Nov. 4, 1958 M. E. STANGL 2,859,372

ELECTRON TUBE

Filed July 10, 1956 2 Sheets-Sheet 1

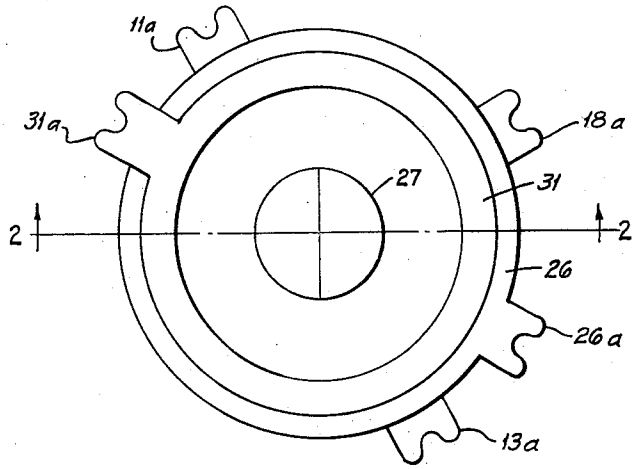


Fig. 1

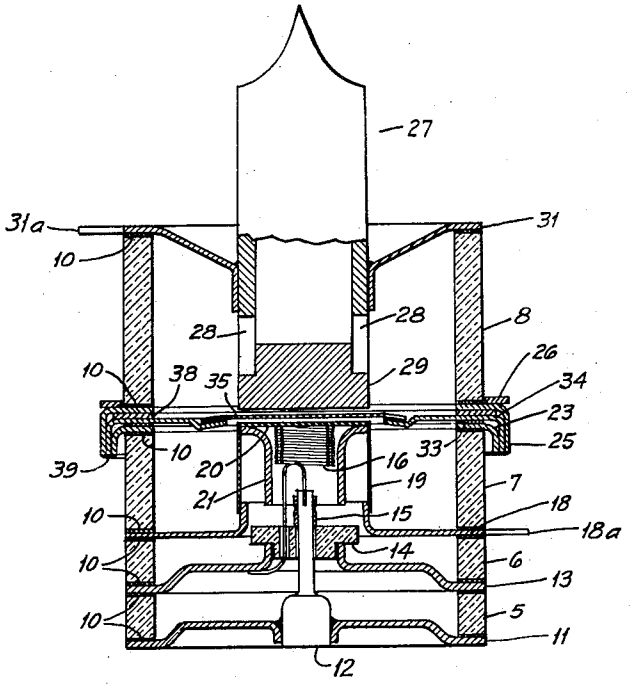


Fig. 2

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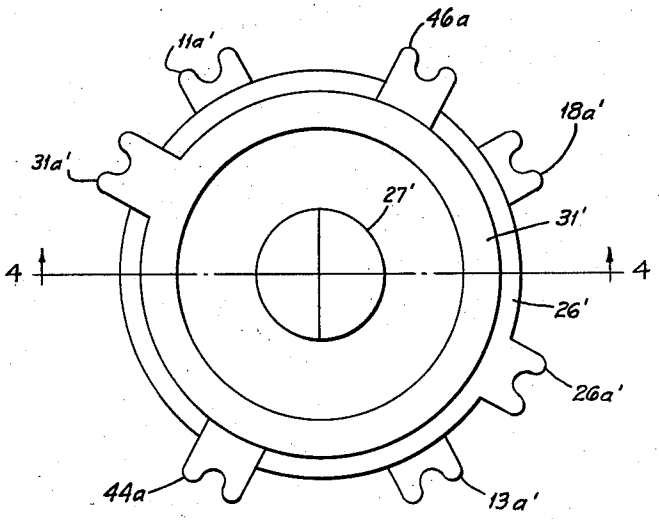


Fig. 3

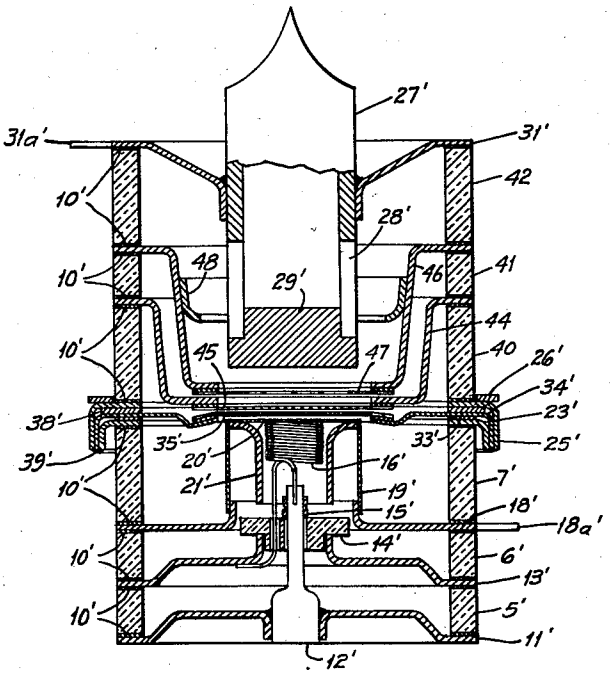


Fig. 4

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ELECTRON TUBE

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9 Claims. (Cl. 313—250)

This invention relates to electron tubes and more particularly to tubes employing ceramic envelope structures.

It is among the objects of the invention to provide a tube configuration which involves a stacked ceramic type envelope in such a manner as to result in a very compact arrangement and one which is particularly suitable for use with tube types requiring closely spaced planar electrodes.

One of the main problems associated with the manufacture of tube types involving closely spaced planar electrodes is that of maintaining the inter-electrode spacings within the required close tolerances. In tubes of conventional glass construction the problem of inter-electrode spacing is complicated by the difficulty experienced in holding glass envelope sections to close tolerances.

Accordingly, another object of the invention is to provide a tube construction in which the inter-electrode spacings are established primarily by ceramic envelope sections which can be worked to relatively close tolerances. In conjunction with the ceramic envelope structure, an object is to incorporate in the envelope an arrangement whereby extremely thin spacing rings can be employed to effect the final spacing.

A further object of the invention is to provide an improved supporting arrangement for the electrodes and heater which includes means for preventing loss of heat from the cathode assembly.

Another object of the invention is to provide a very simple and inexpensive arrangement forming a combined exhaust tube and anode.

Another object of the invention is to provide an envelope structure and electrode arrangement which provides a very rugged tube and one which is particularly adapted for substantial assembly by automatic machinery.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of the invention. It is to be understood that the invention is not limited to the disclosed species, as variant embodiments thereof are contemplated and may be adopted within the scope of the claims.

Referring to the drawings:

Figure 1 shows the top view of a triode embodying the features of the invention.

Figure 2 is a vertical sectional view of the tube taken on line 2—2 of Figure 1.

Figure 3 is a top view of a pentode embodying the features of the invention; and,

Figure 4 is a vertical sectional view of the tube taken on line 4—4 of Figure 3.

Tubes embodying the features of the invention comprise an envelope structure made up of a plurality of annular ceramic sections with relatively thin metal rings sandwiched between the adjacent ceramic sections. A high alumina type ceramic has been found to be most desirable, and the metal rings are preferably made of copper or nickel. In the triode version disclosed in Figures 1 and 2, the ceramic sections are designated

5, 6, 7 and 8. The ends of each of the ceramic sections are metalized as indicated by the reference numeral 10. Any suitable process can be used to metalize the ceramic sections. For example, the areas to be metalized can be coated with an 80%–20% mixture of powdered molybdenum and manganese in a suitable liquid vehicle and then fired in a reducing atmosphere at a temperature of about 1500° C.

A heater supporting ring 11, which is made of metal and serves also as an end plate, is brazed to the lower end of the bottom ceramic section 5. A metal heater pin 12 is brazed in the center aperture in ring 11 so that members 11 and 12 together form a closure for the bottom of the tube. A second heater ring 13 is sandwiched between ceramic sections 5 and 6 and brazed to the adjacent ends of these two sections. A sleeve 14 of insulating material such as alumina ceramic is passed downwardly over pin 12 and received within the center aperture in ring 13. A thin metal band 15 is then passed downwardly against sleeve 14 and crimped inwardly against pin 12 to hold the sleeve in place, or the sleeve can be metalized on its rim and brazed in the aperture in ring 13. A heater coil 16 is positioned above pin 12 with one end of the coil spot welded to pin 12 and the other end spot welded to ring 13.

A cathode supporting ring 18 is sandwiched between ceramic sections 6 and 7 and brazed to the adjacent ends of these sections. A cathode assembly is attached to ring 18 in the following manner: A cylinder 19 of thin metal such as Kovar is brazed or spot welded to ring 18. An electron emitting disk 20 and a suitable heat shield 21 are brazed or spot welded to the upper end of cylinder 19. The insulating sleeve 14 forms effective protections against radiant heat loss from the cathode assembly since it substantially closes the aperture in ring 18.

A metal sealing flange 23 is brazed to the top of ceramic section 7 to complete one section of the tube which can be termed the lower or cathode assembly. Preferably, the cathode assembly is formed in a jig with brazing washers between metal rings 11, 13, 18 and 23 and the adjacent ceramic sections so that the entire assembly can be brazed in one operation. In any event, the lower or cathode assembly is completely brazed before final assembly with the upper or anode assembly which will now be described.

The other section of the tube is the anode assembly and comprises at its lower end a metal sealing flange 25 brazed to the bottom of ceramic section 8. A metal terminal ring 26 is brazed to the top of ring 25 and is provided with the terminal tab 26_a. The anode itself comprises a length of copper exhaust tube 27 having slots 28 and an end disk 29 of metal such as copper brazed in the bottom of the tubulation. The anode is provided with a metal flange or supporting ring 31 which is brazed to the top of ceramic section 8 to form an end plate at the upper end of the tube. As in the case of the cathode assembly, the anode assembly is formed in a jig and is completely brazed before the two assemblies are joined.

One important feature of the anode structure is that it can be accurately positioned relative to the under surface of sealing flange 25. The desired procedure is to braze the entire anode assembly except for the anode structure 27, 29. Then, since tube 27 has straight outer walls, it can be moved axially in the aperture in ring 31 until the lower surface of anode disk 29 is exactly positioned with respect to the under surface of sealing flange 25. When this position is fixed, the tube 27 is brazed in ring 31.

The two separate assemblies are joined in the following manner: A spacing ring 33 is positioned on top of sealing flange 23, and a control grid supporting ring 34 is

mounted on top of ring 33. Various sizes of ring 33 are made available for this purpose, and a ring is selected which has the thickness necessary to provide the proper spacing between the cathode disk 20 and the control grid 35. A conventional wire control grid 35 is brazed on supporting ring 34 before the ring is inserted in the tube. Thus, it will be understood that by selecting a spacing ring 33 of proper thickness, the exact desired spacing between the cathode disk and the control grid 35 can be obtained, regardless of the position of cathode disk 20 relative to the top of ring 23 and regardless of the position of grid 35 relative to the under surface of its supporting ring 34. Similarly, a spacing ring 38 of selectable thickness is positioned on top of ring 34 to obtain the desired spacing between control grid 35 and the bottom surface of the anode disk 29. In order that the accurate inter-electrode spacing achieved in this manner will not be destroyed, there is no brazing or other bonding material between spacing rings 33 and 38 and the adjacent rings 23, 25 and 34. Instead, rings 33 and 38 are seated in direct contact with the adjacent metal rings. In order to close the otherwise open joint, flanges 23 and 25 are sealed at their registering edges by the braze or weld indicated at 39. The spacing rings 33 and 38 are preferably made of metal such as nickel. In order to provide rigidity and positive centering, supporting ring 34 is preferably provided with a downturned rim which fits between the downturned rims of flanges 23 and 25.

The pentode version shown in Figures 3 and 4 involves the essential features of the triode version, and similar parts are designated with primed reference numerals.

In the pentode version the cathode assembly comprises the ceramic insulating sections 5', 6' and 7' brazed to the metal rings 11', 13', 18' and 23'. It will be seen in Figure 4 that each of the ceramic sections is metalized at its ends as indicated at 10'. The heater subassembly comprises the heater pin 12', ceramic sleeve 14', fastening sleeve 15' and heater coil 16'.

The cathode subassembly comprises the supporting sleeve 19', the cathode disk 20', and the heat retaining member 21'. As in the case of the triode version, the complete cathode assembly is fabricated and brazed before it is joined to the anode assembly.

In the triode version the spacing ring 38 was used to obtain accurate spacing between the control grid and anode. In the pentode version the more important spacing is between control grid and screen grid. Thus, spacing ring 38' is used primarily to fix the distance between control grid 35' and screen grid 45.

The anode assembly of the pentode corresponds to the anode assembly of the triode in the following respects. The anode assembly of the pentode comprises the sealing flange 25' to which is brazed the terminal ring 26', having the terminal tab $26_a'$. The anode assembly also comprises the anode unit made up of exhaust tube 27' which has slots 28' and anode disk 29' at its lower end, and the metal supporting flange 31' above slots 28'. There are certain differences between the anode assemblies of the triode and pentode as a result of the two additional grids in the pentode, as will be more fully described hereinafter.

As in the case of the triode, the cathode and anode assemblies of the pentode are both separately fabricated and then joined in a manner which establishes the desired inter-electrode spacing. Spacing ring 33' is placed on top of sealing ring 23', and then the supporting ring 34' which carries the control grid 35' is added. Next the spacing ring 38' is added, and then the sealing ring 25' which carries the anode assembly is placed on top of spacing ring 38'. The final seal 39' is then made at the registering edges of the rings 23', 25' and 34'.

The anode assembly of the pentode corresponds to that of the triode in the previously mentioned respects. It differs in the following respects: Instead of the single ceramic section 8 in the triode, the pentode has three ceramic sections 40, 41 and 42. Between the sections 40 and 41 is brazed a metal supporting ring 44 which carries a conventional wire screen grid 45. Similarly, a metal supporting ring 46 is brazed between the ceramic sections 41 and 42, and suppressor grid 47 is brazed on the supporting ring 46. A shield ring 48 is brazed to the supporting ring 46 in order to prevent materials of volatilization from oxide coated cathode 20' from depositing on the inner wall of ceramic cylinder 42. It will be noted that supporting rings are generally cup-shaped so as to surround the anode and are provided with annular rims which are sandwiched between the ceramic sections 40, 41 and 42.

It has been pointed out that rings 26 and 26' serve respectively as terminals for grids 35 and 35' and for this purpose are provided with terminal tabs 26_a and $26_a'$. It should also be noted that the supporting rings for the various other electrodes serve directly as terminals. Thus in the triode version of Figures 1 and 2 the rings 11, 13, 18, and 31 are respectively provided with terminal tabs 11_a, 13_a, 18_a and 31_a. Similarly in the pentode version of Figures 3 and 4 the rings 11', 13', 18', 44, 46, and 31' are respectively provided with terminal tabs $11_a'$, $13_a'$, $18_a'$, 44_a, 46_a and $31_a'$. Since the tube is small and extremely rugged, it can safely be wired permamently in a circuit by soldering the circuit wires directly to the appropriate terminal tabs.

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

1. An electron tube having an envelope comprising a plurality of ceramic rings stacked one above the other and metal rings sandwiched between said ceramic rings, all of said ceramic rings being of substantially equal diameter and metalized on their ends, metallic bonds joining the metalized ends of each ceramic ring to the adjacent metal ring, some of said metal rings being sandwiched separately between said ceramic rings, and others of said metal rings being sandwiched in a group, said tube having planar type electrodes comprising a cathode, anode, and grid, said cathode being supported by one of said separate metal rings, said grid being supported by one of the rings in said group, said group comprising two sealing rings bonded respectively to the ceramic sections adjacent the group, said grid supporting ring being sandwiched between said sealing rings, spacing rings sandwiched between said grid supporting ring and said sealing rings, and a metallic bond joining said sealing rings together in a vacuum-tight seal externally of the tube.

2. An electron tube having an envelope comprising a plurality of insulating rings, and metal rings sandwiched between said insulating rings, some of said metal rings being sandwiched separately between said insulating rings and others of said metal rings being sandwiched in a group, said tube having planar type electrodes comprising an anode, a cathode, a control grid and at least one other grid, said control grid being supported by one of the metal rings in said group, said cathode being supported by one of said separate metal rings, said other grid being supported by another of said separate metal rings, said cathode supporting ring being spaced from said group toward one end of the tube, and said other grid supporting ring being spaced from said group toward the other end of the tube, said group comprising in addition to said control grid supporting ring two sealing rings respectively bonded to the insulating rings adjacent the group and two spacing rings sandwiched between said sealing rings, said control grid supporting ring being sandwiched between said spacing rings, and said spacing rings being in direct contact with the adjacent surfaces of the control grid supporting ring and sealing rings, and a metallic bond joining said sealing rings together in a vacuum-tight seal externally of the tube.

3. A generally cylindrical electron tube having a first section comprising a metal end plate at one end, a heater,

a supporting rod connected to one end of said heater and attached to said end plate, a first ceramic ring having one end seated on said end plate, a first metal ring surrounding said rod and attached to the other end of said heater, said first metal ring being seated on the other end of said first ceramic ring, a second ceramic ring having one end seated on said first metal ring, a second metal ring seated on the other end of said second ceramic ring, a cathode cylinder attached to said second metal ring and surrounding said heater, an electron emitting disk attached to the end of said cathode cylinder, a third ceramic ring having one end seated on said second metal ring, metallic bonds joining the ends of said first three ceramic rings respectively to said end plate and said first two metal rings, said tube having a second section comprising at least one ceramic ring, one end of said second section being positioned adjacent said third ceramic ring of said first section, an anode attached to the other end of said second section and projecting inwardly of the second section toward said electron emitting disk, and sealing means forming a vacuum-tight joint between said second section and said third ceramic ring of the first section.

4. An electron tube as claimed in claim 3 in which a planar type control grid is positioned between said anode and said electron emitting disk, and a supporting ring for said grid is sandwiched between said first and second sections.

5. An electron tube as claimed in claim 4 in which said second section comprises three ceramic rings, two planar type grids consisting of a screen grid and a suppressor grid, and two supporting rings, one for each of said two grids, said two supporting rings being generally cup-shaped and surrounding said anode, and an annular rim on each of said two supporting rings sandwiched between said three ceramic rings of the second section, and metallic bonds joining said rims to the ends of the adjacent ceramic rings of said second section.

6. An electron tube having an envelope comprising a plurality of ceramic rings metallized on their ends, and metal rings sandwiched between said ceramic rings, metallic bonds joining the metallized ends of said ceramic rings to the adjacent metal rings, a planar type cathode in said tube, an apertured metal end plate at one end of said tube and a metallic bond joining said end plate to the end of the last ceramic ring at said one end of the tube, an exhaust tube metallically bonded in said aperture and closed at its outer end, said exhaust tube having a constant wall thickness and a constant external diameter throughout its length inwardly of said closed end, an end disk attached to the inner end of said tube and forming an anode surface substantially parallel to said cathode, and an exhaust aperture provided for said tube between said end plate and said anode surface of the end disk.

7. An electron tube having an envelope comprising a plurality of metal sections each having a flat annular portion, and cylindrical ceramic sections metalized on their ends and sandwiched between said metal sections, metallic bonds joining the metalized ends of said ceramic sections to said flat portions of the adjacent metal sections, a cathode assembly in said envelope forming a generally cylindrical structure having one end thereof attached to one of said metal sections, said one metal section having an aperture opening into said cylindrical cathode structure, a heater in said cathode structure, an elongated support connected to one end of said heater and attached to a second of said metal sections, a third one of said metal sections being interposed between said first and second sections and connected to the other end of said heater, said heater support extending through an aperture in said third metal section and through the aperture in said one metal section, and an insulating sleeve surrounding said heater support and substantially closing the aperture in said one metal section.

8. An electron tube having an envelope comprising a plurality of ceramic rings and metal rings sandwiched between said ceramic rings, said ceramic rings being metallized on their ends and metallic bonds joining the metallized ends of each ceramic ring to the adjacent metal rings, some of said metal rings being sandwiched separately between said ceramic rings, and others of said metal rings being sandwiched in a group, said tube having planar type electrodes comprising a cathode, anode, and grid, said cathode being supported by one of said separate metal rings, said grid being supported by one of the rings in said group, said group comprising two sealing rings bonded respectively to the ceramic sections adjacent the group, said grid supporting ring being sandwiched between said sealing rings, a spacing ring sandwiched between said grid supporting ring and one of said sealing rings, and a metallic bond joining said sealing rings together in a vacuum-tight seal external of the tube.

9. An electron tube having an envelope comprising a plurality of ceramic rings and metal rings sandwiched between said ceramic rings, said ceramic rings being metallized on their ends and metallic bonds joining the metallized ends of each ceramic ring to the adjacent metal rings, some of said metal rings being sandwiched separately between said ceramic rings, and others of said metal rings being sandwiched in a group, said tube having planar type electrodes comprising a cathode, anode, control grid, and another grid, said cathode being supported by one of said separate metal rings, said control grid being supported by one of the rings in said group, said other grid being supported by another of said separate metal rings, said cathode supporting ring and said other grid supporting ring being positioned on opposite sides of said group of rings, said group comprising two sealing rings bonded respectively to the ceramic sections adjacent the group, said control grid supporting ring being sandwiched between said sealing rings, a spacing ring sandwiched between said control grid supporting ring and the sealing ring nearest said other grid supporting ring, and a metallic bond joining said sealing rings together in a vacuum-tight seal externally of the tube.

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