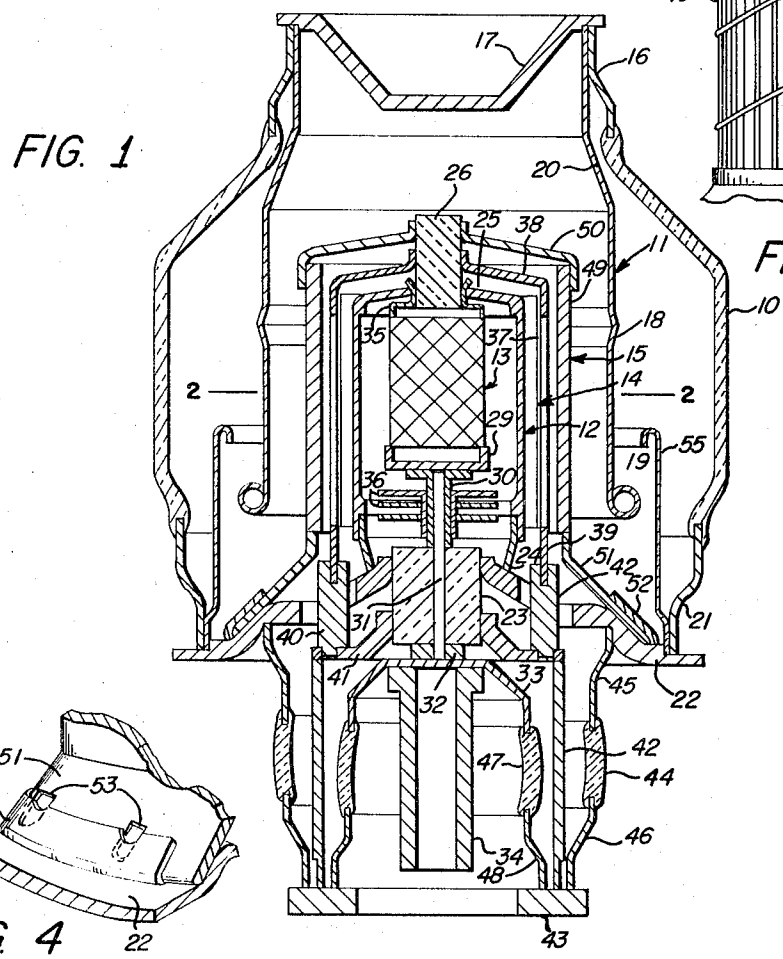

FIG. 1

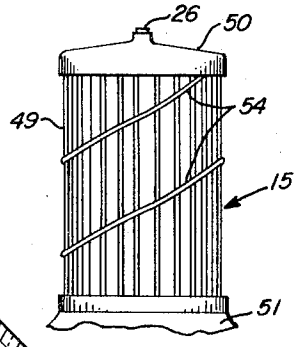

FIG. 5

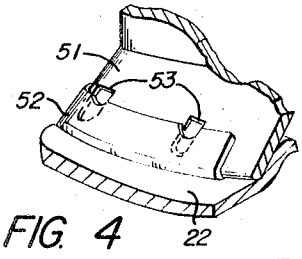

FIG. 4

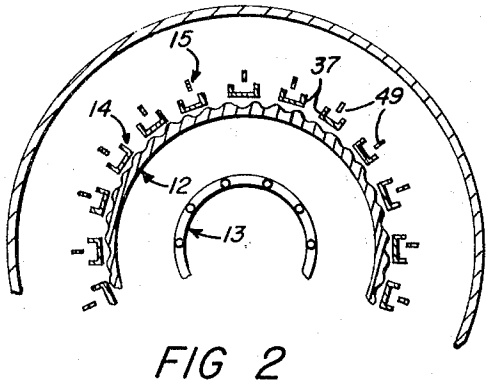

FIG 2

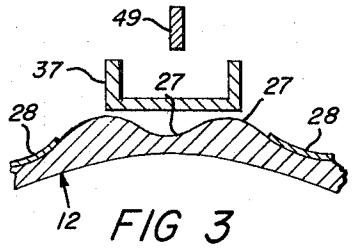

FIG 3

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VIBRATION RESISTANT ELECTRON TUBE

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This invention relates to electron beam tubes and has particular reference to such tubes having novel electrodes and mounting structures therefor which permit operation under severe vibration conditions and with relatively low drive power.

A serious problem in the manufacture of electron tubes is to provide a tube which will operate efficiently under severe vibration conditions such as are encountered in some industrial applications or in missile installations. Such tubes must be rugged to withstand vibration but should preferably also be so constructed that driving power is low to obtain maximum operational efficiency.

In accordance with this invention the electrode structures within the tube envelope are so constructed and mounted that motion is considerably damped. This, combined with resonant frequencies of the electrode members which are of high values, produces efficient operational stability of the tube during vibration. For example, a tube constructed and arranged as taught herein should be capable of operating as a pulse switch tube at 300 kilowatts peak output with a duty of .001, and should operate stably at 10 *g* acceleration for a 50-2000 c.p.s. range at constant output power. We have made our tube with electrode structures which are as short as possible without interfering with the operational characteristics required of the electrodes, thus considerably increasing the resonant frequencies, and have rigidized the structures to further damp vibratory motions in a novel manner.

Accordingly, it is a primary object of this invention to provide an improved beam type electron tube which will operate efficiently under severe vibration conditions.

Another object is to provide an electron tube of the above character wherein the electrode structures are provided with sufficiently high resonance frequencies such as will not affect the stability of operation of the tube during vibration.

Another object is the provision of an electron tube having novel and extremely rugged electrode supporting structures.

A further object is the provision of novel means in an electron tube for rigidizing electrode structures and preventing relative movements therebetween.

A still further object is to provide novel means for supporting electrodes upon terminal mounts whereby expansion of parts during tube operation will cause increase in the ability of the parts to resist relative movements when subjected to severe vibration conditions.

Other objects and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawings, wherein:

FIG. 1 is an axial sectional view of an electron tube embodying the invention;

FIG. 2 is an enlarged fragmentary horizontal sectional view taken substantially on line 2—2 of FIG. 1;

FIG. 3 is an enlarged fragmentary transverse sectional view of a portion of the electrode structures;

FIG. 4 is an enlarged fragmentary view of the supporting structure for the shield grid; and

FIG. 5 is a reduced front elevational view of the screen grid.

Referring more particularly to the drawings, the tube embodies a vacuum-tight envelope which includes a glass bulb **10**, at one end of which is mounted an anode **11**, and supporting at its other end a cathode **12**, a cathode heater **13**, a control grid **14** and a screen grid **15**.

A relatively short metal cylinder **16** is sealed at one end to the anode end of the bulb **10** and has its other end sealed to an inverse frusto-conical member **17** which closes the end of the envelope. Member **17** is relatively thick and because of its shape is not sensitive to vibrations. The member **17** may carry a suitable exhaust tubulation (not shown) if desired as a means whereby the envelope may be evacuated.

The anode **11** is a hollow cylinder which has one end sealed to the inner surface of Kovar cylinder **16** and extends inwardly therefrom toward the opposite end of the tube. Means such as a bead **18** may be provided to stiffen the intermediate wall portion of the anode cylinder **11** as well as the open end portion **19** thereof to eliminate any frequency modes during vibration. Cylinder **11** is further rigidized by a conical portion **20** which also permits the major portion thereof to assume a larger diameter than the end portion which is joined to the Kovar cylinder **16**.

The other end of the bulb **10** is sealed by a second metal cylinder **21** to an inverse substantially conically shaped support or terminal member **22** which has a central bore within which is fixedly located one end of a cylinder or block **23** of nonconductive insulating material such as ceramic. The cylinder **23** is of substantial size and has a coefficient of expansion greater than that of the closely encircling support member **22**. Thus, when heated during operation of the tube, the cylinder **23** will expand to such a degree as to place itself under compression by more closely engaging member **22** and in this way will suppress resonances in the terminal mounting structure during vibrations of more than 2000 c.p.s.

One end of a metal frusto-conical ring **24** is brazed or otherwise affixed to the upper surface of member **22**, and carries on its opposite end the hollow cylindrical cathode **12**. The cathode is open at the end which is joined to ring **24** but the other end is sealed by a cap **25** through which extends a central axially extending nonconductive ceramic pin or cylinder **26**. The cathode is adapted to be provided with a predetermined electrical potential from terminal **22** through the ring **24**.

The outer surface of the cathode **12** is provided with a plurality of spaced longitudinally extending grooves **27** (FIG. 3), and alternate grooves are each provided with a selected heat-sensitive electron-emissive material **28** such as one of the oxides commonly used for this purpose in the electron tube industry and which, when subjected to heat, is capable of emitting copious supplies of electrons which are directed toward the anode **11**.

The means for heating the cathode **12** to the elevated temperatures required for liberation of electrons includes the heater **13** located interiorly of the cathode **12** and comprising a relatively open mesh of wires, preferably tungsten, supported at the lower end of the structure by a metal cup **29**. Cup **29** is firmly attached to an eyelet **30** fixedly mounted on one end of a thin pin or shaft **31** which extends through the ceramic cylinder **23**. The other end of shaft **31** is fixed to a ring **32** which is fixed to the inner side of a closure member **33** forming a part of the envelope. To the outer surface of the closure member **33** and opposite the ring **32** is affixed a heater terminal **34** which may take the form of a tube, as shown in FIG. 1.

The other end of the heater **13** is fixed to a cap **35** which has a central opening in which is located one end of the ceramic pin **26**, the cap being provided around the opening with a flange which bears snugly throughout its inner surface upon the pin **26** and which projects through the adjacent opening in the end cap **25** of the cathode cylinder **12**. In this way the cathode forms one side of the circuit through the heater, and when the ceramic pin **26** is expanded by heat it will cause increased

pressure between the flange and cap **25**, thereby providing better electrical contact and rigid support of the parts.

Means may be provided externally of the envelope for aiding in the dissipation of heat from the shaft **31**, closure member **33** and terminal **34** such as by attaching a radiator (not shown) to the end of the terminal. In order to confine the heat from the heater within the effective portion of the cathode, disc-like heat reflectors or baffles **36** are mounted over the eyelet **30** as shown in FIG. 1. Thus, heat attempting to escape through the open end of the cathode cylinder is reflected back into the interior. Heat losses are further reduced by the use of a shaft **31** which is of relatively small diameter and which thus forms a thermal dam.

The control grid **14** encircles the cathode and is comprised of spaced grid members **37** (FIGS. 2 and 3) which extend parallel to the cathode and to each other and in predetermined spaced relation to respective nonemitting portions of the cathode. Members **37** are channel- or U-shaped so as to be mechanically rigid under vibration and are formed of thin sheet material, such as sheet molybdenum, whereby the weight of each member **37** as well as of the entire control grid is considerably reduced, increasing the resonant frequency of the structure by several factors. An additional advantage achieved by a grid member of this shape is the enlargement of the radiating surface area compared with the surface area of solid members. This provides improved electron beaming and a high amplification factor which decreases driving power.

The upper ends of the grid members **37** are brazed to a cap **38** which has a central opening for snugly receiving the ceramic pin **26**, and the lower ends are fixed to tubular ring **39** which is mounted firmly in the ends of a number of rugged posts **40**. Posts **40** project freely through respective openings in the cathode terminal **22** and are firmly mounted in an annular frusto-conical support **41** which has a central opening snugly embracing the ceramic cylinder **23**. To provide additional support for the control grid and to provide means for conducting electrical potential thereto, the periphery of support **41** is fixed to the inner end of an axially extending tubular member **42**, the outer end of which is fixed to a heavy ring-type terminal **43**.

Closing the envelope outwardly of member **42** is an encircling glass ring **44** which is sealed at each end by metal rings **45** and **46** to the cathode and control grid terminals **22** and **43** respectively. The envelope is similarly closed inwardly of member **42** by glass ring **47** which is sealed at one end to the closure member **33** and at the other end by a metal ring **48** to the terminal **43**.

The shield grid **15** which encircles the control grid **14** comprises a plurality of flat wire elements **49** which are radially spaced outwardly of respective control grid members **37** and extend parallel thereto. The upper ends of the elements **49** are brazed or otherwise fixed to a cap **50** which also has a central opening snugly receiving the ceramic pin **26**. The shield grid is operable at cathode potential and, therefore, is mounted upon the cathode terminal **22** by means of a substantially frusto-conical support **51** to which the lower ends of elements **49** are fixed. Support **51** is shaped to interfit closely over a sizable circumferential surface portion of terminal **22** and is held firmly in place by a number of elongated tabs **52** which are each brazed along one edge to the cathode terminal **22** adjacent the lower end of the grid support **51** and are bent into overlying relation to support **51** as shown best in FIG. 4. Support **51** is provided with a number of recesses or slots **53** in which indented portions of the tabs are located so as to prevent respective rotary movements of the parts and also to further rigidize the structure. The height of tabs **52** is somewhat greater than the height of the surface portion of the terminal **22** which is engaged by the support **51**. Thus, the process of bending the tabs inwardly toward the axis of the structure tends to still more firmly secure the grid in place upon the terminal, thus dampening vibrational resonances in the structure.

One or more spaced spirals **54** (FIG. 5) of relatively fine wire is wound around the outside of the shield grid **15** and welded to each grid element **49**, thus effectively dampening torsional movements during vibration.

A tubular shield **55** is attached at one end to the cathode terminal **22** or to the cylinder **21** at the joint therebetween and extends toward the opposite end of the tube beyond and spaced outwardly of the adjacent end of the anode **11**. This protects the glass-metal seals from possible destruction by high voltage field concentrations.

It is particularly pointed out that horizontal and vertical movements of the grids, cathode and heater with respect to each other are effectively prevented by the novel employment of the ceramic pin **26** and the ceramic cylinder **23**. Furthermore, the pin **26** and the cylinder **23** provide accurate and constant spacing between the electrodes, with cylinder **23**, particularly, being of substantial size and strength and mounted so as to contribute to the rigid support of the cathode and grids whereby they are relatively unaffected by vibrations, with the suppression of resonances, during vibration, of more than 2000 c.p.s. under acceleration forces of 10 g. and more.

Furthermore, the overall electrode structures are relatively short in length and large in diameter to obtain sufficiently high resonance frequencies which will not affect operational stability of the tube during vibration.

From the foregoing it will be apparent that a novel tube has been achieved in accordance with the objects of this invention. It is to be understood, however, that modifications and changes may be made by those skilled in the art without departing from the spirit of the invention as expressed in the accompanying claims.

What is claimed is:

1. An electron tube comprising a glass bulb, a relatively heavy substantially frusto-conical end member sealed to one end of the bulb, a tubular anode mounted at one end adjacent the seal between the end member and bulb, an inverse relatively heavy frusto-conical terminal member sealed to the opposite end of the bulb, a pair of rigid substantially frusto-conical inwardly extending supports mounted on the inner side of the terminal member, a cathode fixedly mounted on one of the supports, a first grid fixedly mounted on the other support and encircling the cathode, a relatively heavy partly conical supporting plate spaced outwardly from the terminal member, a second grid located between the cathode and first grid, means rigidly affixed to the plate and freely penetrating the terminal member and having the second grid firmly mounted thereon, the unsupported ends of the cathode and both grids carrying apertured caps, and a nonconductive cylinder of heat expandable ceramic material mounted in said caps and retaining the cathode and grids immovably in assembled spaced relation.

2. An electron tube comprisig a glass bulb, a relatively heavy substantially frusto-conical end member sealed to one end of the bulb, a tubular anode mounted at one end adjacent the seal between the end member and bulb, an inverse relatively heavy frusto-conical terminal member sealed to the opposite end of the bulb, a pair of rigid substantially frusto-conical inwardly extending supports mounted on the inner side of the terminal member, a cathode fixedly mounted on one of the supports, a first grid fixedly mounted on the other support and encircling the cathode, a relatively heavy partly conical supporting plate spaced outwardly from the terminal member, a second grid located between the cathode and first grid, means rigidly affixed to the plate and freely penetrating the terminal member and having the second grid firmly mounted thereon, the unsupported ends of the cathode and both grids carrying apertured caps, and a nonconductive cylinder of heat expandable ceramic material mounted in said caps and retaining the cathode and grids

immovably in assembled spaced relation, said cylinder being of a material having a coefficient of expansion greater than that of the caps for expanding into tight engagement with said caps when heated during operation of the tube.

3. An electron tube comprising a glass bulb, a relatively heavy substantially frusto-conical end member sealed to one end of the bulb, a tubular anode mounted at one end adjacent the seal between the end member and bulb, an inverse relatively heavy frusto-conical terminal member sealed to the opposite end of the bulb, a pair of rigid substantially frusto-conical inwardly extending supports mounted on the inner side of the terminal member, a cathode fixedly mounted on one of the supports, a first grid fixedly mounted on the other support and encircling the cathode, a relatively heavy partly conical supporting plate spaced outwardly from the terminal member, a second grid located between the cathode and first grid, and support means for the second grid rigidly affixed at one end to the plate and freely penetrating the terminal member and having the second grid firmly mounted on the opposite end thereof, the supporting plate and terminal member having concentric apertures therein, and a nonconductive block of heat expandable ceramic material mounted in said apertures for retaining the plate and terminal member in assembled spaced relation.

4. An electron tube comprising a glass bulb, a relatively heavy substantially frusto-conical end member sealed to one end of the bulb, a tubular anode mounted at one end adjacent the seal between the end member and bulb, an inverse relatively heavy frusto-conical terminal member sealed to the opposite end of the bulb, a pair of rigid substantially frusto-conical inwardly extending supports mounted on the inner side of the terminal member, a cathode fixedly mounted on one of the supports, a first grid fixedly mounted on the other support and encircling the cathode, a relatively heavy partly conical supporting plate spaced outwardly from the terminal member, a second grid located between the cathode and first grid, and support means for the second grid rigidly affixed at one end to the plate and freely penetrating the terminal member and having the second grid firmly mounted on the opposite end thereof, the supporting plate and terminal member having concentric apertures therein, and a nonconductive block of heat expandable ceramic material mounted in said apertures for retaining the plate and terminal member in assembled spaced relation, said nonconductive block having a coefficient of expansion greater than that of the supporting plate and terminal for expanding into tight engagement therewith when heated during operation of the tube.

5. An electron tube comprising a glass bulb having an anode at one end and an apertured cathode terminal at the other end, a hollow cylindrical cathode mounted at one end on said terminal, a nonconductive block of heat expandable ceramic material having a coefficient of expansion greater than that of the terminal mounted in the aperture in the terminal, and a heater within the cathode having one end attached to the unsupported end of the cathode and supported at its other end by means carried firmly by and penetrating the nonconductive block.

6. An electron tube comprising a glass bulb having an anode in one end and a cathode in the other end, a terminal plate for the cathode sealed to the cathode end of the bulb and having an annular portion which is provided with an inwardly inclined inner surface of restricted length in an axial direction between the cathode and the seal to the bulb, a grid encircling the cathode, a substantially frusto-conical member having the grid mounted on its smaller end, the larger end of the member having its inner surface interfitting with said inclined inner surface of the plate, means for fixedly retaining the member on the plate, said grid being comprised of a plurality of longitudinally extending and relatively thin elements spaced at a predetermined distance from and parallel to the cathode, and at least one spiral winding connecting said elements and fixedly attached to each thereof to suppress resonant frequencies in the elements.

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