

Oct. 27, 1959

J. A. McCULLOUGH ET AL
CERAMIC TYPE ELECTRON TUBE

2,910,607

Filed Feb. 4, 1955

4 Sheets-Sheet 1

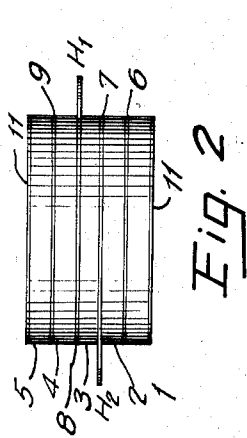


Fig. 2

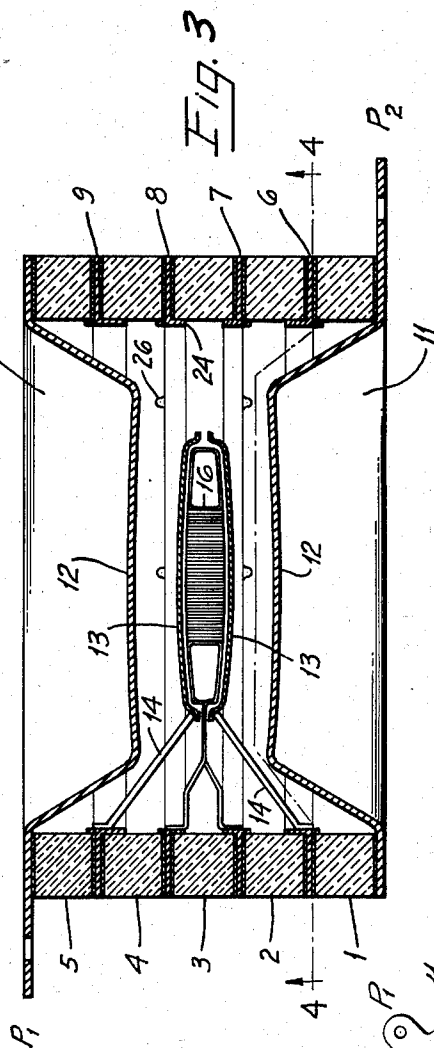


Fig. 3

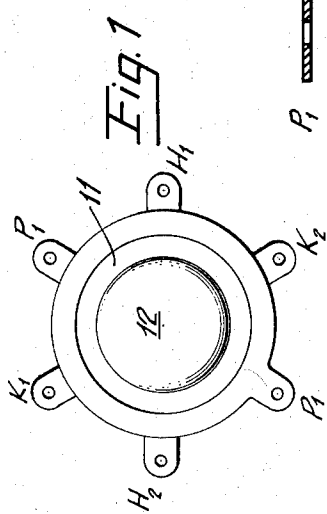


Fig. 1

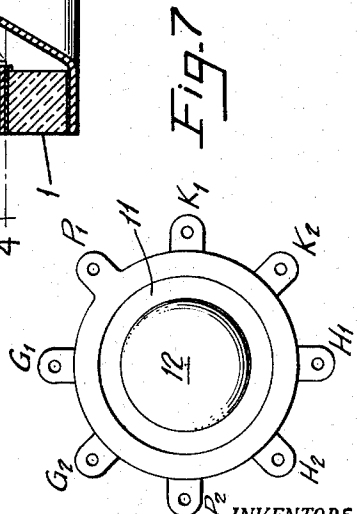


Fig. 7

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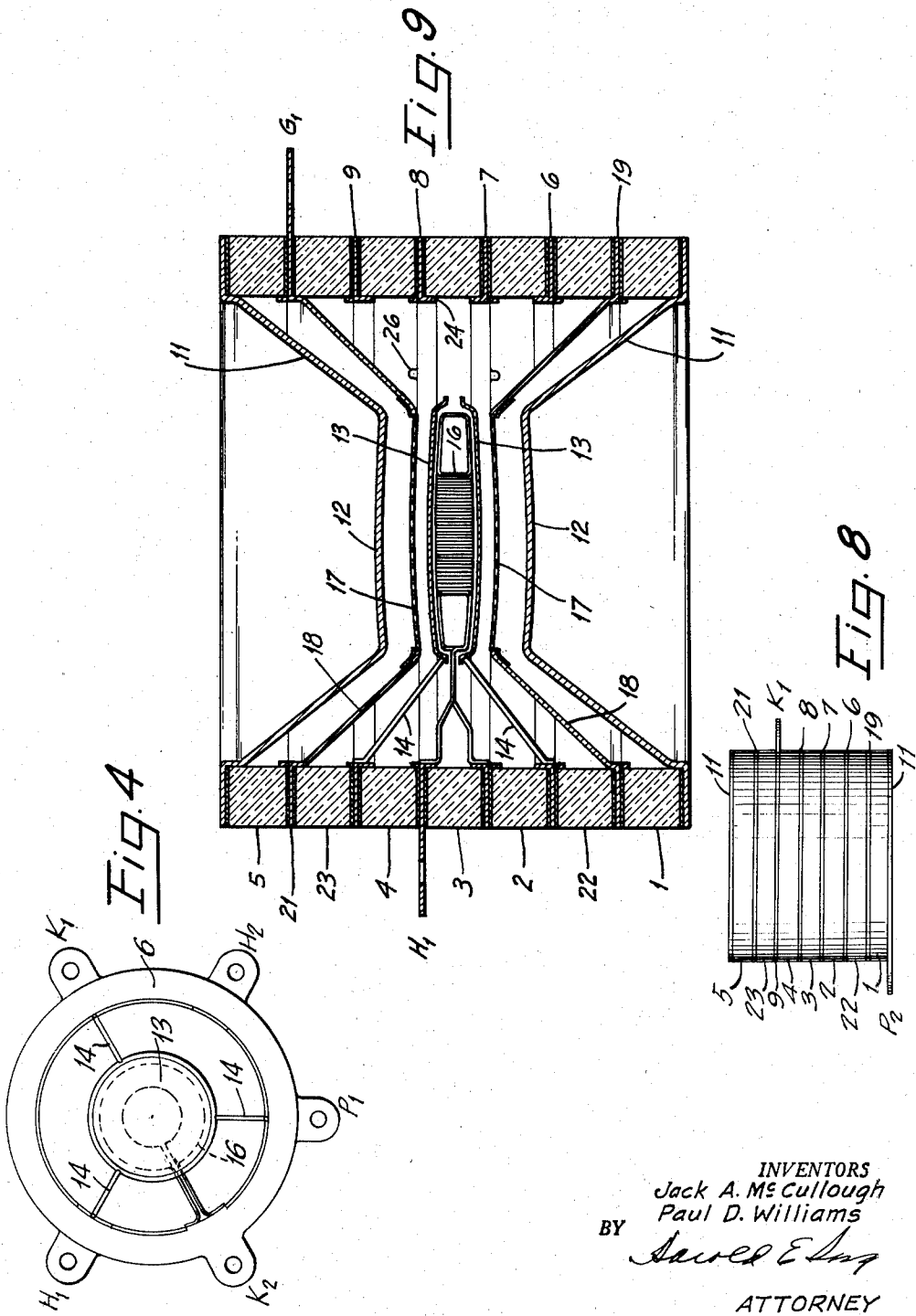
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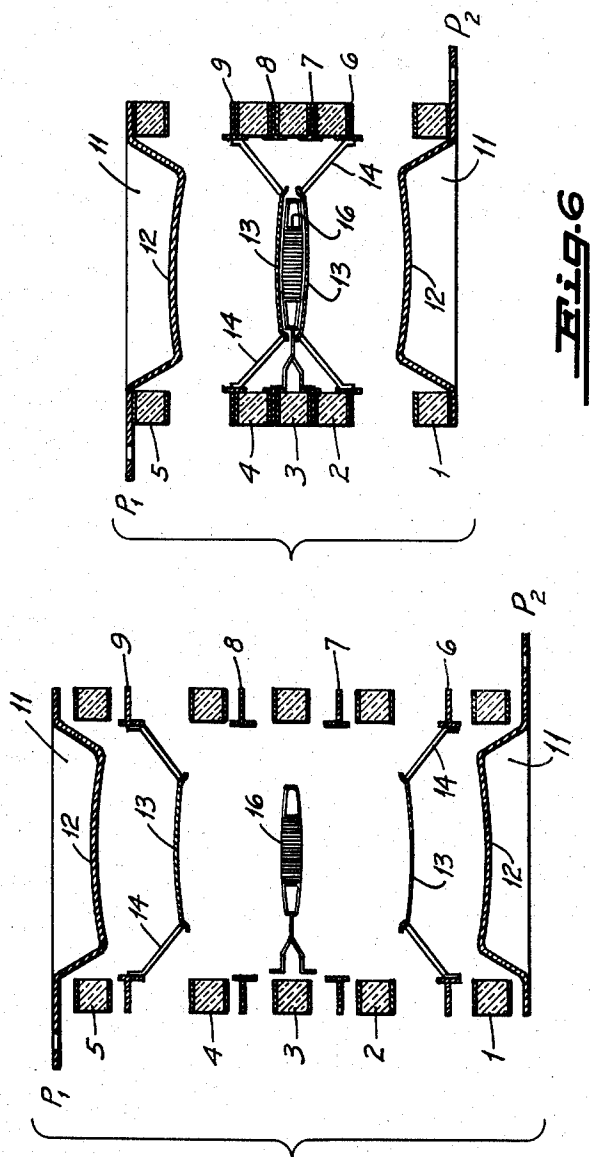
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CERAMIC TYPE ELECTRON TUBE

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4 Sheets-Sheet 3



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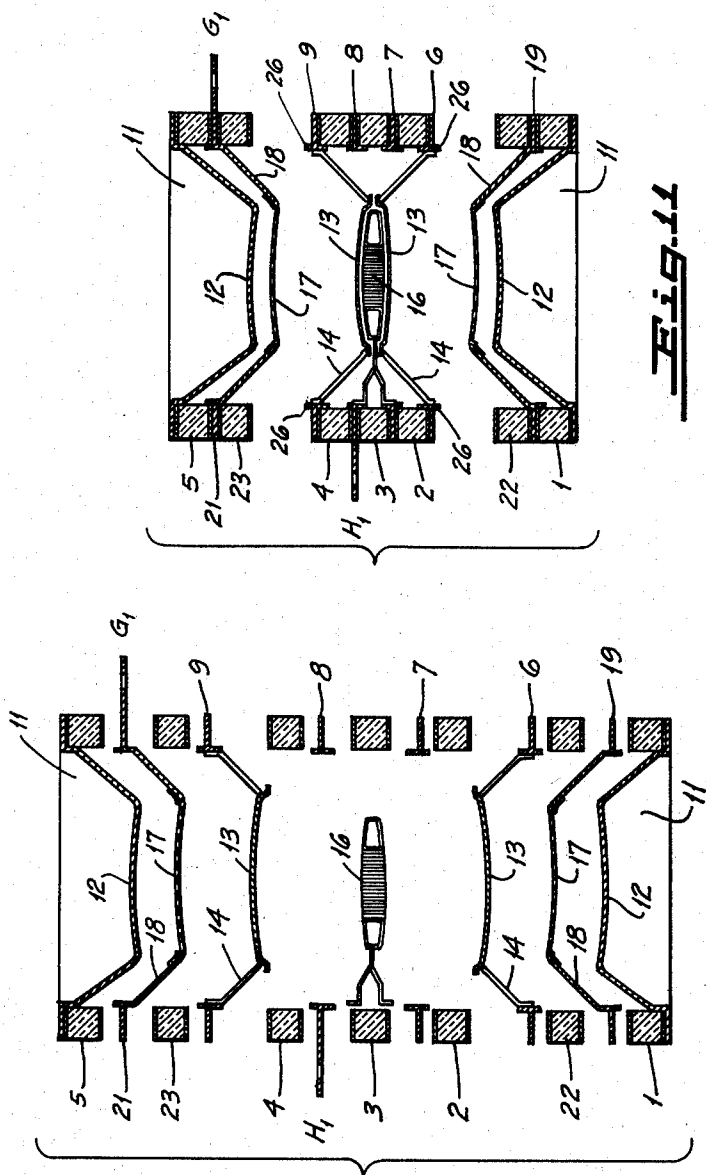
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CERAMIC TYPE ELECTRON TUBE

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7 Claims. (Cl. 313—250)

Our invention relates to electron tubes wherein the envelope embodies ceramic material rather than the conventional glass structure, and more particularly to ceramic type tubes in which the envelope is built up of ceramic rings assembled in stacked relationship.

It is among the objects of our invention to improve the reliability of electron tubes by providing a ceramic tube structure which is mechanically rugged and which will operate in relatively high ambient temperatures.

Another object is to provide a tube adapted for fabrication without skilled personnel and in which the stacked type of structure is ideally suited for assembly by automatic machine operations.

Another object is to improve the life expectancy of electron tubes and to insure reasonably long life even under adverse operating conditions.

A further object is to provide an electron tube adapted to be wired or soldered into a circuit in a manner similar to a condenser or a resistor.

Still another object includes the provision of a stacked ceramic type tube wherein flat metal rings are sandwiched between ceramic rings of the envelope, which metal rings provide electrode supports and terminals.

A further object is to provide a tube of the character described in which the electrodes and associated envelope wall members are first stacked in separate subassemblies, these structural units being then stacked and sealed together to complete the envelope.

A still further object is to provide a tube structure and assembly technique which is particularly well adapted for the smaller tubes such as those in the receiving tube category.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of our invention. It is to be understood that we do not limit ourselves to this disclosure of species of our invention, as we may adopt variant embodiments thereof within the scope of the claims.

Referring to the drawings:

Figure 1 is a plan view of a duo-diode embodying the improvements of our invention; and

Figure 2 is an elevational view of the same.

Figure 3 is an enlarged vertical sectional view of the duo-diode; and

Figure 4 is a horizontal section taken in a plane indicated by line 4—4 of Figure 3.

Figure 5 is a fully exploded sectional view of the tube; and

Figure 6 is a partially exploded view of the same, showing the subassemblies.

Figures 7, 8, 9, 10 and 11 show our improvements incorporated in a duo-triode and correspond to Figures 1, 2, 3, 5 and 6 of the duo-diode.

Referring first to Figures 1 to 6, the duo-diode embodying our invention comprises an evacuated envelope of generally cylindrical shape resembling a pill box. The

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duo-diode illustrated is a twin rectifier in the receiving tube category, the actual tube being about one inch in diameter and approximately $\frac{3}{4}$ inch high. The entire tube is made up of ceramic and metal parts which fit together in stacked relationship, the end walls being of metal to provide anodes and the cylindrical side wall comprising ceramic and metal rings sandwiched and brazed together, which metal rings serve as supports for internal electrodes and also as electrode terminals. The tube does not require a socket, inasmuch as it is designed with lugs for soldering or wiring directly into a circuit as one would do with other more reliable components such as condensers or resistors. The mechanical ruggedness and inherent reliability of our improved electron tube make such handling of the tube possible.

In greater detail and referring particularly to the enlarged view of Figure 3, our stacked tube structure comprises a series of five ceramic rings 1, 2, 3, 4 and 5 with four flat metal rings 6, 7, 8 and 9 sandwiched therebetween. The ceramic is preferably a highly refractory material such as alumina which is a dense body of good mechanical strength, these ceramic rings being metalized at both ends by a suitable metalizing procedure such as the molybdenum-manganese powder sintering process. The interposed metal rings are quite thin, say about .020 inch thick, and are of good electrical conductivity such as copper. These sandwiched parts are brazed together using high temperature brazing alloys, certain of the parts being preferably brazed together in subassemblies before making the final brazes as hereinafter described. The brazed joints form strong mechanical bonds and also provide vacuum-tight seals so that the cylindrical side wall of the final tube is a solid impervious cylinder of rugged construction.

Since the ceramic bodies themselves are strong mechanically and since the brazed joints are of good adherence, it is seen that the envelope structure provides the desired electrical insulation between metal members without sacrifice of ruggedness, it being recalled that an object of our invention is to provide an electron tube of superior reliability under adverse conditions such as shock and vibration. Another feature to be emphasized is that the ceramic bodies and brazing compositions are all of thermal-resistant materials, thus providing an envelope structure which will operate without failure in high ambient temperatures, such as in aircraft where high ambients are frequently encountered.

The use of sandwiched metal rings in the side wall structure provides the desired electrical lead-in conductors through the envelope, which rings perform the dual function of electrode anchoring supports and terminal members. An important structural feature here is that these interposed metal rings are relatively thin compared to the thickness of the adjacent ceramic rings. This minimizes any mismatch due to differences in thermal coefficients of expansion and further enhances the mechanical strength of the layer-like wall structure under conditions of thermal shock over wide ranges of heat cycling.

The ceramic rings are of simple rectangular cross-section and all of the same dimensions, so that one size of ceramic body satisfies the entire tube. This is important in the interests of simplicity and economy.

End walls 11 of the envelope are of metal, preferably stamped out of copper disks, and also provide the anodes 12 of the tube. These anode walls are dished inwardly so that the two circular anodes are brought together into proper close spaced relationship with respect to other electrode structures located centrally in the envelope. This feature enables keeping the envelope side wall of sufficient height to stack in the necessary ceramic rings for insulation purposes.

The duo-diode illustrated has an oxide coated type of cathode, preferably with two separate electron emitting surfaces heated by a common heater. Such cathode structure simply comprises two nickel cathode disks 13, each carrying an oxide coating facing outwardly. Each cathode disk of the circular cathode structure is separately supported by a group of, say, three radial wire rods 14 connected to a metal ring of the envelope side wall, the lower cathode disk being connected to ring 6 and the upper to ring 9. During fabrication of the tube, each half of the cathode is put together as a unitary structure; namely, a cathode disk together with its radial supports and side wall ring are all made up and welded together as one piece (see Figure 5).

The reason for the slender rod-like supports for the cathode disks is to minimize heat conduction away from the cathode and thus keep the heater watts down. Adequate mechanical support and rigidity are obtained by arranging the inwardly extending supporting rods 14 in conical formation, the rods of each half of the cathode converging toward the center of the envelope. Similar rigidity for anodes 12 is achieved by dishing the end walls inwardly along conical surfaces, which surfaces are nested within the conically formed cathode support members 14. Extreme rigidity and compactness of electrode structure are thus obtained.

The cathode heater 16 is a coil of insulated wire, formed as a toroid and interposed between the cathode disks. One end of the heater is connected to side wall ring 7 and the other end to ring 8. Thus, the heater connections are made to the inner pair of side wall rings, and the cathode connections are made to the outer pair of rings.

External connections to the tube are made to terminal lugs formed as integral extensions on the metal side wall rings. As best shown in Figure 1, the terminal lugs are preferably spaced about the circumference of the envelope and are identified by heater terminals H₁ and H₂, cathode terminals K₁ and K₂, and anode terminals P₁ and P₂. These terminals may be used as soldering lugs for wiring the tube into a circuit, which is possible with our tube because of its extreme ruggedness and reliability.

The tube being described is preferably made up of individual parts or components as illustrated in the fully exploded view of Figure 5. These components are then stacked together into three subassemblies, including a cathode-heater assembly unit and two anode assembly units. These three subassemblies are shown in the partially exploded view of Figure 6. There are two simple operations involved in making up each subassembly; first, a stacking operation, and, second, a brazing operation. Since the individual components are self-jigging concentrically and vertically, it is seen that skilled operators are not required and that the stacking is well suited to automatic machine assembly. The brazing operation is likewise simple, merely involving the placement of brazing materials at the joints and loading all into a suitable brazing furnace. The brazing material is preferably in the nature of thin flat rings, say .005 inch thick, first spot welded to opposite sides of the copper rings so that the brazing material is automatically incorporated when the tube parts are stacked together. Large numbers of such subassemblies can be loaded into a single furnace and brazed at one time. A brazing alloy such as copper-gold is preferably used in making up the subassemblies.

The cathode and anode assembly units may then be brazed together and the tube evacuated through an exhaust tubulation (not shown) in the usual manner. We prefer, however, to pump the tube in an exhaust chamber while the parts are separated as shown in Figure 6, using suitable holders to control the separation of the parts while in the vacuum. After outgassing the parts and activating the cathode, the final step involves bringing the parts together and making the final brazes while the whole is still in the vacuum furnace. Localized heating

at the desired joints may be readily achieved by radiant or induction heating methods. Brazing material used at the final brazes is an alloy such as copper-silver having a lower melting point than that used for brazing up the subassemblies.

Figures 7 to 11 illustrate our improvements incorporated in a duo-triode. This tube is similar in structure to the duo-diode first described, and like numerals are used to designate duplicate parts, the duo-triode differing only by the addition of two grid structures and an additional pair of ceramic rings in the side wall. The cathode-heater subassembly seen in Figure 11 is identical with that of the first tube. The two end units, which in this case comprise grid-anode subassemblies, include the grids 17 which are mounted on conical supports 18 extending inwardly from metal side wall rings 19 and 21. The added pair of ceramic rings 22 and 23 serve to insulate the grids from the cathode. Conical grid supports 18 are preferably stamped out as an integral part of the side wall rings and are seated in nested relationship to the anode walls. As was the case of the cathode components, the grid components are also initially made up as unitary structures, viz., the grid disks 17 are first welded in place so that a grid disk together with its support 18 and associated side wall ring comprises a single structure (see Figure 10). Each grid-anode subassembly thus comprises an anode, a grid structure, and two ceramic rings all stacked and brazed together as seen in Figure 11.

In final assembly of the duo-triode, the grid-anode and cathode-heater subassemblies are stacked and brazed together in a manner similar to the tube first described. The additional grid terminals in the case of the duo-triode are designated G₁ and G₂ in Figure 7.

In both the diode and triode types of structure, the electrodes are preferably given some degree of curvature to prevent oil-canning and to provide additional rigidity. As illustrated, cathode disks 13, grid disks 17, and anode disks 12 are all slightly domed, convex outwardly, relative to the center plane of the tube.

In mass production our structural approach to the tube making problem, utilizing tube parts which become common to a variety of tube types, has many advantages. Thus, the basic diode type may be expanded into triode, tetrode or pentode types merely by stacking in the requisite number of grids. The principal manufacturing advantage, however, comes about because of the stacked relationship of all of the components in the tube. This, together with the fact that the individual components may be precision formed, insures accurate assembly procedures. Critical electrode spacings are easily established and maintained, since the supporting members and ceramic spacing rings are all capable of being made to precise dimensions.

Self-jigging of the individual components is an important feature when stacking the parts together. Coaxial alignment is achieved by the annular seats or stops provided between the electrode supports and the associated ceramic rings. Taking the anodes, for example, it is seen that a seat is provided at the junction between the horizontal ring portion and inwardly extending conical portion of the anode wall, which insures that the anodes will automatically be positioned concentrically with respect to the ceramic rings. In the case of the other electrode components, suitable vertical flanges 24 and outturned lips 26 are provided on the metal side wall rings to center the parts with respect to the next adjacent ceramic rings. See Figures 3 and 9. Such lips 26 on the cathode components also function to align the subassemblies when the final seals are made, as seen in Figures 6 and 11.

Life histories on receiving type electron tubes, particularly in military applications, indicate that many tube losses heretofore experienced are directly attributable to physical weaknesses in the tubes, namely, mechanical or structural failures under shock and vibration and failures

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due to inability of the tubes to withstand higher temperature environments. Such classes of failures leading to short tube life show up as broken envelopes, cracked seals, shorted electrodes, opened connections, and the like. With our improved tube structure most of the above problems have been solved and tubes of great reliability have been achieved.

We claim:

1. A stacked ceramic type electron tube comprising a generally cylindrical envelope having side and end walls, the side wall comprising a plurality of metalized ceramic rings with a flat metal ring sandwiched between two of said ceramic rings, the outer surface of said metal ring being exposed to the outside of said envelope, metallic bonds uniting the two ceramic rings to said metal ring, a planar type electrode in the envelope, and a conductive support for the electrode extending inwardly from said metal ring, said electrode support being of conical formation, said metal ring providing a terminal for the electrode, at least one of the end walls of the envelope being of metal providing an anode, and said anode wall being dished inwardly along a conical surface nested within the conically formed electrode support.

2. A stacked ceramic type electron tube comprising a generally cylindrical envelope having side and end walls, the side wall comprising metalized ceramic rings with a flat metal ring sandwiched between each pair of ceramic rings, metallic bonds uniting said ceramic and metal rings, the outer surface of each of said metal rings being exposed to the outside of said envelope, a circular cathode structure located centrally in the envelope, a conductive support for the cathode extending inwardly from one of said metal side wall rings, disk-shaped grids in the envelope disposed at opposite sides of the cathode, conductive supports for the grids extending inwardly from others of the metal side wall rings, said metal rings providing terminals for the cathode and grids, said grid supports being of conical formation, each converging toward the center of the envelope, the end walls of the envelope being of metal providing anodes, and said anode walls being dished inwardly along conical surfaces nested within the conically formed grid supports.

3. A stacked ceramic type electron tube comprising a generally cylindrical envelope having side and end walls, the side wall comprising five metalized ceramic rings and four flat metal rings stacked together so that a metal ring is sandwiched between each pair of the ceramic rings, metallic bonds uniting said ceramic and metal rings, the outer surface of each of said metal rings being exposed to the outside of said envelope, a circular cathode structure located centrally in the envelope and comprising a pair of electron emitting disks, a common heater for the cathode interposed between the disks, conductors for the heater connected to the center pair of the metal side wall rings, and conductive supports for the cathode disks extending inwardly from the outer pair of said metal rings, said metal rings providing terminals for the cathode disks and heater, and said end walls of the envelope being of metal providing anodes.

4. A stacked ceramic type electron tube comprising a generally cylindrical envelope having side and end walls, the side wall comprising seven metalized ceramic rings and six flat metal rings stacked together so that a metal ring is sandwiched between each pair of the ceramic rings, metallic bonds uniting said ceramic and metal rings, the outer surface of each of said metal rings being exposed to the outside of said envelope, a circular cathode structure located centrally in the envelope and comprising a pair of electron emitting disks, a common heater for the cathode interposed between the disks, conductors for the heater connected to the center pair of the metal side wall rings, conductive supports for the cathode disks extending inwardly from the next outer pair of said metal rings, disk shaped grids in the envelope disposed at opposite sides of the cathode, conductive sup-

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ports for the grids extending inwardly from the outermost pair of said metal rings, said metal rings providing terminals for the cathode disks and heater and grids, said grid supports being of conical formation, each converging toward the center of the envelope, said end walls of the envelope being of metal providing anodes, and said anode walls being dished inwardly along conical surfaces nested within the conically formed grid supports.

5. A cathode-heater structure for a dual electron tube of stacked ceramic construction, said cathode-heater structure comprising a first ceramic ring metallized on both ends, a first pair of metal rings, metallic bonds each uniting one of said pair of metal rings to one end of said first ceramic ring, a heater contained within said first ceramic ring, one end of said heater being electrically connected to one of said pair of metal rings and the other end of said heater being electrically connected to the other of said pair of metal rings, a second ceramic ring metallized on both ends, a metallic bond uniting one end of said second ceramic ring to one of said pair of metal rings opposite from said first ceramic ring and in coaxial alignment therewith, a third ceramic ring metallized on both ends, a metallic bond uniting one end of said third ceramic ring to the other of said pair of metal rings opposite from said first ceramic ring and in coaxial alignment therewith, a second pair of flat metal rings, a metallic bond uniting one of said second pair of metal rings to the free end of said second ceramic ring and a metallic bond uniting the other of said second pair of metal rings to the free end of said third ceramic ring, a first cathode disk supported on and electrically connected to one of said second pair of metal rings adjacent one side of said heater, and a second cathode disk supported on and electrically connected to the other of said second pair of metal rings adjacent the other side of said heater.

6. A stacked ceramic type electron tube comprising a generally cylindrical envelope having side and end walls, the side wall comprising a plurality of metalized ceramic rings and a plurality of flat metal rings, one of said plurality of metal rings being sandwiched between each pair of ceramic rings, metallic bonds uniting said ceramic and metal rings, a double cathode structure located centrally in the envelope and comprising a pair of electron emitting disks and a common heater interposed between said disks, opposite ends of said heater being connected to different ones of an adjacent pair of metal rings, a conductive support for one of said cathode disks extending inwardly from another of said metal rings, a conductive support for the other of said cathode disks extending inwardly from yet another of said metal rings, said adjacent pair of metal rings providing terminals for said heater and said other metal rings each providing a terminal for the cathode disk connected thereto, and said end walls of said envelope being of metal providing anodes.

7. A stacked ceramic type electron tube comprising a generally cylindrical envelope having side and end walls, the side wall comprising metalized ceramic rings with a flat metal ring sandwiched between each pair of ceramic rings, metallic bonds uniting said ceramic and metal rings, the outer surface of each of said metal rings being exposed to the outside of said envelope, a double cathode structure located centrally in the envelope and comprising a pair of electron emitting disks, a common heater for the cathode interposed between the disks, a conductive support for one of the cathode disks extending inwardly from one of said metal side wall rings, a conductive support for the other cathode disk extending inwardly from another of said metal side wall rings, said metal rings providing terminals for the cathode disks, and said end walls of the envelope being of metal providing anodes.

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