March 27, 1956 H. E. SORG 2,740,067

CERAMIC VACUUM TUBE

Filed Oct. 13, 1952 5 Sheets-Sheet 1

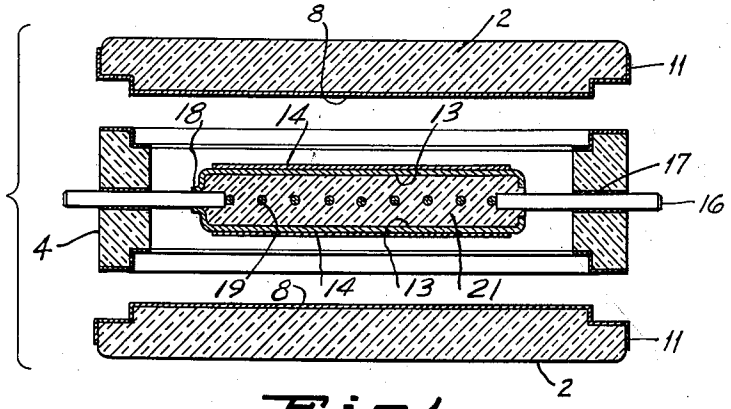


Fig. 1

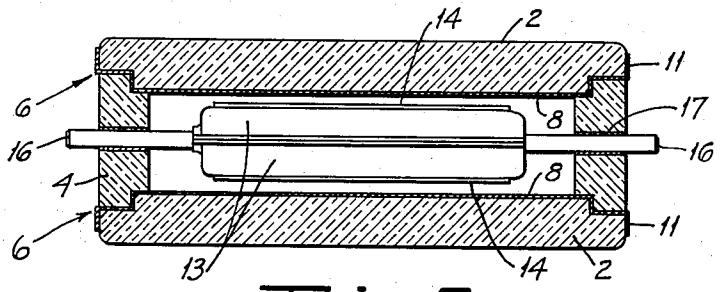


Fig. 2

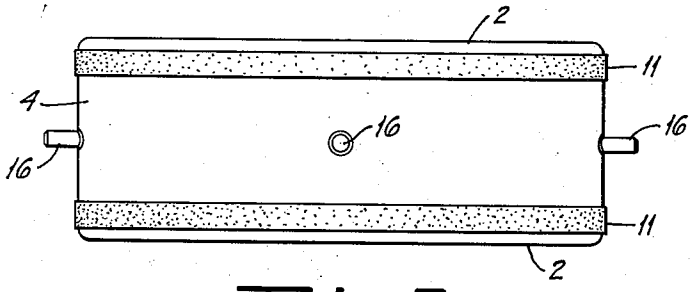


Fig. 3

INVENTOR.
Harold E. Sorg
BY Harold E. Sorg
ATTORNEY

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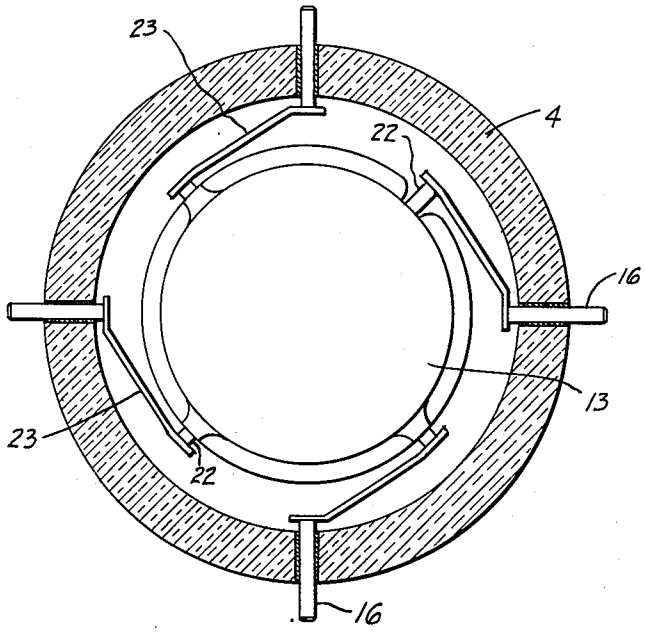


Fig.4

INVENTOR.
Harold E. Sorg
BY Harold E Sorg
ATTORNEY

March 27, 1956 H. E. SORG 2,740,067

CERAMIC VACUUM TUBE

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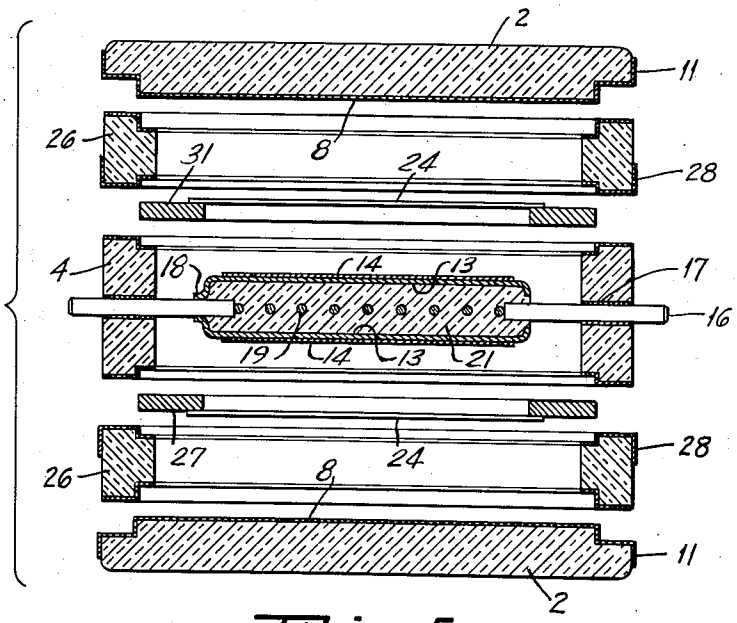


Fig. 5

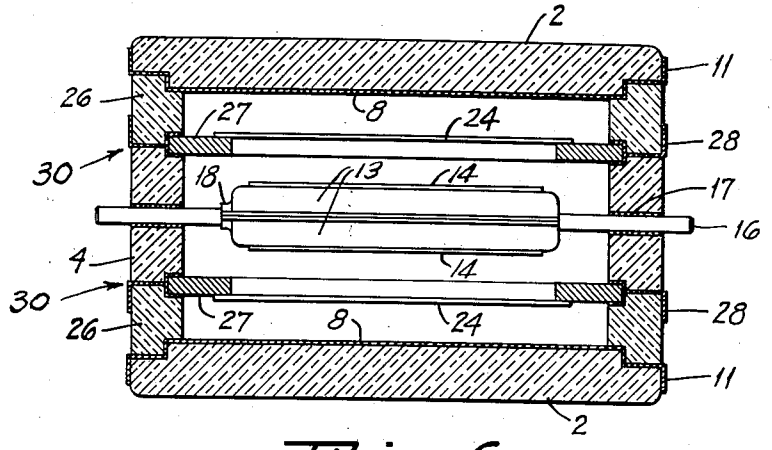


Fig. 6

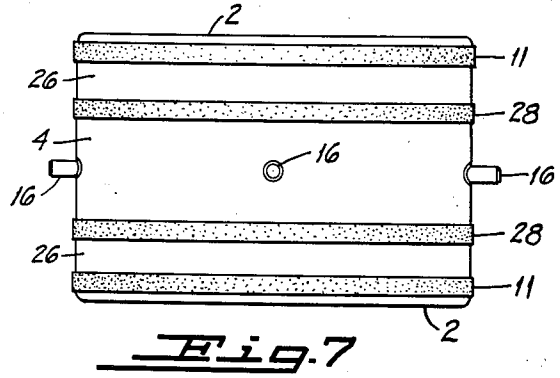


Fig. 7

INVENTOR.
Harold E. Sorg
BY Harold E. Sorg
ATTORNEY

March 27, 1956 H. E. SORG 2,740,067

CERAMIC VACUUM TUBE

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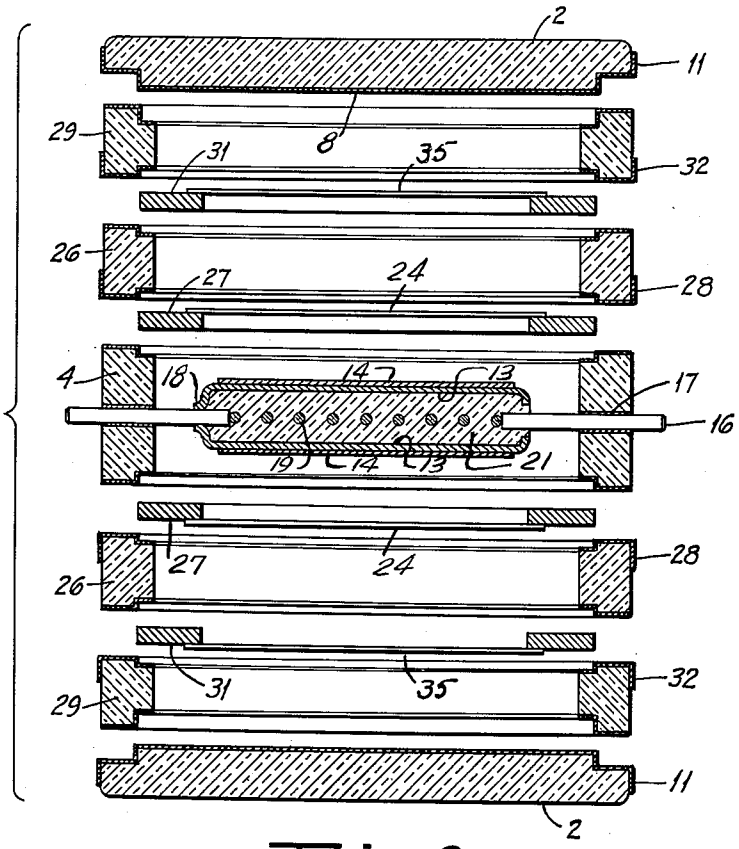


Fig. 8

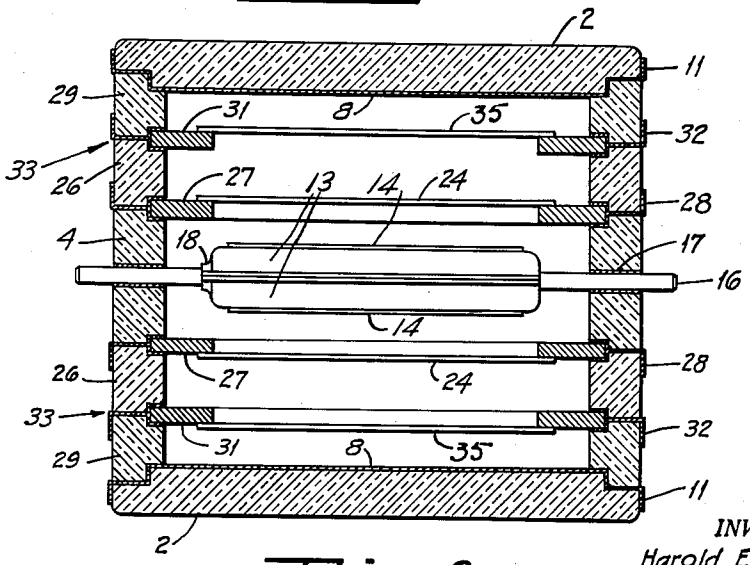


Fig. 9

INVENTOR.
Harold E. Sorg
BY Harold E. Sorg
ATTORNEY

March 27, 1956 H. E. SORG 2,740,067

CERAMIC VACUUM TUBE

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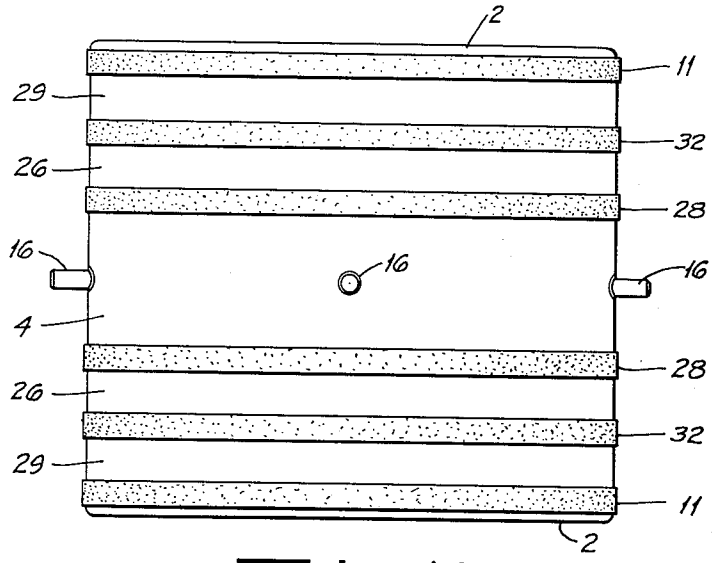


Fig. 10

INVENTOR.
Harold E. Sorg
BY Harold E Sorg
ATTORNEY

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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 October 13, 1952, Serial No. 314,497

4 Claims. (Cl. 313—245)

My invention relates to electron tubes and more particularly to constructions having ceramic envelopes incorporated in tubes having twin sections such as twin diodes. twin triodes, etc.

It is among the objects of my invention to provide a twin section type of tube which is of compact and rugged construction.

Another object is to provide a tube assembly having a stacked envelope structure suitable for a variety of types such as twin diodes, twin triodes and twin tetrodes.

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.

Figure 4 is a horizontal sectional view looking down on the cathode and showing a modified cathode supporting structure.

Figures 5, 6 and 7 are similar views showing a triode type of tube; and

Figures 8, 9 and 10 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 one inch or so in diameter. The envelope comprises disk-shaped upper and lower end walls 2 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 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 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 brazing 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 1350° 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 together 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 end walls 2 function as the anodes of the twin-diode, the inner faces of these ceramic walls being metalized as above described to provide the active anode surfaces 8. Ceramics such as the alumina type bodies are quite good heat conductors and will adequately dissipate the heat in small tubes having relatively low anode dissipation ratings. Anode terminals 11 are also formed by metalized areas on the ceramic envelope, preferably along the peripheral edges of the end walls to form ring-shaped terminals. As shown in Figure 1, the inner anode surfaces and associated terminals are electrically connected by the metalized regions across the joints. The two anodes in my improved tube are thus incorporated in a very simple manner.

The cathode in tube is centrally located between the end walls and is common to the two diode sections. It preferably comprises a button-like structure formed by two cup-shaped sections 13 of metal, may be nickel, coated on the upper and lower surfaces with an electron emissive material 14 such as the conventional barium-strontium oxides. The cathode button is supported by a spider-like arrangement comprising radial metal rods 16 extending through holes in the side wall 4. The interiors of these holes are metalized and the rods are brazed thereto at 17. The metal halves 13 of the cathode are preferably spot welded at the ears 18 to say three of the rods 16 so as to give a solid mounting for the cathode button.

The heater for the cathode preferably comprises a flat spiral of heater wire 19 embedded in a suitable insulating material 21. At least one of the rods 16 is brought into the cathode button through an enlarged hole in the metal parts 13 so that it is insulated from the cathode, such rod being connected to one end of the spiral 19 to provide a heater lead. The other end of the heater wire may be common to the cathode and is connected to one of the other lead-in rods.

Instead of mounting the cathode button directly on the inner ends of rods 16 as shown in Figures 1 and 2, it may be desirable to incorporate a modified structure to allow for radial expansion of the button when the cathode is heated. This is simply done by making the rods in two pieces and offsetting the rod portions as shown in Figure 4, the main rods 16 being fixed on the envelope wall and the short rods 22 being carried by the cathode button. These rods are then connected by metal straps 23 spot welded to the ends of the rods, which straps extend tangentially of the cathode button. The straps stand edgewise alongside the button so that the latter is held rigidly relative to the axial dimension of the tube, this being important to retain the desired cathode-to-anode spacings. At the same time the straps provide some degree of flexibility in the radial direction so as to com-

pensate for such expansion. This removes the stress from the supporting rods and also from the button and prevents the latter from buckling or distorting. The cathode mounting arrangement shown in Figure 4 also has another advantage in that it permits the entire cathode and heater structure, including rods **22** and straps **23**, to be fabricated as a separate unit, which unit may then be mounted by simply spot welding straps **23** to the rods **16**.

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 the tube the several ceramic wall sections are metalized over the areas shown in Figure 1. The rods **16** are then brazed in place and the cathode button is mounted in position on the rods, after which the cathode is coated with the emissive material **14**. The side wall **4** with its cathode unit is thus completed as a separate subassembly as shown in Figure 1.

The tube may be exhausted in several ways. If desired a suitable exhaust tubulation (not shown) may be provided on the envelope for evacuation purposes, such as a conventional metal tubulation which is pinched off after exhaust. With such tubulation type exhaust procedure the walls of the envelope would be brazed together at the joints **6** prior to exhaust and the tube subsequently evacuated in the usual manner.

I prefer, however, to avoid the tubulation by utilizing a bell jar system of exhaust. With this procedure the tube parts shown in Figure 1 are placed in a bell jar or vacuum chamber while end walls **2** are still separated from the wall **4**, a suitable fixture in the bell jar being provided for holding the parts. The tube is then evacuated and the cathode is formed in the bell jar, the last step being to bring the end walls into position and making the brazes at joints **6** while the parts are under vacuum in the jar. The heat for brazing in this case is supplied by radiation heaters located adjacent the joints in the bell jar.

An important feature of my tube structure is that the envelope wall section **4** functions as a spacer element to establish the cathode-to-anode spacings in the tube. Since the ceramics are strong mechanically and can be ground to precise dimensions the electrode spacings are accurately determined.

Figures 5, 6 and 7 show my improved tube structure embodied in a twin triode having control grids **24**. The cathode supporting center wall **4** and the anode forming end walls **2** are similar to those described for the diode construction and are like numbered. The added parts comprise the grid structures **24** and the short wall sections **26**. Ceramic sections **26** are notched or recessed like the center section so they fit the end walls **2**. The adjacent notched edges of wall sections **4** and **26** provide interior grooves for holding the grids.

Grids **24** are flat disk-shaped structures having parallel wires mounted on supporting rings **27** of metal. These grid rings are brazed between the metalized side wall sections. Metalized strips on the side wall of the envelope provide the grid terminals **28** which connect with the grids through the intermediate joints **30**. In the assembly of the twin triode the cathode carrying center section **4**, grids **24** and wall sections **26** are preferably all completed and brazed together as a sub-assembly. The parts are then preferably exhausted in a bell jar and the final brazes made as was the case with the diode.

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

Figures 8, 9 and 10 show my improvements embodied in a twin tetrode having the added screen grids **35**. Here again the tube components follow the triode structure and are like numbered. The added parts comprise the screen grids **35** and extra wall sections **29**. Ceramic sections **29** are notched or recessed like the other wall sections so that they fit the end walls **2**. The adjacent notched edges of wall sections **26** and **29** provide interior grooves for holding the screen grids.

Screen grids **35** are also flat disk-shaped structures having parallel wires mounted on the metal supporting rings **31**, the latter being engaged in the grooves and brazed between the metalized ceramic sections **26** and **29**. Metalized strips on the side wall of the envelope provide screen grid terminals **32** which connect with the grids through the intermediate joints **33**.

The twin triode thus forms the foundation structure for the twin tetrode, the latter merely requiring the addition of the screen grids **35** and the extra wall sections **29**. As in the case of the diode and triode, the electrode spacings in the twin tetrode are established by the envelope sections. This stacking procedure may be continued to produce still further tube types. For example, the addition of other wall sections and another pair of grids (serving as suppressor grids) would produce a twin 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. 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 at said joints, the inner faces of the end walls being metalized, providing anodes, said metallic bonds at the upper and lower joints providing lead-in conductors connected to said anodes, a cathode supported on the side wall and having electron emitting surfaces facing the anodes, said ceramic side wall comprising sections fitted together at joints lying intermediate the end walls, metallic bonds uniting the side wall sections at the last mentioned joints, and disk-shaped grids interposed between the cathode and said anodes and supported on the side wall, the metallic bonds at the intermediate joints providing lead-in conductors for the grids.

2. A stacked ceramic type electron tube comprising an envelope having the shape of a flat cylinder with side and end walls, the side wall comprising metalized ceramic rings sealed in a vertical stack and providing spaced annular side wall joints between said rings, metallic layers uniting the metalized ceramic rings at said joints, said end walls providing anodes having inner anode surfaces lying substantially parallel with the planes of said joints, a central cathode structure in the envelope having upper and lower emitting surfaces substantially parallel with said anode surfaces, disk-like grids interposed between the cathode and anodes and lying substantially parallel

with said anode and cathode surfaces, conductive supports for the grids extending inwardly from said spaced side wall joints, and terminals on the envelope connected to the grid supports through the metallic layers of said joints.

3. A stacked ceramic type electron tube comprising an envelope having the shape of a flat cylinder with side and end walls, the side wall comprising metalized ceramic rings sealed in a vertical stack and providing spaced annular side wall joints between said rings, metallic layers uniting the metalized ceramic rings at said joints, said end walls providing anodes having inner anode surfaces lying substantially parallel with the planes of said joints, a central cathode structure in the envelope having upper and lower emitting surfaces substantially parallel with said anode surfaces, a heater for the cathode interposed between said emitting surfaces, disk-like grids interposed between the cathode and anodes and lying substantially parallel with said anode and cathode surfaces, conductive supports for the grids extending inwardly from said spaced side wall joints, and terminals on the envelope connected to the grid supports through the metallic layers of said joints.

4. A stacked ceramic type electron tube comprising an envelope having the shape of a flat cylinder with side and end walls, the side wall comprising metalized ceramic rings sealed in a vertical stack and providing spaced annular side wall joints between said rings, metallic layers uniting the metalized ceramic rings at said joints, said end walls providing anodes having inner anode surfaces lying substantially parallel with the planes of said joints, a central cathode structure in the envelope having upper and lower emitting surfaces substantially parallel with said anode surfaces, disk-like grids interposed between the cathode and anodes and lying substantially parallel with said anode and cathode surfaces, conductive supports to the grids extending inwardly from said spaced side wall joints, each of said grids together with its support comprising a structurally integral grid-unit positioned in stacked relationship with respect to the stacked side wall rings, and terminals on the envelope connected to the grid supports through the metallic layers of said joints.

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