Dec. 7, 1965 D. D. MEACHAM ETAL 3,222,557

TUBE HAVING A HEAT CONDUCTING MOUNT

Filed Oct. 3, 1961 2 Sheets-Sheet 1

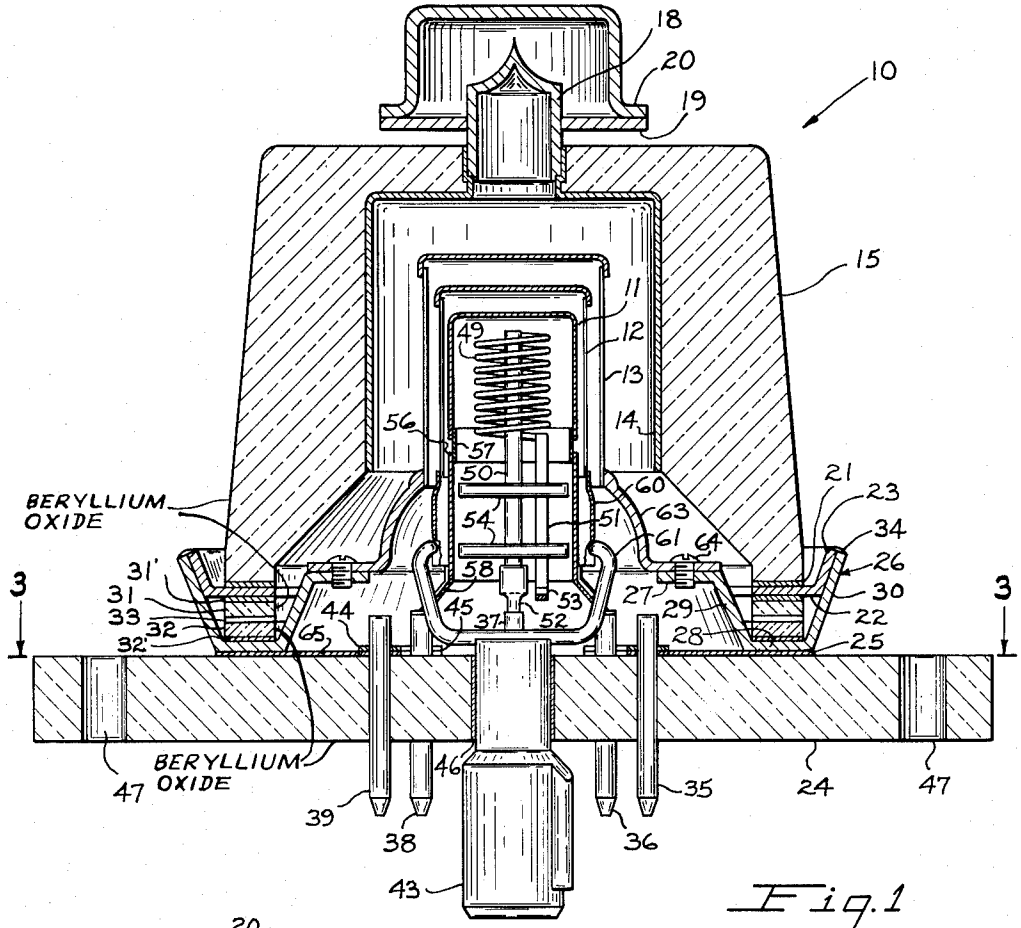


Fig. 1

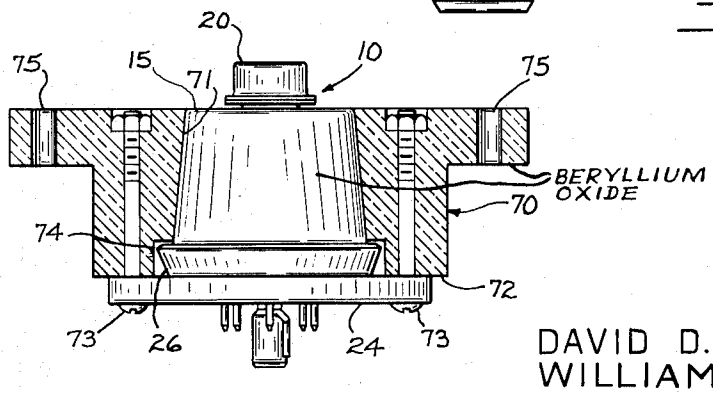


Fig. 2

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Fig. 3

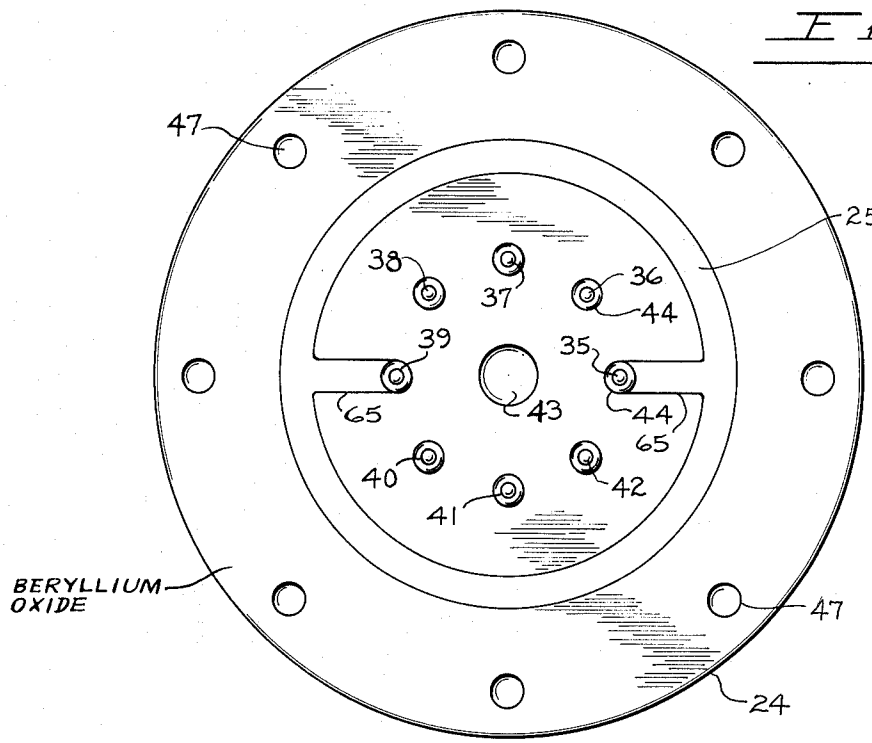
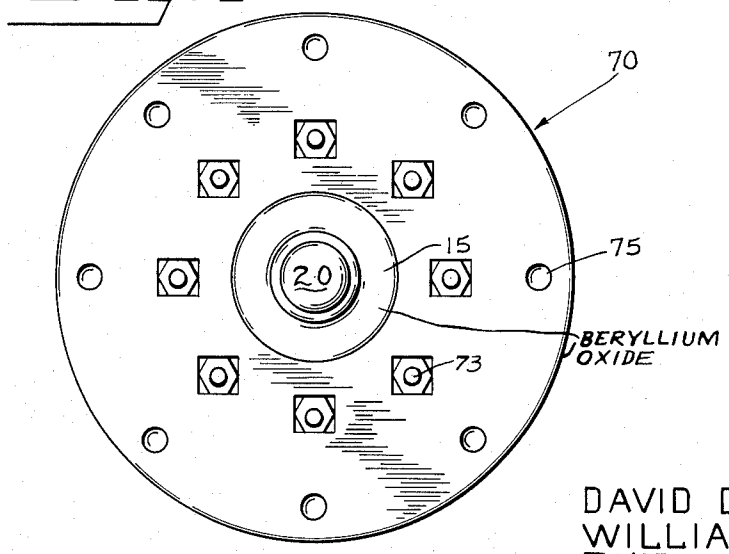


Fig. 4



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TUBE HAVING A HEAT CONDUCTING MOUNT

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This invention relates to electron tubes and associated apparatus. More particularly the invention relates to an electron tube having improved heat conducting features and associated apparatus having heat conducting features specifically cooperating with the heat conducting features of the tube.

High power electron tubes generate great quantities of heat, and the problem of dissipating the heat is often a limiting factor in the operation of the tubes. Normally it is the anode which requires the greatest amount of cooling. Accordingly, the previous approach to the problem has been to employ what is termed an external anode; that is, the anode is formed as a portion of the envelope wall rather than being positioned inside an insulating envelope. In this way the heat generated by electrons striking the anode is conducted through the metal anode wall directly to the exterior of the tube. The cooling is further improved by providing heat radiating fins on the outer surface of the anode.

Although the heat dissipating properties of an external anode tube are vastly better than those of an internal anode tube, the external anode construction creates other problems. For example, the conventional external anode tube presents a large metal surface which is electrically charged and therefore results in large capacitance between the anode and adjacent portions of the tube and the equipment in which the tube is mounted. In addition, the metal external anode is inherently a heavy member which adds to the weight of the tube and also aggravates vibration problems. Further, the equipment required to force cooling fluid over the external anode is an additional source of weight and expense.

Accordingly it is an object of this invention to provide an electron tube in which heat may be dissipated from the anode in an improved manner which reduces or eliminates the undesirable effects of the conventional metal external anode.

Not only must heat be dissipated from the anode but it must also be dissipated from other portions of the electron tube such as the grids. Therefore another object of the invention is to provide an electron tube having improved over-all cooling features.

The basis of the invention resides in the use of a material having electrical insulating properties and good thermal conductivity. Beryllium oxide is the best substance for this purpose which is known at this time. Although the basis of the invention resides in the use of an insulating material having good thermal conductivity, the invention itself resides in the specific type of construction which makes it possible to realize the benefits of a substance such as beryllium oxide.

More specifically, the electron tube of this invention comprises an external anode member and header made of beryllium oxide rather than metal or other ceramics. The inside surface of the beryllium oxide wall is metalized to provide the electron receiving surface of the anode as is

old in the art. This invention provides a novel heat conducting mount, or heat sink, of beryllium oxide which makes it possible to attach the tube rigidly to its associated chassis and at the same time provide efficient heat dissipation. The invention comprises a configuration in which the tube and the mount, or heat sink, are each shaped to cooperate with the other in a manner which will make the most efficient use of the properties of beryllium oxide in dissipating heat from the various parts of the tube which require cooling and will also provide for rigid mounting of the tube.

Accordingly, another object of the invention is to provide a combined electron tube and heat conducting mount wherein the interengaging parts of the tube and mount are made of beryllium oxide. In addition to its thermal efficiency this arrangement makes it possible to connect the heavy anode end of a tube to the associated equipment chassis in a very rigid manner without creating any electrical capacitance problems.

A further object of the invention which is related to the preceding object is to provide a beryllium oxide heat conducting mount, or heat sink, for electron tubes.

An additional object of the invention is to provide an improved construction for an electron tube of the type having terminal pins projecting through a ceramic header at one end of the tube. As will become more apparent from the following detailed description this object is related to simplicity of manufacture and rigidity of construction as well as to thermal properties.

Additional objects and features of advantage will be apparent from the following description read in connection with the accompanying drawings in which:

FIGURE 1 is a cross sectional view of an electron tube made in accordance with the invention;

FIGURE 2 is a cross sectional view of a heat conducting mount or heat sink according to the invention and showing the tube of FIGURE 1 in elevation in the mount, all in reduced scale relative to FIGURE 1;

FIGURE 3 is a scaled down view taken on line **3—3** of FIGURE 1 and shows the upper face of the header; and

FIGURE 4 is a top view of the tube and mount shown in FIGURE 2.

Referring to the drawings in more detail FIGURE 1 shows an electron tube **10** of the type having cylindrical electrodes consisting of a cathode **11**, control grid **12**, screen grid **13**, and an anode formed by a metallic layer **14** on a cup-shaped beryllium oxide envelope member **15**. The metallic layer is preferably formed by metalizing the inner surface of member **15** with a conventional ceramic metalizing process as is well known in the art. Also, it is desirable to deposit a coating of copper on the metalizing layer. The upper end of member **15** is apertured to receive the conventional copper exhaust tubulation **18** which is pinched-off after the tube has been evacuated. The metallic layer **14** is carried across the upper end of member **15** and along the walls of the tubulation aperture so that the tubulation can be brazed in member **15**. In this way the metallic layer also serves as an electrical lead-through. A two piece protective cap **19, 20** is brazed to the exhaust tubulation and provides a convenient anode terminal. The lower edge of the cup-shaped member **15** is metalized at **21**, and is brazed to a metal sealing ring having a flat portion **22** and an upturned rim portion **23**.

Thus the upper end portion and most of the side portion of the tube envelope are formed by the berryllium

oxide member **15**. The lower end of the tube comprises a header **24** also made of beryllium oxide. As shown best in FIGURES 1 and 3, the header is provided with a ring of metalizing **25** which is brazed to a grid support and sealing ring **26**. Ring **26** is made of metal and is generally dipper-shaped in cross-section, having a flat grid-support portion **27**, a flat bonding portion **28** and two upturned portions **29, 30**. Two beryllium oxide backing rings **31** and **32** are metalized at **31'** and **32'** and are brazed to metal ring portions **22** and **28** respectively. Backing ring **31** has a plurality of radial grooves **33** which permit exacuation of the space inside the sealing ring portion **30**. The sealing ring portions **23** and **30** are welded together at **34** to provide the final seal for the tube. As will be explained in more detail, all of the electrodes except the anode are mounted on header **24**. Thus, all of the electrodes can be assembled with full accessibility before anode member **15** is in place, and then the anode member is added and the final seal **34** is made. It will be noted that this is a very desirable arrangement for simple rugged tube construction wtih a disk-shaped header of any ceramic material, including aluminum oxide ceramic.

As shown best in FIGURES 1 and 3, the header **24** is provided with a plurality of apertures which receive metal terminal pins **35–42** arranged in a circle around a center pin **43**. The pins **35–42** are hermetically sealed to the header by means of metal washers **44** which are brazed to the pins and to a ring of metalizing **45** around each pin aperture. The wall of the center pin aperture is metalized at **46**, and the pin **43** is brazed directly to the metalizing **46**. The header is also provided with a plurality of bores **47** for a purpose to be hereinafter described.

The cathode **11** is of the indirectly heated, oxide coated type, and is heated by a wire coil **49** attached to metal support posts **50** and **51**. Post **50** provides the main support and is attached to pin **37** by a connecting tab **52**. Post **51** is attached to pin **41** by a tab **53**, shown partly in section in FIGURE 1. Aluminum oxide ceramic disks **54** are attached to posts **50** and **51** to rigidify the posts and also to block the loss of heat from coil **49**. The cathode **11** is supported on a metal cylinder **56** through an intermediate thin metal heat dam **57**. Support cylinder **56** has four feet **58** (two shown in FIGURE 1) which are attached to terminal pins **36, 38, 40** and **42**.

The control grid **12** is a conventional cylindrical cage type construction comprising circumferentially spaced vertical wires. Control grid **12** is mounted on a metal support cylinder **60** which is attached to center pin **43** by means of a metal yoke **61**. Cylinder **60** is provided with a slight indentation on each side to facilitate a better bond with the ends of yoke **61**. The screen grid **13** is made in the same manner as the control grid and is mounted on a metal support cone **63** having a flat rim portion which is attached by screws **64** to portion **27** of support ring **26**. Pins **35** and **39** serve as terminals for the screen grid, and the electrical connection therefor is provided by metalizing strips **65** on the header. In order to be visible on the drawings all of the metalizing layers are shown thicker than actual. The metalizing layers are all formed by a conventional ceramic metalizing process as is well known in the art.

It will be noted that the envelope wall of the tube is made entirely of beryllium oxide except for the terminal pins, sealing rings and tubulation. Since the thermal conductivity of beryllium oxide is in the same class as metals and since the noted exceptions are metals, it will be understood that heat generated in the tube is very quickly conducted to the outside of the envelope. More specifically the heat conductivity of beryllium oxide is better than that of brass and very nearly as good as copper. Obviously, the tube could be efficiently cooled by blowing cooling air over the large, heat conductive envelope surface. At the same time the envelope surface does not include a large metal area which would cause electrical problems.

However, the cooling efficiency can be further increased, even to the extent of eliminating the need for cooling air equipment, by placing the tube envelope in heat conducting contact with a large area, large volume heat sink. This further improvement has been achieved according to the invention by providing a beryllium oxide heat conductor **70**. The beryllium oxide member **70** provides a large volume, large area heat conductor and therefore is in itself a heat sink for dissipating heat from the tube. However, the dissipation of heat is even further increased when the heat conductor **70** is in heat conducting contact with the metal chassis (not shown) which is a standard part of the equipment which uses electron tubes.

As shown in FIGURE 2, the tube **10** is mounted in the heat conductor **70** with the anode member **15** and the header **24** both in contact with the member **70**. A significant feature of the invention involves the particular matching shapes of the tube and the heat conductor. The outer wall surface of anode member **15** is frusto-conical in shape and the bore **71** in member **70** is tapered to match. Member **70** is also provided with a flat rim **72** to achieve good contact with the flat outer portion of header **24**. Rim **72** is drilled so that the tube can be rigidly clamped in place, as by bolts **73** which are received in holes **47** in the header. Heat conductor **70** is recessed at **74** to accommodate the sealing rings **23** and **26** on the tube. It will be noted that the header **24** is made larger than necessary for envelope purposes so that it extends radially beyond the other envelope portions in order to provide a substantial attachment to the heat conductor **70**. The specific configuration of the member **70** is not critical except for the provisions of bore **71** and sealing rim **72**, and the provision of some means for obtaining good heat conducting attachment to a metal chassis. The member **70** in FIGURE 2 can be attached to a chassis by passing bolts through bores **75**. Obviously, the chassis would require a bore to accommodate terminal cap **20** and to permit an electrical lead to be attached to the cap. The socket for the tube would of course be attached to the terminal pins at the bottom of the tube. Since the tube **10** is a negative grid tube, the metallic layer **14** is properly termed an anode. However, it will be understood by those skilled in the art that in beam type tubes such as klystrons and traveling wave tubes, the electrode termed a collector has the same heat dissipation problems and benefits from the same solution. Although anodes and collectors serve different electrical purposes, they are identical in that each receives and is heated by the electrons emitted by the cathode.

The combination of the beryllium oxide tube **10** and the beryllium oxide heat conductor **70** has many advantages. The heat conducting contact between the tube side wall and heat conductor is maintained throughout the temperature range in which the tube operates. If member **70** were metal, the difference in coefficients of expansion would prevent such continued close contact and might result in cracking the beryllium oxide ceramic of the tube. In addition, the beryllium oxide member **70** weighs less than a similarly shaped mass of metal having equivalent heat dissipating properties, such as copper. Further, the fact that beryllium oxide is an electrical insulator eliminates the electrical problems caused by the usual metal external anode and makes it possible to attach heat conductor **70** directly to a metal chassis. Also, the member **70** serves as a means for mounting tube **10** on a chassis in an extremely rigid manner which is very important in applications where severe vibration and shock are present.

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

1. An electron tube having a hermetically sealed envelope and cylindrical electrodes within the envelope, said

envelope comprising an inverted cup-shaped beryllium oxide member forming one end of the envelope, a disk-shaped beryllium oxide header forming the other end of the envelope, terminal pins for some of said electrodes hermetically sealed in said header, one of said electrodes being a grid connected to one of said pins internally of said envelope, said cup-shaped member having a frusto-conical outside wall surface with its large diameter end adjacent the header end of the tube, said cup-shaped member having a cylindrical inside wall surface, one of said electrodes being an electron receiving electrode formed by an electrically conductive layer on said cylindrical inside wall surface of said cup-shaped member, another of said electrodes being a second grid, a metal support ring for said grid, said support ring having an annular U-shaped section, the bottom of said U-shape being flat and metallically bonded to the face of said header, a metal sealing ring metallically bonded to the rim of said cup-shaped member and having an outer flange portion nested within the outer leg of said U-shaped section, and a metallic bond sealing said flange to said outer leg.

2. An electron tube having a hermetically sealed envelope and electrodes within the envelope, said envelope comprising an inverted cup-shaped upper portion and a disk-shaped beryllium oxide header forming the lower end of the envelope, terminal pins hermetically sealed in said header, one of said electrodes being a cathode connected to one of said pins internally of said envelope, another of said electrodes being an electron receiving electrode formed by said cup-shaped portion, a further one of said electrodes being a grid, a metal support ring for said grid having a flat portion metallically bonded to the face of said header and an outer rim portion projecting to the outside of said envelope, a metal sealing ring having a flat portion metallically bonded to the lower edge of said cup-shaped portion and an outer rim portion in contact with the rim portion of the support ring, and a metallic bond hermetically joining said rim portions, the diameter of said header being substantially greater than the largest diameter of said rim portions.

3. An electron tube having a hermetically sealed envelope and electrodes within the envelope, said envelope comprising a disk-shaped ceramic header forming one end of the envelope, terminal pins hermetically sealed in said header, at least one of said electrodes being supported on at least one of said pins, another of said electrodes being a grid, a metal support ring for said grid having a flat portion metallically bonded to the face of said header and an outer rim portion projecting to the outside of said envelope, a metal sealing ring having a portion bonded to the section of the envelope adjacent said header and an outer rim portion in contact with said rim portion of the support ring, a first ceramic ring bonded to said flat portion of the support ring, a second ceramic ring abutting the first ceramic ring and bonded to said sealing ring, and a metallic bond hermetically joining said rim portions.

4. Electron tube apparatus comprising an electron tube and a heat conductor, said electron tube having a hermetically sealed envelope and electrodes within the envelope, said envelope comprising an annular beryllium oxide side wall having a frusto-conical outside surface, one of said electrodes being an electron receiving electrode formed by an electrically conductive layer on the inside surface of said side wall, and terminals for the remainder of said electrodes all projecting through portions of said envelope other than said frusto-conical side wall, and said heat conductor comprising a beryllium oxide member having a tapered bore matching the shape of said frusto-conical surface, and means for clamping said tube in said heat conductor with said frusto-conical surface in heat conducting engagement with the wall of said tapered bore, whereby said beryllium oxide wall of the tube remains in intimate contact with said heat conductor throughout temperature changes and without imposing stresses such as would result if the beryllium oxide wall of the tube had a different coefficient of expansion from that of the heat conductor.

5. Electron tube apparatus comprising an electron tube and a heat conductor, said electron tube having a hermetically sealed envelope and electrodes within the envelope, said envelope comprising a disk-shaped beryllium oxide header at one end and an annular beryllium oxide side wall having a frusto-conical outside surface, the large diameter end of said frusto-conical surface being adjacent the header end of the tube, one of said electrodes being an electron receiving electrode formed by an electrically conductive layer on the inside surface of said side wall, terminals for the remainder of said electrodes all projecting through portions of said envelope other than said frusto-conical side wall, said header having an attachment rim projecting outwardly from the envelope, and said heat conductor comprising a beryllium oxide member having a tapered bore matching the shape of said frusto-conical surface, said beryllium oxide member having a flat mounting rim around the large end of said bore, the axial relation between said mounting rim and said bore being equivalent to the axial relation between said attachment rim and said frusto-conical surface so that when said frusto-conical surface is in contact with the wall of said bore said attachment rim is in contact with said mounting rim, and means for clamping said tube and heat conducting mount together.

6. Electron tube apparatus comprising an electron tube and a heat conductor, said electron tube having a hermetically sealed envelope and electrodes within the envelope, said envelope comprising a beryllium oxide wall, and one of said electrodes being an electron receiving electrode formed by an electrically conductive layer on the inside of said beryllium oxide wall, and a heat conductor comprising a beryllium oxide member having a bore therein matching the outer surface of said beryllium oxide envelope wall, and means for clamping said tube and heat conductor together with said envelope wall received in said bore, whereby said beryllium oxide wall of the tube remains in intimate contact with said heat conductor throughout temperature changes and without imposing stresses such as would result if the beryllium oxide wall of the tube had a different coefficent of expansion from that of the heat conductor.

7. Electron tube apparatus comprising an electron tube having a hermetically sealed envelope and electrodes within the envelope, said envelope comprising a beryllium oxide wall section, one of said electrodes being an electron receiving electrode, the inside wall surface of said beryllium oxide section having an electrically conductive layer forming said electron receiving electrode, and a beryllium oxide heat conductor having a surface matching the outside surface of said beryllium oxide wall section, and means for releasably clamping the outside surface of said beryllium oxide wall section in heat conducting contact with said matching wall surface of the heat conductor, whereby said beryllium oxide wall of the tube remains in intimate contact with said heat conductor throughout temperature changes and without imposing stresses such as would result if the beryllium oxide wall of the tube had a different coefficient of expansion from that of the heat conductor.

8. An electron tube having a hermetically sealed envelope and electrodes within the envelope, said envelope comprising a disk-shaped ceramic header forming one end of the envelope, terminal pins hermetically sealed in said header, at least one of said electrodes being supported on at least one of said pins, another of said electrodes being a grid, a metal support ring for said grid having a flat portion metallically bonded to the face of said header and an outer rim portion, a metal sealing ring having a portion bonded to the section of the envelope adjacent said header and an outer rim portion in contact with said rim portion of the support ring, a metal-

lic bond hermetically joining said rim portions, and a metalizing coating on said header electrically connecting said support ring to another of said terminal pins.

9. Electron tube apparatus comprising an electron tube having a hermetically sealed envelope and electrodes within the envelope, said envelope comprising a beryllium oxide wall section, and a beryllium oxide heat conductor having a surface matching the outside surface of said beryllium oxide wall section, and means for releasably clamping the outside surface of said beryllium oxide wall section in heat conducting contact with said matching wall surface of the heat conductor, whereby said beryllium oxide wall of the tube remains in intimate contact with said heat conductor throughout temperature changes and without imposing stresses such as would result if the beryllium oxide wall of the tube had a different coefficient of expansion from that of the heat conductor.

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