July 28, 1953 H. E. SORG ET AL 2,647,218

CERAMIC ELECTRON TUBE

Filed Dec. 26, 1950

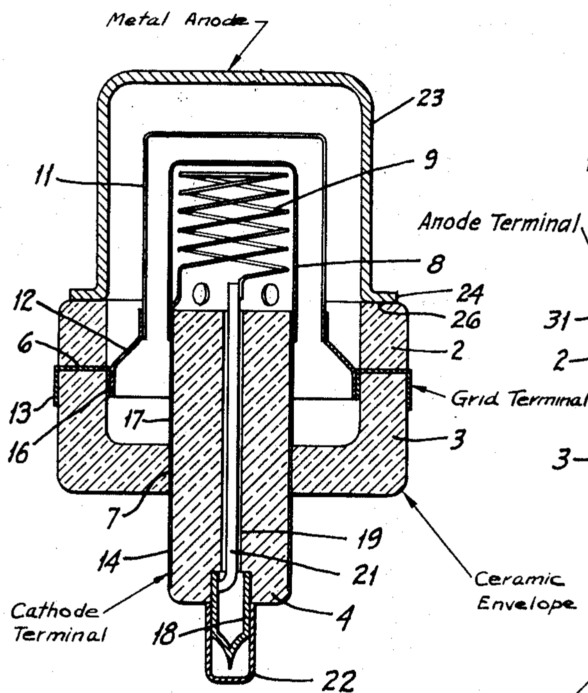

Fig.1

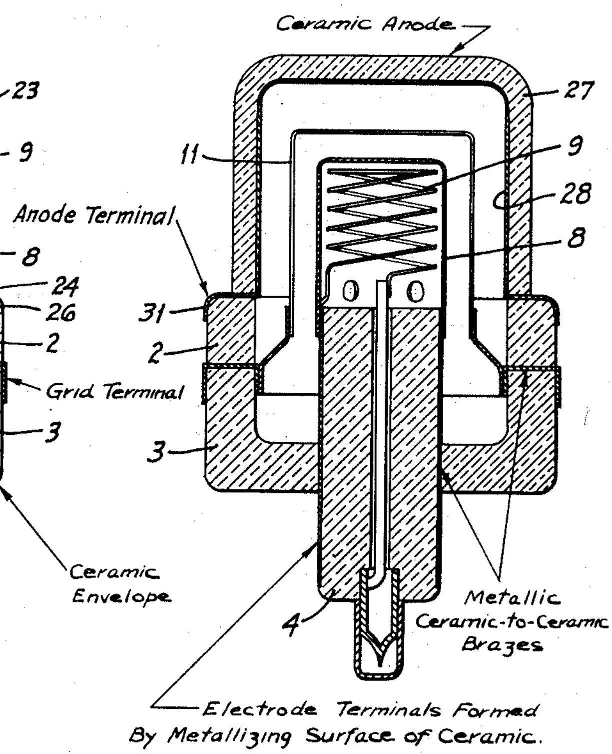

Fig.2

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Patented July 28, 1953

2,647,218

UNITED STATES PATENT OFFICE

2,647,218

CERAMIC ELECTRON TUBE

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Application December 26, 1950, Serial No. 202,666

6 Claims. (Cl. 313—247)

1

Our invention relates to electron tubes and more particularly to improvements in the envelope structure of such tubes.

It is among the objects of our invention to provide a tube having improved electrical, thermal and mechanical properties, and of a simplified structure adapted to economical manufacture.

Another object is to provide a tube of the character described in which the envelope is built up of ceramic sections metallically bonded together.

Still another object is to provide such a ceramic envelope in which the metallic bonds are utilized for establishing electrical connections to electrodes within the tube, thereby eliminating the metal parts usually required in tube construction.

A further object is to provide a tube in which electrical connections such as terminals on the envelope are formed by metalized areas on the ceramic.

A still further object is to provide a tube in which the external anode is also of ceramic, wherein the active anode surface comprises a metalized inner face on the ceramic.

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 vertical sectional view of a ceramic tube embodying the improvements of our invention; and

Figure 2 is a similar view in which the anode is also of ceramic.

In terms of broad inclusison our electron tube comprises an envelope having a ceramic wall, and an electrical connection to an electrode within the envelope comprising a metalized area on the ceramic wall. In our preferred construction the envelope is made up of ceramic sections metallically bonded together, the electrical lead-in connection to an electrode being established through the metallic bond. External terminals on the envelope are preferably formed by metalized areas on the ceramic sections. As embodied in a triode type of tube having coaxial terminals we construct the envelope with coaxial ceramic sections metallically bonded together, with a terminal on one section connected to the grid through one of the metallic bonds, and with a terminal on another section connected

2

to the cathode through another metallic bond. The anode is preferably of the external type supported on the ceramic envelope. This anode may be of the usual metal construction, or, in one form of our invention, may also be of ceramic metalized on the inner face to provide the active anode surface.

In greater detail and referring to Figure 1 of the drawing, a triode type of tube embodying our invention comprises an evacuated envelope made up of coaxial wall sections of ceramic. In its simplest form the envelope comprises three ceramic wall sections, namely, an upper cylindrical side wall section **2**, a lower cup-shaped wall section **3** aligned with the upper section, and a central tubular stem section **4** extending through the lower section. The pair of sections **2** and **3** are joined along abutting edges to make a vacuum-tight seal by a metallic bond **6**, and the second pair of sections **3** and **4** are likewise joined along abutting surfaces by a metallic bond **7**. The metallic bonding area **6** thus extends laterally through the side of the envelope, while the metallic bonding area **7** extends downwardly through the bottom. This arrangement of the joints is mentioned because the metallic bonds in our improved tube are utilized as lead-in conductors to the electrodes, as hereinafter described.

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 **6** and **7** forming the vacuum-tight seals may be made in several ways, utilizing known metalizing 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 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 surface 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 triode illustrated having an indirectly heated cathode, the latter comprises a cathode sleeve 8 such as nickel enclosing a suitable heater 9, the sleeve 8 being coated with an electron emissive material such as the conventional barium-strontium oxides. With the coaxial electrode structure shown, the cathode is surrounded with a cylindrical cage-type wire grid 11 mounted on a conical metal bracket 12. In our preferred construction the cathode is supported by the ceramic stem section 4 which projects upwardly into the envelope for that purpose, and the grid is supported by a ceramic side wall section of the envelope.

Terminal means are provided on the envelope, utilizing the bonded joints 6 and 7 as lead-in conductors, for establishing electrical connections with grid and cathode. For this purpose a ring-shaped metal grid terminal 13 is provided on the envelope side wall in contact with the laterally extending metallic bond 6, and a ring-shaped metal cathode terminal 14 is likewise provided on the external portion of the stem member 4 in contact with the downwardly extending metallic bond 7. Internal connections 16 and 17 are also made between the brazes and the respective electrodes to complete the electrical circuits.

In our preferred tube construction the above mentioned external terminals and internal connections are formed by metalized areas on the ceramic sections. Thus when the ceramic stem 4 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 cathode terminal 14 and internal connection 17. Likewise, when a side wall section such as the ceramic section 3 is treated the metalized areas adjacent the lateral joint are preferably extended to provide an external band for the terminal 13 and an internal band for the grid connection 16. Grid bracket 12 may thus be connected or brazed directly to the internal metalized area 16 and cathode sleeve 8 may be connected directly to the metalized area 17.

The metalized areas and brazes are shown in the drawings as layers of considerable thickness for convenience of illustration. Actually these layers are quite thin, say of the order 0.002'' to 0.005'' thickness, and appear as films or metal skins on the surfaces of the ceramic.

The above construction eliminates the metal pieces which usually have to be interposed in a tube envelope, and provides a substantially all-ceramic envelope. If desired, silver or the like may be flowed over the exposed sintered areas to further improve the electrical conductivity of such metalized areas. Our improved envelope construction provides a tube which 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. The tube structure, as shown, is well adapted for providing coaxial terminal arrangements which is desirable in coaxial or cavity type circuits. These features all contribute to make the tube ideally suited for operation at the ultra-high frequencies.

A metal exhaust tubulation 18 is preferably brazed into the lower end of stem 4, communicating with the interior of the envelope through the passage 19, which tubulation is pinched off after exhaust. One end of heater 9 is preferably connected to the cathode sleeve 8 and the other end is preferably brought out by a wire 21 through passage 19 and connected to tubulation 18. A cap 22 on the tubulation provides a convenient heater terminal coaxial with the cathode terminal 14.

While our improved envelope structure is adaptable for tubes having either internal or external anodes, we find the construction particularly well suited for the external type of anode. In the tube illustrated in Figure 1 the anode 23 is of metal which may carry a finned air cooler or water jacket (not shown) in the usual manner. The anode is preferably cup-shaped with a flange 24 seated on the upper section 2 of the envelope. This anode is brazed to a metalized edge of the ceramic section to form a metallic bond 26 in a manner similar to the brazes between the ceramic sections.

Figure 2 shows a modified construction in which the anode is also made of a ceramic section 27. In this case the active surface 28 of the anode is formed by metalizing the inner face of the cup-shaped ceramic section 27. This metalizing may be accomplished by the molybdenum sintering process as described for the envelope sections, and, if desired, may have silver or nickel flowed over the sintered surface to improve conductivity of the metalized area. The anode is brazed to the upper envelope section to provide a metallic bond 29 which also functions as a lead-in conductor for the anode, the metalized area being preferably continued down along the upper side of section 2 to form an anode terminal 31. This provides an anode having an electrically insulated outer surface which is desired in some applications. In other cases the anode section may be metalized both inside and out.

While we have shown a triode having a single grid, it is understood that our improved structure is well adapted for tubes having several grids. For example in the case of a tetrode, an additional cylindrical wall section would be incorporated between sections 2 and 3, thus providing an additional brazed joint to serve as a lead-in connection for the screen grid.

Likewise, it is understood that the electrodes need not be cylindrical, as our construction is manifestly well suited for tubes in which the electrodes are arranged in parallel planes.

We claim:

1. An electron tube comprising an envelope having upper and lower side sections of ceramic, a stem section of ceramic extending through said lower section, a grid in the envelope supported by a side section, a cathode in the envelope supported by the stem section, a metallic bond uniting said upper and lower side sections, a grid terminal on the envelope connected to the grid through said metallic bond, a metallic bond uniting the lower side and stem sections, and a cathode terminal on the envelope connected to the cathode through the last mentioned metallic bond, and a metal anode bonded to and extending beyond the upper side section, said

anode forming the upper portion of the envelope.

2. An electron tube comprising an envelope having upper and lower side sections of ceramic, a stem section of ceramic extending through said lower section, a grid in the envelope supported by a side section, a cathode in the envelope supported by the stem section, a metallic bond uniting said upper and lower side sections, a grid terminal on the envelope connected to the grid through said metallic bond, a metallic bond uniting the lower side and stem sections, a cathode terminal on the envelope connected to the cathode through the last mentioned metallic bond, and an external anode forming part of the envelope and supported by the upper wall section.

3. An electron tube comprising an envelope having sections of ceramic, metallic bonds uniting said sections, a grid and cathode in the envelope, a grid terminal on the envelope connected to the grid through one of said metallic bonds, a cathode terminal on the envelope connected to the cathode through another of said metallic bonds, and an external anode forming part of the envelope and supported by a ceramic section of said envelope.

4. An electron tube comprising an envelope having sections of ceramic, metallic bonds uniting said sections, a grid and cathode in the envelope, a grid terminal on the envelope connected to the grid through one of said metallic bonds, a cathode terminal on the envelope connected to the cathode through another of said metallic bonds, and an external anode forming part of the envelope and supported by a ceramic section of said envelope, said grid and cathode terminals comprising metalized areas on the ceramic sections.

5. An electron tube comprising a generally cylindrical envelope having sections of ceramic fitted together at a joint extending transversely through the side of the envelope, a metallic bond uniting the sections at said joint, a grid in the envelope, a grid terminal on the outer cylindrical surface of the envelope connected to the grid through said metallic bond, and an external anode forming part of the envelope and supported by a ceramic section of the envelope.

6. An electron tube comprising a generally cylindrical envelope having sections of ceramic fitted together at a joint extending transversely through the side of the envelope, a metallic bond uniting the sections at said joint, a grid in the envelope, a tubular metal cylindrical grid support having a lower end adjacent said joint, a grid terminal on the outer cylindrical surface of the envelope connected to the grid support through said metallic bond, and an external anode forming part of the envelope and supported by a ceramic section of the envelope.

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