July 10, 1956 | H. E. SORG | 2,754,445

CERAMIC VACUUM TUBE

Filed Aug. 1, 1952 | 3 Sheets-Sheet 1

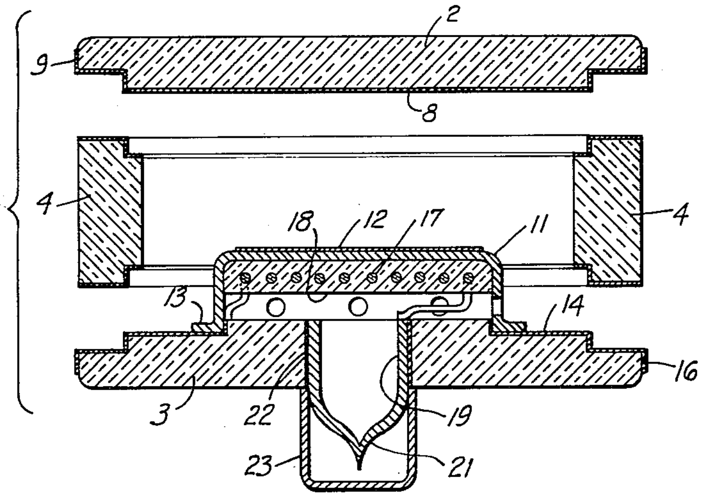

Fig.1

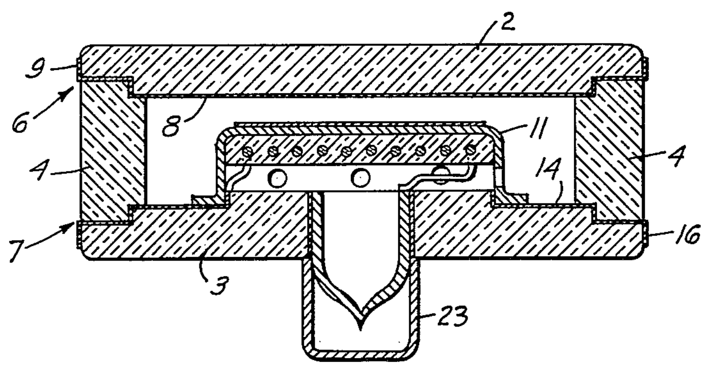

Fig.2

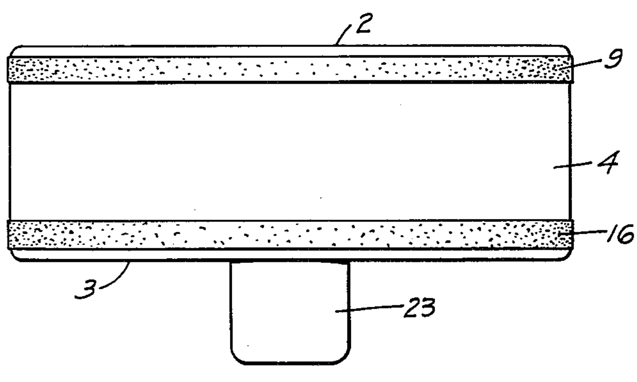

Fig.3

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Filed Aug. 1, 1952 3 Sheets-Sheet 2

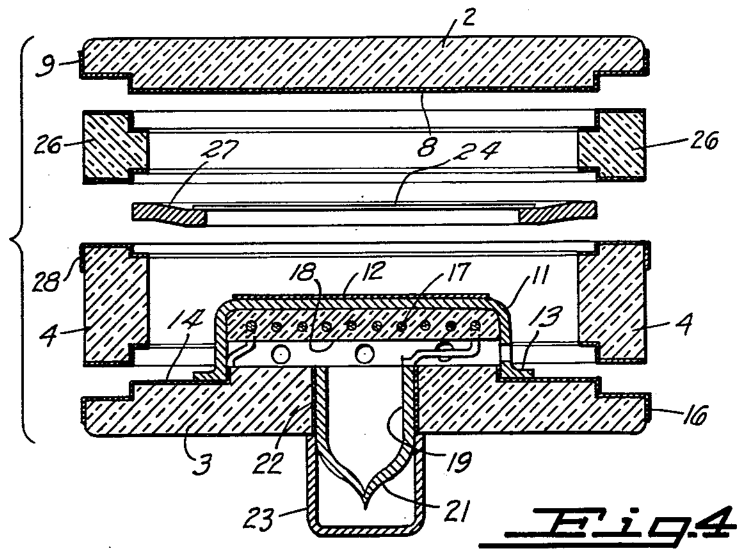

Fig.4

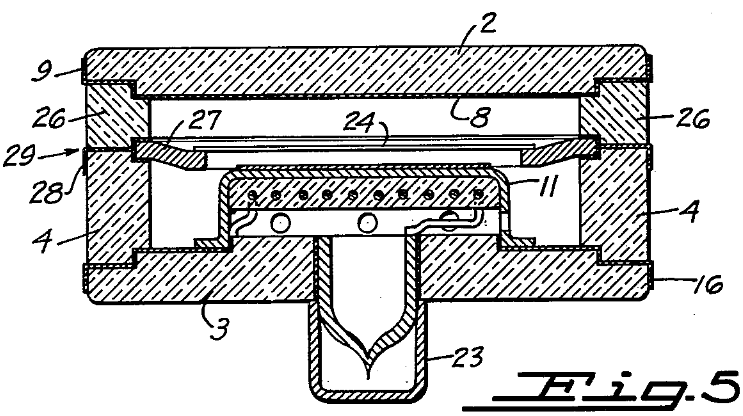

Fig.5

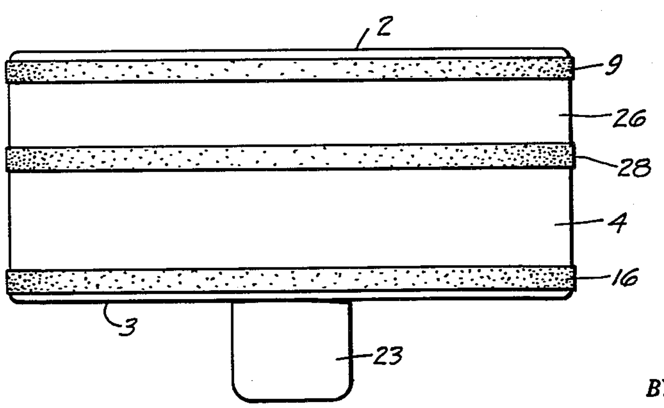

Fig.6

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CERAMIC VACUUM TUBE

Filed Aug. 1, 1952 3 Sheets-Sheet 3

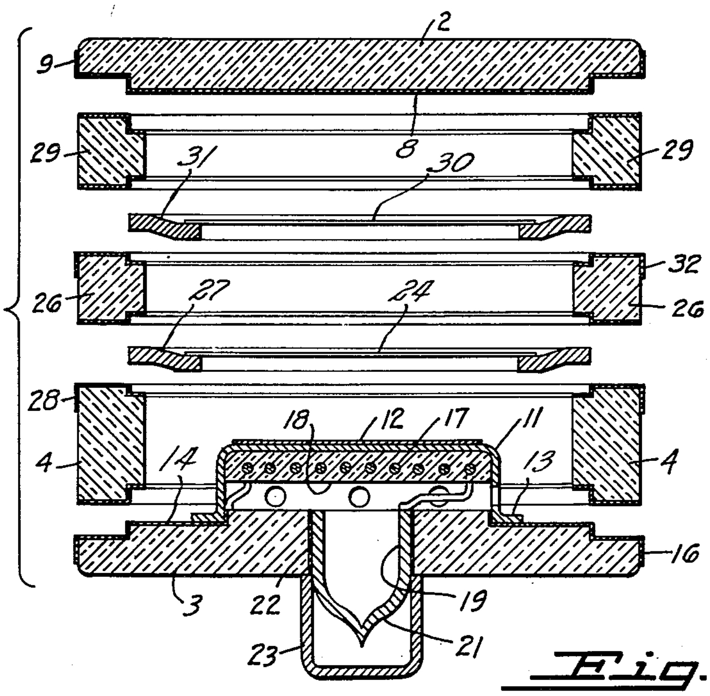

Fig. 7

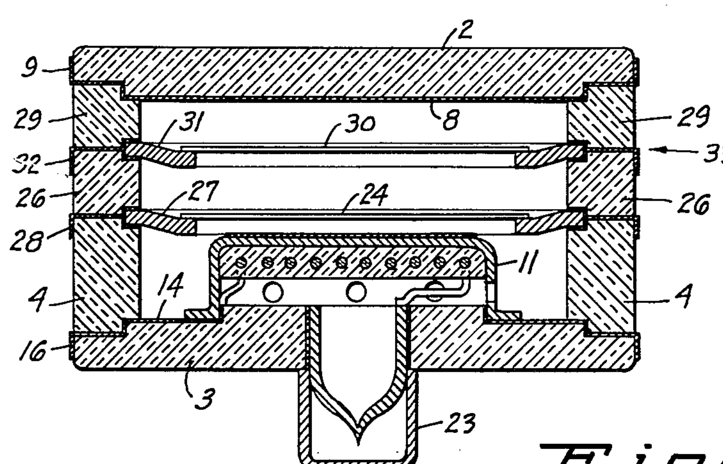

Fig. 8

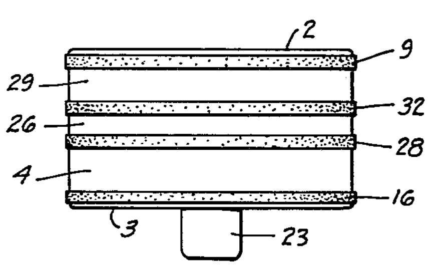

Fig. 9

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1

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CERAMIC VACUUM TUBE

Harold E. Sorg, Redwood City, Calif., assignor to Eitel-McCullough, Inc., San Bruno, Calif., a corporation of California

Application August 1, 1952, Serial No. 302,175

3 Claims. (Cl. 313—250)

My invention relates to electron tubes and more particularly to improvements in the mechanical construction and assembly of such tubes.

Vacuum tubes in the past have not been dependable in many types of electronic equipments, both commercial and military, because of failures attributable to the fragile construction of the tubes. Such failures are largely due to the inherent weakness of mechanical designs employed in the glass tubes which grew out of the old lamp industry. Electron tubes, particularly in the receiving tube category, have served a good purpose in home receiving sets and other amusement devices but leave much to be desired with regard to dependability and ruggedness under adverse conditions such as shock and vibration and elevated temperature environments.

The broad object of my invention is to overcome the above limitations by providing a tube having a ceramic envelope which is of compact and rugged construction.

Another object is to provide improvements in the internal electrode structure, in combination with the ceramic envelope.

Still another object is to provide a tube assembly suitable for a variety of tube types, such as diodes, triodes, etc.

A further object is to provide a tube structure which is designed to facilitate fabrication and which is adaptable for automatic assembly operations.

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

Referring to the drawings:

Figure 1 is an exploded view of a diode type of tube embodying my invention.

Figure 2 is a cross-sectional view of the assembled diode; and

Figure 3 is a side elevational view of the same.

Figures 4, 5 and 6 are similar views showing a triode type of tube; and

Figures 7, 8 and 9 are comparable views showing a tetrode.

In greater detail and referring first to Figures 1, 2 and 3, my improved tube structure comprises an all-ceramic envelope which has the general shape of a flat cylinder. Considered as a tube in the receiving tube category the views shown are quite enlarged, an actual tube being of the order of say ¾ inch diameter. The envelope comprises disk-shaped upper and lower end walls **2** and **3** of ceramic and a cylindrical side wall **4** also of ceramic. The ceramic used in making up the envelope is preferably an alumina type body, as such ceramics have good mechanical strength and are able to withstand high temperatures. Other commercially available ceramics, such as the zircon type bodies, may also be used.

To facilitate assembly the wall pieces are preferably interfitted at the joints for self-alignment of the parts. In the construction illustrated, the parts are notched or

2

recessed along the edges so as to provide an interlocking type of joint. The ceramic wall pieces are metallically bonded together along the upper and lower joints **6** and **7** to form vacuum-tight seals. The metal bonding layers at these joints also function as lead-in conductors for the electrodes as hereinafter described.

The ceramic-to-ceramic seals may be made in several ways using known metalizing and brabing techniques. For example, the opposed surfaces of the ceramics at the joints may be coated with finely divided metal powder and fired to sinter the metal particles to the ceramic. A satisfactory procedure is to coat with a mixture of molybdenum and manganese powders and fire in hydrogen to a temperature of about 135° C. This produces a thin layer firmly bonded to the ceramic. The sintered area is then preferably electroplated with nickel to produce a solid metal surface. Another metalizing technique is to paint titanium or zirconium hydride powders on the ceramic and fire in vacuum to about 1200° C.

The metalized ceramics may then be brazed or soldered togeher with silver solder or brazing alloys such as silver-copper, gold-copper or the like. The brazes are readily made by fitting the ceramic envelope sections together with rings of wire solder adjacent the joint and then elevating the temperature of the whole up to the melting point of the solder in a suitable furnace. The solder or brazing alloy flows between the metalized ceramic surfaces at the joint and produces a seal which is vacuum-tight and strong mechanically. The joint also provides a good electrical conductor leading into the envelope.

In my tube the upper end wall **2** also functions as the anode, the inner face of the ceramic being metalized as above described to provide the active anode surface **8**. Ceramics such as the alumina type ceramic bodies are quite good heat conductors and will adequately dissipate the heat in small tubes having relatively low anode dissipation ratings. Anode terminal **9** is also formed by a metalized area on the ceramic envelope, preferably along the peripheral edge of end wall **2** to form a ring-shaped terminal. As shown in Figure 1, the anode face **8** and anode terminal **9** are connected by the metalized region across the joint, these several areas being covered by a continuous coating and preferably metalized at the same time.

The cathode in my tube is supported by the lower end wall **3** and preferably comprises a cup-shaped cathode body **11**, say of nickel, coated on the upper surface with an electron emissive material **12** such as the conventional barium-strontium oxides. Cathode **11** is preferably engaged over a circular inwardly projecting portion of the ceramic wall for alignment purposes and the flange of the cathode is preferably outturned to provide a lip **13**. This lip is brazed or spotwelded to the metalized inner surface **14** of the end wall, which metalized area extends across the joint region and also along the outer peripheral edge to form the cathode terminal **16**. The heater for cathode **11** preferably comprises a flat spiral of heater wire **17** embedded in a suitable insulating material **18**. One end of the heater coil is connected to cathode body **11** and the other end is brought out to a separate terminal.

In the tube illustrated a metal exhaust tubulation **19** extends downwardly from the lower wall **3**, which tubulation is pinched off at tip **21** after evacuation of the envelope. This tubulation is fitted in a central hole having a metalized inner surface and is secured by a braze **22** to such surface. The tubulation **19** also functions as a lead-in conductor for an end of the cathode heater. A metal cap **23** over the tubulation provides a button-like terminal.

The metalized areas on the envelope parts are shown as having appreciable thickness for convenience of illustration. Actually these are quite thin metal layers, say of the order of 0.005" thickness, and appear as films or metal skins on the surfaces of the ceramic. Such metalized areas have good electrical conductivity, make excellent terminal surfaces and are ideal for brazing operations.

In the assembly of my tube the ceramic wall sections are first metalized and then the cathode structure and exhaust tubulation are mounted in place on the lower wall. The side wall section is then fitted between the end walls and the envelope is sealed by brazing at the joints **6** and **7**. These joints may be brazed separately or simultaneously. After final brazing the tube is ready for exhaust and may be evacuated in the usual manner. An important feature of this type tube structure and assembly is that the envelope wall section **4** functions as a spacer element to establish the cathode-to-anode spacing in the tube. Since the ceramics are strong mechanically and can be ground to precise dimensions the electrode spacing is accurated determined.

Figures 4, 5 and 6 show my improved tube structure embodied in a triode having a control grid **24**. The cathode supporting lower wall **3**, anode forming upper wall **2** and side wall section **4** are similar to those described for the diode structure and are like numbered. The added parts comprise the grid structure **24** and a second side wall section **26**. Ceramic section **26** is notched or recessed like the lower side wall section so that it fits anode forming end wall **2**. The adjacent notched edges of wall sections **4** and **26** provide an interior groove for holding the grid.

Grid **24** is a flat disk-shaped type of structure having parallel wire mounted on a supporting ring **27** of metal. This grid ring is engaged in the above mentioned groove and is brazed between the metalized side wall sections. A metalized strip on the side wall of the envelope provides the grid terminal **28** which connects with the grid through the intermediate joint **29**.

The diode thus forms the foundation structure for the triode, the latter requiring merely the addition of the grid disk **24—27** and the extra wall section **26**. As in the case of the diode, the electrode spacings in the triode are established by the envelope sections, thus, the grid-to-cathode spacing is set by the ceramic section **4** and the grid-to-anode spacing is determined by ceramic section **26**. Another important feature is that the grid is positively and rigidly held by the brazed connection between the envelope sections.

Figures 7, 8 and 9 shown my improvements embodied in a tetrode having an added screen grid **30**. Here again the tube components follow the triode structure and are like numbered. The added parts comprise the screen grid structure **30** and a third side wall section **29**. Ceramic section **29** is notched or recessed like the other wall sections so that it fits the anode forming end wall **2**. The adjacent notched edges of wall sections **26** and **29** provide a second interior groove for holding the screen grid.

Screen grid **30** is also a flat disk-shaped type of structure having parallel wires mounted on a metal supporting ring **31**. This ring is engaged in the groove and brazed between metalized ceramic sections **26** and **29**. A metalized strip on the side wall of the envelope provides a screen grid terminal **32** which connects with the grid through the second intermediate joint **33**.

The triode thus forms the foundation structure for the tetrode, the latter requiring merely the addition of the screen grid disk **30—31** and the extra wall section **29**. As in the case of the diode and triode, the electrode spacings in the tetrode are established by the envelope sections. This stacking procedure may be continued to produce still further tube types. For example, the addition of another wall section and another grid (serving as a suppressor grid) would produce a pentode.

There are many advantages to my improved tube structure, some of which have already been mentioned. Another important advantage comes about because of utter simplicity of the structure and the stacking arrangement which permits a variety of types to be built up from common parts. The metalized envelope sections and electrodes may be assembled by simple stacking operations, which can be done by automatic machinery. When stacked with rings of suitable brazing material adjacent the joints, the entire tube may be brazed together in one operation in a furnace. This is all very desirable from an economic manufacturing standpoint. Probably the greatest advantages, however, have to do with improved tube reliability. My tube structure is extremely strong mechanically and has excellent thermal resistance properties for high temperature operation. Tube failures heretofore due to the fragile construction of glass type tubes are largely or completely eliminated. The all-ceramic brazed type of construction is compact and inherently rugged and provides a tube which will withstand shock and vibration and will operate satisfactorily in elevated temperature environments.

I claim:

1. An electron tube comprising a generally cylindrical envelope having upper and lower disk-shaped end walls of ceramic, a cylindrical side wall of ceramic fitted to the end walls along upper and lower joints, metallic bonds uniting the ceramic parts together at said joints, the inner face of the upper ceramic wall being metalized, providing an anode, a cathode supported on the lower wall and having an electron emitting surface facing the anode, the metallic bond at the upper joint providing a lead-in conductor for the anode and the metallic bond at the lower joint providing a lead-in conductor for the cathode, said ceramic side wall comprising a pair of sections fitted together at a joint lying intermediate the end walls, a metallic bond uniting the side wall sections together at the last mentioned joint, and a disk-shaped grid interposed between the cathode and anode, said grid having a supporting ring engaged between the side wall sections, the metallic bond at the intermediate joint providing a lead-in conductor for the grid.

2. An electron tube comprising a generally cylindrical envelope having upper and lower disk-shaped end walls of ceramic, a cylindrical side wall of ceramic fitted to the end walls along upper and lower joints, metallic bonds uniting the ceramic parts together at said joints, the inner face of the upper ceramic wall being metalized, providing an anode, a cathode supported on the lower wall and having an electron emitting surface facing the anode, the metallic bond at the upper joint providing a lead-in conductor for the anode and the metallic bond at the lower joint providing a lead-in conductor for the cathode, said ceramic side wall comprising a pair of sections fitted together at a joint lying intermediate the end walls, a metallic bond uniting the side wall sections together at the last mentioned joint, and a disk-shaped grid interposed between the cathode and anode, the side wall having a groove at the joint between the sections, said grid having a supporting ring engaged in said groove, the metallic bond at the intermediate joint providing a lead-in conductor for the grid.

3. An electron tube comprising a generally cylindrical envelope having upper and lower disk-shaped end walls of ceramic, a cylindrical side wall of ceramic fitted to the end walls along upper and lower joints, metallic bonds uniting the ceramic parts together at said joints, the inner face of the upper ceramic wall being metalized, providing an anode, a cathode supported on the lower wall and having an electron emitting surface facing the anode, the metallic bond at the upper joint providing a lead-in conductor for the anode and the metallic bond at the lower joint providing a lead-in conductor for the cathode, said ceramic side wall comprising a plurality of stacked sections fitted together at vertically spaced joints lying intermediate the end walls, metallic bonds uniting the side wall

sections together at the last mentioned joints, and disk-shaped grids interposed between the cathode and anode, the side wall having grooves at the joints between the sections, said grids having supporting rings engaged in said grooves, the metallic bonds at the intermediate joints providing lead-in conductors for the grids.

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