Sept. 27, 1955 H. E. SORG ET AL 2,719,185

CERAMIC ELECTRON TUBE

Filed Jan. 23, 1951 2 Sheets-Sheet 1

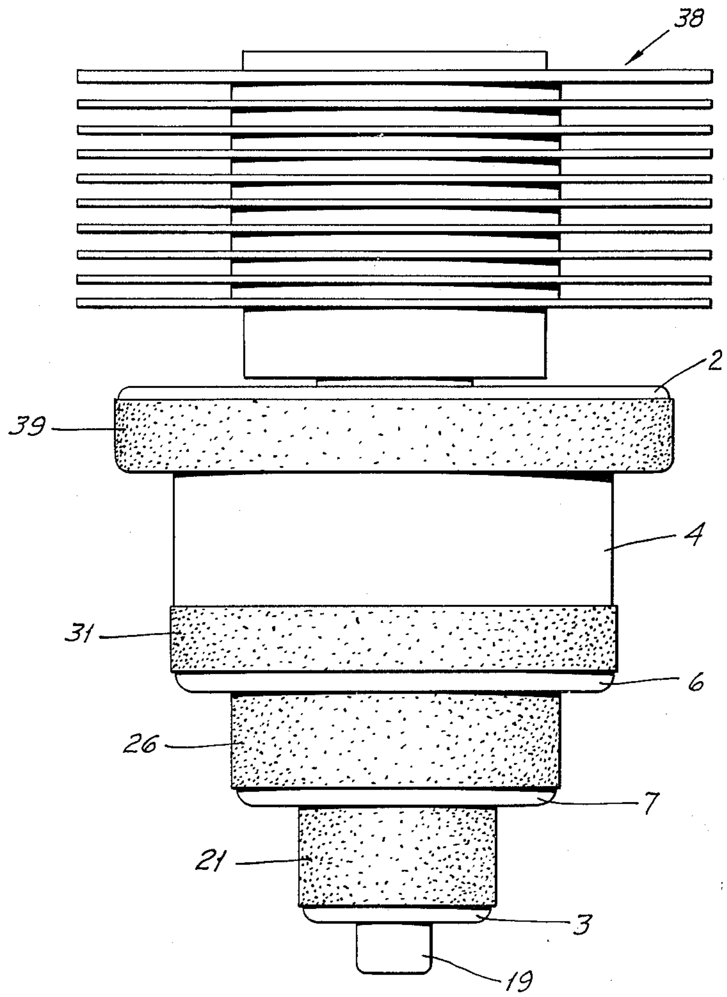

Fig. 1

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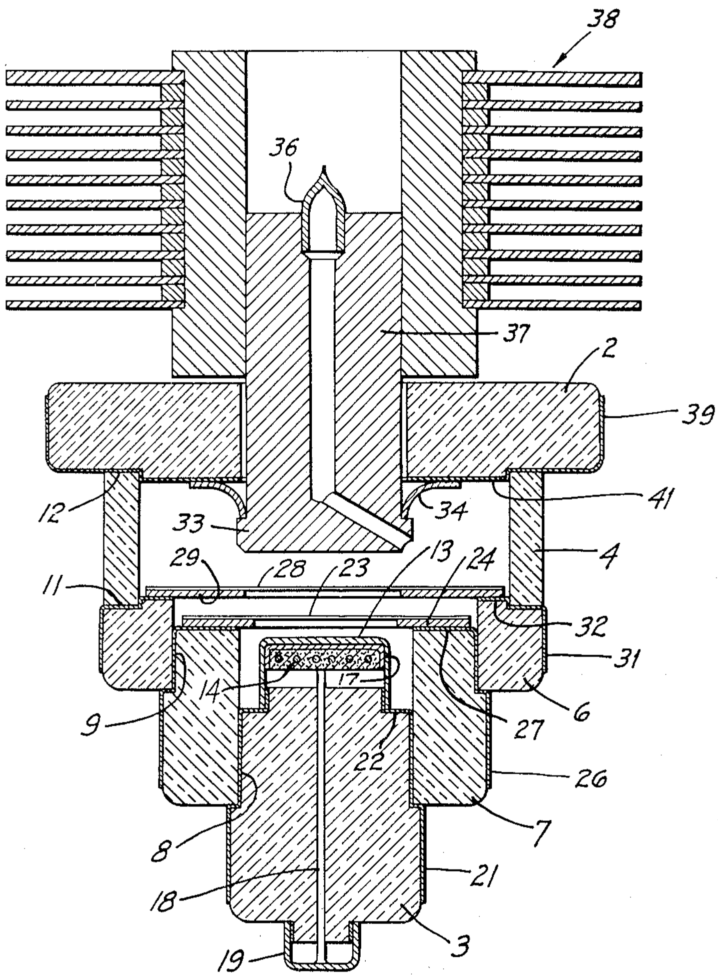

Fig. 2

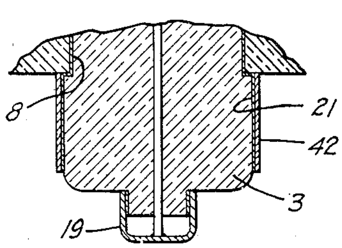

Fig. 3

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CERAMIC ELECTRON TUBE

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Application January 23, 1951, Serial No. 207,302

5 Claims. (Cl. 174—50.53)

Our invention relates to electron tubes and more particularly to tubes having ceramic envelopes such as disclosed in our copending United States Letters Patent 2,647,218 granted July 28, 1953.

It is among the objects of our invention to provide further improvements in a tube wherein the envelope comprises ceramic sections metallically bonded together and in which the metallic bonds serve as lead-in conductors for the electrodes.

Another object is to provide such a tube having its envelope built up of vertically disposed coaxial ceramic sections, the sections being preferably interfitted at the joints for alignment.

Another object is to provide a tube of the character described wherein the electrode terminals comprise metalized areas on the outer surfaces of the ceramic sections, and in which the sections have different external diameters to provide offset coaxial terminals.

A further object is to provide a tube structure having improved electrical, thermal and mechanical properties, and which is particularly well adapted for economical manufacture.

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 drawing:

Figure 1 is a side elevational view of a tube embodying the improvements of our invention; and

Figure 2 is a vertical sectional view of the same.

Figure 3 is a fragmentary view showing a modified terminal construction.

In terms of broad inclusion our improved electron tube comprises an envelope made up of ceramic sections metallically bonded together at the joints, the external terminal being preferably formed by metalized areas on the ceramic sections and connected to the internal electrodes through the metallic bonds. The ceramic envelope sections are preferably coaxial and vertically disposed, the outer cylindrical surfaces of the sections being of different diameters decreasing in size toward the lower end of the envelope to provide offset coaxial terminals for the electrodes. In our preferred construction the envelope sections are interfitted at the joints, as by recessed edges, to facilitate alignment during assembly. The tube structure embodying our invention is particularly well adapted for tubes having a number of electrodes, such as triodes or tetrodes, and especially to such tubes having planar type electrodes.

In greater detail and referring to Figures 1 and 2 of the drawings, we show a planar electrode tetrode for purposes of illustration. The improved tube comprises an evacuated envelope made up of vertically disposed coaxial sections of ceramic, namely, an upper ring-shaped section **2**, a lower stem section **3**, and three cylindrical side wall sections **4**, **6** and **7** interposed between the end sections. The envelope is thus built up of a series of vertically stacked ceramic sections, which sections are coaxial about the central axis of the tube. The envelope sections have outer cylindrical surfaces of different diameters decreasing in size toward the lower end of the envelope for the purpose of providing offset coaxial terminals as hereinafter described.

In order to facilitate assembly, the ceramic envelope sections are preferably interfitted at the joints for self-alignment of the parts when the sections are stacked together. This is accomplished by recessing the sections to provide annular seats for receiving adjacent sections, as seen in Figure 2. The several sections are thus seated one against the other, which serves to align the parts coaxially and vertically.

The ceramic envelope sections in our tube are metallically bonded together at the joints to form vacuum-tight seals; the stem and wall sections **3** and **7** being united by a metallic bond **8**, the wall sections **7** and **6** being united by a metallic bond **9**, the wall sections **6** and **4** being united by a metallic bond **11**, and the wall and upper sections **4** and **2** being likewise united by a metallic bond **12**. These metallic bonding layers extend along the abutting surfaces between the parts from the inside to the outside of the envelope and also function as lead-in conductors for the electrodes as hereinafter described in greater detail.

The ceramic used in making up the envelope may be of any suitable ceramic-like material, such as the alumina or zircon type ceramic bodies commercially available. We prefer the alumina or zircon type bodies because their mechanical strength, thermal resistance and electrical insulating properties are favorable, although other type ceramics are also satisfactory.

Metallic bonds **8**, **9**, **11** and **12** forming the vacuum-tight seals may be made in several ways, utilizing known metallizing and brazing techniques. For example, the opposed surfaces of the ceramic pieces may be coated with finely divided molybdenum powder, or a mixture of molybdenum and iron powders or the like, and then fired in hydrogen to a temperature of about 1500° C. to sinter the metal powder to the ceramic surface. This produces a thin metallic layer firmly bonded to the ceramic. Such metalized surfaces may then be brazed or soldered together with silver solder or brazing alloys such as silver-copper, gold-copper or the like. The brazes are readily made by fitting the metalized ceramic pieces together with rings of wire solder adjacent the joints, and then elevating the temperature of the whole up to the melting point of the solder in a suitable furnace. Another metalizing technique is to paint titanium or zirconium hydride powders on the surfaces of the ceramic parts and fire in vacuum to about 1200° C., after which the metalized surfaces may be brazed together with silver solder or the like. We prefer the molybdenum sintering process because it does not require a vacuum furnace for the firing operation.

In the tube illustrated having an indirectly heated cathode the latter comprises a cup-shaped cathode sleeve **13** such as nickel enclosing a suitable heater **14**, the end of the cathode sleeve being coated with an electron emissive material such as the conventional barium-strontium oxides. In our preferred construction the cathode is supported by the ceramic stem section **3** which projects into the envelope for that purpose, the cathode sleeve being fitted on the reduced inner end of the stem. A convenient heater structure comprises a flat helix of wire embedded in a suitable insulating material carried by a cup-shaped liner **17** pressed into the cathode sleeve, one end of the heater wire being connected to the cathode sleeve and the other end brought out by a lead 18 through a hole in the stem and connected to a cup-shaped metal terminal 19 brazed to a reduced end of the ceramic stem section.

As hereinbefore mentioned, the metallic bonds between the ceramic sections are utilized as lead-in conductors to the electrodes. In the case of the cathode the bond 8 serves as the lead-in conductor. Another feature in our construction is that the external terminals on the envelope as well as the internal connections to the electrodes are preferably formed by metalized areas on the ceramic sections. Thus, when the ceramic stem 3 is treated, as by molybdenum sintering, to metalize the region adjacent the joint, it is also preferably metalized over substantially its entire length so as to simultaneously provide the external cathode terminal 21 and the internal connection 22, the cathode sleeve 13 being connected or brazed directly to the metalized area 22.

Control grid 23 of the tetrode illustrated lies transversely across the envelope above the cathode and comprises parallel grid wires fastened to a metal ring 24. The control grid is supported by side wall section 7 of the envelope, section 7 projecting internally to provide a flat ledge for that purpose. Metallic bond 9 serves as the lead-in conductor for the control grid and the external terminal 26 as well as the internal connection 27 are formed by metalized areas on the ceramic section 7. Thus, when section 7 is treated to metalize the region adjacent the joint, the metalized areas are preferably extended to provide an external band on the outer cylindrical surface for the grid terminal 26 and an internal band on the inner flat ledge for the grid connection 27, the grid ring 24 being connected or brazed directly to the metalized area 27.

Screen grid 28 also lies transversely across the envelope and comprises parallel wires fastened to a metal ring 29, the screen grid being supported by side wall section 6 which has an inwardly projecting ledge for that purpose. Metallic bond 11 serves as the lead-in conductor for the screen grid, and the external terminal 31 as well as the internal connection 32 are formed by metalized areas on the ceramic section 6. Thus, when section 6 is treated to metalize the region adjacent the joint the metalized areas are preferably extended to provide an external band on the outer cylindrical surface for the screen grid terminal 31 and an internal band on the inner flat ledge for the screen grid connection 32, the grid ring 29 being connected or brazed directly to the metalized area 32.

The metal anode 33, say of copper, preferably projects into the envelope through the upper ring-shaped section 2 and is supported on the latter by a metal sealing flange 34. Exhaust tubulation 36 is preferably mounted on the anode and outwardly projecting portion 37 of the anode preferably carries a suitable cooler 38. Metallic bond 12 serves as the lead-in conductor for the anode and the external terminal 39 as well as the internal connection 41 are formed by metalized areas on the ceramic section 2. Thus, when section 2 is treated to metalize the region adjacent the joint, the metalized areas are preferably extended to provide an external band on the outer cylindrical surface for the anode terminal 39 and an internal band on the inner surface for the anode connection 41, the anode sealing flange 34 being brazed directly to the metalized area 41.

The brazes at the joints and metalized areas for the terminals are shown as having appreciable thickness for convenience of illustration. Actually these are quite thin metallic layers, say of the order of 0.002″ to 0.005″ thickness, and appear as films or metal skins on the surfaces of the ceramic. If desired, silver, copper or the like may be flowed or electroplated over the sintered areas to further improve the electrical conductivity of such areas. Copper plating on the sintered areas, for example, makes excellent terminal surfaces and is ideal for brazing the surfaces together at the joints either with or without the use of additive brazing material.

Since the several electrode terminals 39, 31, 26 and 21 are on the outer cylindrical surfaces of the ceramic sections, which surfaces are of different diameters decreasing in size toward the lower end of the envelope, it will be seen that our structure provides offset coaxial terminals on the tube. As clearly shown in Figures 1 and 2, the anode terminal 39 is on a surface of larger diameter than that of the cathode terminal 21, and screen and control grid terminals 31 and 26 are on surfaces of intermediate diameter. Such terminal arrangement is particularly well suited for coaxial type cavity circuits used in high frequency work.

Our improved tube construction eliminates the metal pieces which usually have to be interposed in a tube envelope, and provides a substantially all-ceramic envelope. The tube is extremely strong mechanically and has excellent thermal resistance properties for high temperature operation. Another important feature is that excellent paths for radio-frequency current are provided for circuit connections to the electrodes, which paths are short, direct and of low loss. These advantages together with the coaxial terminal arrangement all contribute to make the tube ideally suited for operation at the ultra-high frequencies. Still another important advantage of our tube is that it is easy to assemble and is well adapted for economical high speed production. The interengaging feature at the joints of the ceramic sections, so that the envelope can be accurately assembled by simply stacking the sections together, contributes to the ease of tube fabrication. In our tube the metalized envelope sections are stacked together with rings of suitable brazing material adjacent the joints and the entire assembly placed in a furnace for brazing in one operation.

Mounting of the electrodes directly on the ceramic sections eliminates internal hardware and still further improves the tube for operation at the higher frequencies.

Furthermore, and this is important, the ceramic envelope sections may be accurately sized, even by finish grinding if desired, to precisely and accurately establish the spacings between the electrodes, such as the cathode-to-grid, grid-to-grid and grid-to-anode spacings. With precision made envelope sections, which is possible in our construction, and with the interengaging feature at the joints which self-aligns the sections both concentrically and longitudinally, it will be seen that the spacings between the electrodes are under precise control during assembly of the tube. All of this is achieved without requiring special jigs or skilled operators. Another advantage, since the envelope sections are made of the same kind of material having the same coefficient of expansion, is that mechanical stresses between the parts during temperature fluctuations are minimized. Thus, envelope cracks, seal failures and other undesired effects are avoided which frequently occur in conventional tubes where different kinds of materials are used in envelope constructions.

Figure 3 is a fragmentary view of the stem section showing a modified terminal arrangement in which a metal sleeve 42 is brazed to the external metalized area of the stem to provide the cathode terminal, which sleeve is thus connected to the electrode via the braze 8 as previously described. Similar sleeves may likewise be provided on the other sections for the grid and anode terminals. Such sleeved terminal construction is desirable in some cases where a heavier terminal structure is desired although the metalized terminal surface first described is simpler and adequate in most instances.

While we have illustrated our improvements in connection with a tetrode having planar electrodes, it is understood that the structure is well suited for tubes having other internal electrode assemblies such as triodes or pentodes, or tubes having cylindrical instead of planar electrodes. Likewise, our improvements may be incorporated in tubes having radiation cooled internal anodes as well as tubes having externally cooled anodes, as will be readily appreciated.

We claim:

1. An electron tube having an envelope comprising a series of vertically stacked coaxial sections of ceramic fitted together at joints between the sections, said sections having abutted portions at the joints to establish vertical alignment of the stacked sections, metallic bonds uniting the ceramic sections at the joints, said sections having outer cylindrical surfaces of different diameters decreasing in size toward an end of the envelope, metalized areas on said cylindrical surfaces providing exposed offset coaxial terminals, and electrodes in the envelope connected to the terminals through said metallic bonds.

2. An electron tube having an envelope comprising a series of vertically stacked coaxial sections of ceramic fitted together at joints between the sections, said sections having telescoping portions at the joints establishing coaxial alignment of the stacked sections, metallic bonds uniting the ceramic sections at the joints, said sections having outer cylindrical surfaces of different diameters decreasing in size toward an end of the envelope, metalized areas on said cylindrical surfaces providing exposed offset coaxial terminals, and electrodes in the envelope connected to the terminals through said metallic bonds.

3. An electron tube having an envelope comprising a series of vertically stacked coaxial sections of ceramic fitted together at joints between the sections, said sections having partially abutting and partially telescoping portions at the joints establishing both vertical and coaxial alignment of the stacked sections, metallic bonds uniting the ceramic sections at the joints, said sections having outer cylindrical surfaces of different diameters decreasing in size toward an end of the envelope, metalized areas on said cylindrical surfaces providing exposed offset coaxial terminals, and electrodes in the envelope connected to the terminal through said metallic bonds.

4. An electron tube having an envelope comprising a series of vertically stacked coaxial sections of ceramic fitted together at joints between the sections, metallic bonds uniting the ceramic sections at the joints, metalized areas on outer cylindrical surfaces of the ceramic sections providing terminals, and electrodes in the envelope connected to the terminals through said metallic bonds, said electrodes having active surfaces disposed in spaced horizontal planes and each electrode being supported by a different ceramic section of the envelope, said sections having abutting portions along horizontal planes at the joints to establish vertical alignment of the stacked sections and to fix the spacing between the electrodes.

5. An electron tube having an envelope comprising a series of vertically stacked coaxial sections of ceramic fitted together at joints between the sections, metallic bonds uniting the ceramic sections at the joints, metalized areas on outer cylindrical surfaces of the ceramic sections providing terminals, and electrodes in the envelope connected to the terminals through said metallic bonds, said electrodes having active surfaces disposed in spaced horizontal planes and each electrode being supported by a different ceramic section of the envelope, the envelope sections having inwardly projecting portions providing flat supporting ledges for the electrodes, said sections having abutting portions along horizontal planes at the joints to establish vertical alignment of the stacked sections and to fix the spacing between the electrodes.

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