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VACUUM TUBE WITH STRUCTURALLY INTEGRATED BY-PASS CAPACITOR

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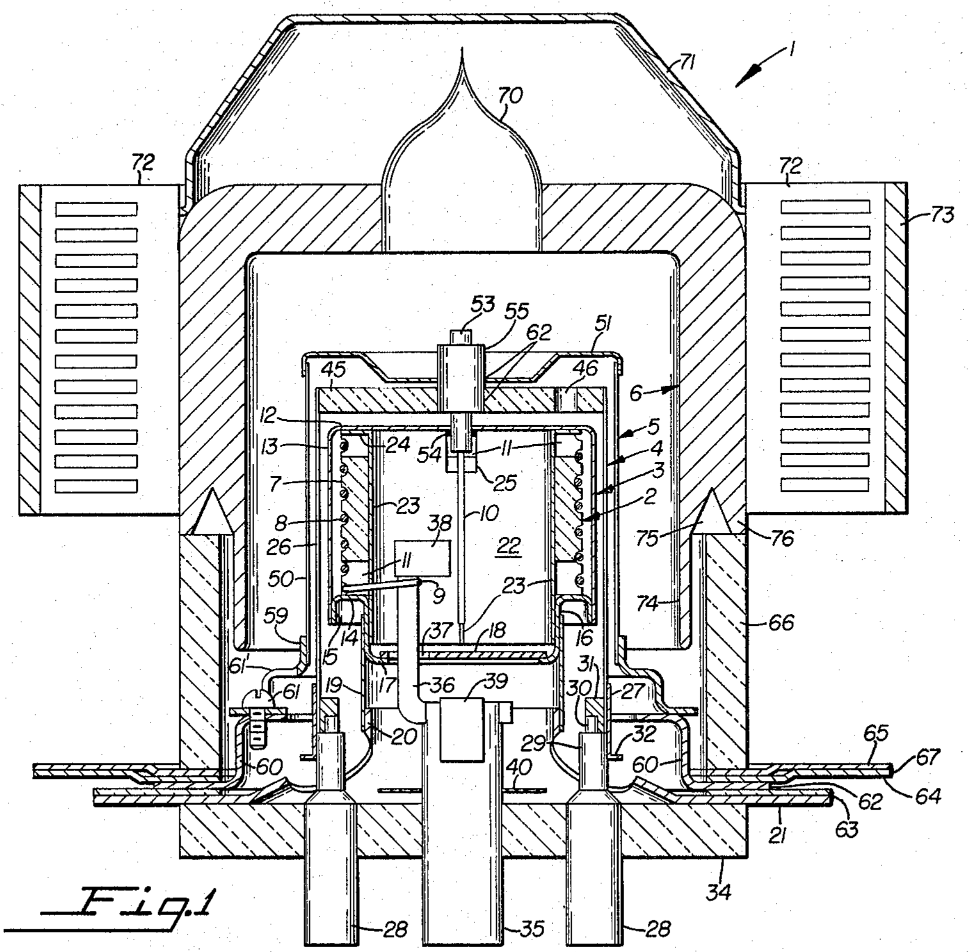

Fig.1

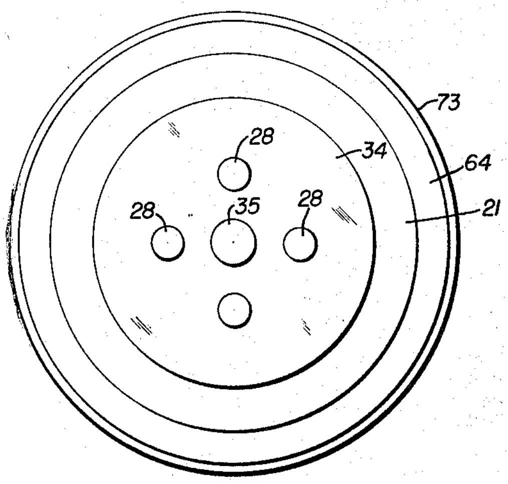

Fig.2

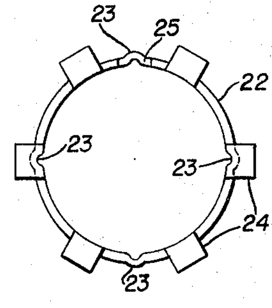

Fig.3

INVENTOR.
WILLIAM D. SMITH

BY Robert W. Dilts

ATTORNEY

United States Patent Office

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VACUUM TUBE WITH STRUCTURALLY INTEGRATED BY-PASS CAPACITOR

William D. Smith, Santa Clara, Calif., assignor, by mesne assignments, to Varian Associates, a corporation of California

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This invention relates to electron tubes and more particularly to features designed to provide an imporved tube which is adapted for distributed amplifier service and capable of withstanding rough handling and extreme conditions of shock and vibration.

In order to operate a tube in distributor amplifier service it is known that good by-pass capacitance is required between the cathode and screen grid. In normal tube construction the terminal arrangement is such that the cathode and screen grid terminals are separated by the terminal for some other electrode such as the control grid. An improved terminal arrangement has been developed to place the cathode and screen grid terminals in ring form directly adjacent each other for convenient by-passing between them somewhere in the circuit, such as in the socket for the tube. Such improved arrangement is disclosed in the copending application, Serial No. 57,970, filed September 23, 1960, now Patent No. 3,111,-600, in the name of Martin E. Levin and assigned to the assignee of the present invention. It has also been proposed to build a by-pass capacitor into the tube disclosed in said copending application. However, previous attempts to provide a suitable built-in capacitor construction have been unsuccessful.

Accordingly, it is an object of this invention to provide a tube construction embodying a cathode-to-screen by-pass capacitor constructed as part of the tube in a manner which provides the desired electrical characteristics and also provides physical protection for the relatively fragile dielectric portion of the capacitor.

A further object of the invention is to provide a tube of the type described in which the final seal for the tube is incorporated in the built-in cathode-to-screen capacitor construction, and in a way that solves the thermal problems introduced by the heat required for the final seal.

In electron tubes, particularly those designed for distributed amplifier service, it is desirable to minimize the capacitance between the control grid and cathode, and between the control grid and screen grid. Also, as previously mentioned herein, it is desirable to maximize the capacitance between the cathode and screen grid. In conventional tube construction, the end cap for the cylindrical control grid cage is made of metal which results in substantial capacitance between the control grid and each of the adjacent cathode and screen grid electrodes.

Accordingly another object of the invention is to provide an electron tube having cylindrical electrode in which the upper ends of the cathode, control grid and screen grid are designed to minimize the capacitance between the cntrol grid and the other two of said electrodes, and at the same time introduce some capacitance between the upper end of the cathode and the upper end of the screen grid.

A further object of the invention is to provide rigidifying means for insulatingly interconnecting the upper ends of the cathode, control grid and screen grid.

An additional object of the invention is to provide a tube having improved means for rigidly securing the control grid on support pins and for rigidly securing the heater inside the cathode.

Other and further objects and features of advantage will be apparent to those skilled in the art from a reading

of the following detailed description in conjunction with the accompanying drawings, in which:

FIGURE 1 is a cross sectional view taken on the center line of tube according to the invention.

FIGURE 2 is a bottom plan view of the tube on reduced scale; and

FIGURE 3 is a top view of a reinforcing sleeve in the heater-cathode package of FIGURE 1.

In more detail the drawings disclose a generally cylindrical electron tube **1** having a heater **2**, a cathode **3**, a control grid **4**, a screen grid **5**, and an anode **6**.

The heater **2** comprises a length of ceramic cylinder **7** having a helical groove along its outer surface in which a helical heater wire **8** is received. The ends **9** and **10**, of the heater wire project inwardly through the ceramic cylinder which for this purpose has at least one slot **11** in each end. Preferably, for convenience of assembly, the ceramic cylinder **7** has four slots **11** at each end spaced 90° apart.

The cathode comprises an inverted metal can having a flat top **12** and a cylindrical side wall **13** which is coated on its outer surface with a conventional oxide type emissive coating. The lower end of the cathode is closed by a member having an annular flat portion **14** for supporting the cylinder **7**, a downturned flange **15** which is welded to the lower end of cathode wall **13**, a side wall **16**, a bottom rim **17**, and a closure disk **18** welded to rim **17**. A thin wall metal heat dam **19** is welded at its upper end to wall **16** and at its lower end to a cathode support ring **20** preferably made of metal having low thermal conductivity, such as Kovar. Support ring **20** projects outwardly of the tube envelope to provide an annular ring terminal **21** for the cathode.

In order to form a rigid heater-cathode package, a metal sleeve **22** is fitted inside the ceramic cylinder **7**. As shown in FIGURES 1 and 3, the sleeve **22** has longitudinally extending ribs **23** which form a press fit with the inside of cylinder **7** and the side wall **16** of the closure member at the bottom of the cathode can. In addition, the top of sleeve **22** is provided with a radial flange structure, preferably in the form of tabs **24**. The assembly procedure is to press sleeve **22** into the ceramic cylinder **7**, and then spotweld heater end **10** to the inside of the sleeve. Then the closure member is spot welded in place to compress the ceramic cylinder between tabs **24** and the flat portion **14** on the closure member. Sleeve **22** is of course apertured to accommodate heater end **9** and has an aperture **25** for the heater end **10**.

The control grid **4** is of the conventional cage type construction comprising a plurality of vertical wires **26** parallel with the tube axis and spaced around a circle. The lower end of each of the wires **26** is spot welded to a metal support ring **27**. The control grid terminal is provided in the form of four terminal pins **28**, each having reduced diameter portions **29** and **30**. A recessed metal ring **31** is brazed to pins **28** so that it fits over and around the reduced portions **30**, with the outer surface of ring **31** being flush with the reduced portions **29**. The grid support ring **27** is spot welded to ring **31**, and if desired, ring **27** can extend down along the reduced portions **29** and terminate in a flange **32** for additional rigidity.

Pins **28** are brazed in metalized apertures in a ceramic header disk **34**. A center pin **35**, serving one end of the heater is also brazed in a metalized aperture in disk **34**. An L-shaped rod **36** has its foot brazed in a slot at the top of pin **35** and extends upwardly through an aperture **37** in member **18**. The end **9** of the heater is spot welded to the upper portion of rod **36**. Numerals **38** and **39** designate strips of conventional getter material welded in place on rod **36** and pin **35**, respectively. A metal disk **40** is brazed to pin **35** to prevent material evaporated from parts heated during processing or operation (usually from cathode-heater structure) from depositing on header 34 adjacent pin 35.

The upper end of the control grid is provided with an end cap in the form of a ceramic disk 45. The periphery of disk 45 is metalized and brazed to the upper ends of the grid wires 26. The conventional way of making the top of the control grid has been to use either a solid metal cap or employ U-shaped grid wires so that the bight portions of the U-shaped wires cross over each other at the top of the grid and in effect form a metal end cap. The use of a ceramic end cap minimizes the undesirable capacitance between the control grid and the adjacent cathode and screen grid, and in addition provides some desirable capacitance between the cathode and screen grid. The single off-center aperture 46 in the ceramic disk 45 is simply for the purpose of jigging the disk against rotation during brazing of the grid wires to the disk.

The screen grid 5 is also of conventional cage type construction comprising a plurality of vertical wires 50 parallel with the tube axis and spaced around a circle. The upper end of each of the wires 50 is spot welded to a metal end cap 51, which may if desired be dished down in the middle for the purpose of increasing the capacitance between the end caps 12 and 51 of the cathode and screen grid, respectively.

In order to assure rigid coaxial relation between the cathode, control grid and screen grid, a metal pin 53 is welded to the cathode end 12 at 54. A cylindrical ceramic sleeve 55 is tightly fitted over pin 53. The pin 53 and sleeve 55 extend through appropriate apertures in the end caps 12, 45 and 51. The outer periphery of sleeve 55 is metalized in the area where it passes through the metal end cap 51 and the ceramic end cap 45. These respective metalized areas are brazed to the metal cap 51 and the ceramic cap 45, the latter having the wall of its sleeve-receiving aperture metalized for this purpose.

The lower ends of the screen grid wires are spot welded to a two-piece screen grid support ring comprising a first metal ring 59 and a second metal ring 60. In order to provide the proper electrical characteristics and high thermal conductivity for dissipating heat from the screen grid, the rings 59 and 60 are both preferably made of copper. The two rings are joined by screws 61, preferably three, equally spaced around the rings. The ring 59 has a cut-out 61′ at each screw to permit proper seating of the screws.

The ring 60 has a flat flange portion 62 positioned close to the cathode terminal ring 21 and separated therefrom only by a dielectric ring 63, preferably of ceramic. The outer diameter of portion 62 is selected to provide the desired by-pass capacitance between the cathode ring 21 and the screen grid ring portion 62. The combined screen grid terminal connection and final seal is supplied in the form of two rings 64 and 65. These rings, and particularly the lower one 64, are made of metal having a lower coefficient of thermal conductivity than copper, for example Kovar. The portion of ring 64 which projects beyond rings 21 and 63 serves efficiently as the terminal ring for the screen grid, and of course the top of ring 65 could be used for this purpose. However, it should be noted that the overlapping condition of rings 21 and 64 makes it possible to use the tube in a socket into which the tube is lowered axially so that the bottom of ring 21 abuts an inner ring of socket contact fingers and the bottom of the overlapping portion of ring 64 abuts a radially outer ring of socket contact fingers.

The by-pass capacitor and final seal construction forms part of the vacuum envelope for the tube in the following way. The ceramic header disk 34 is metalized in the annular area where it abuts the flat portion of the cathode ring 20, and such metalized area is brazed to the abutting portion of ring 20. The ceramic ring 63 is metalized top and bottom in the areas where it abuts the screen ring 62 and the cathode ring portions 20, 21, and such metalized areas are brazed to the adjacent rings. The

metal rings 62 and 64 are brazed together along their abutting surfaces. The upper side of ring 65 is brazed to a ceramic cylinder 66, the lower end of which is metalized for this purpose. Rings 64 and 65 are not initially connected, and the final seal is made by hermetically joining said rings, preferably by a heliarc weld 67 around the periphery of the rings.

The anode 6 comprises an inverted cup-shaped member, preferably made of copper. A conventional exhaust tubulation 70 is brazed in the top of the anode and is protected by a metal cap 71. Conventional radial cooling fins 72 are brazed around the outside of the anode and are also brazed to an outer shroud ring 73. The cap 71 is preferably held in place by crimping fins 72 over the lip of the cap in three or four places. The length of the side wall ceramic 66 required for voltage hold-off makes it necessary to provide the anode internally with a downwardly extending rim portion 74. It would of course be possible to eliminate the rim portion 74 and instead increase the height of the anode and the length of the other electrode supports so that the effective electrode areas would be above the ceramic wall 66. However, this alternative would result in undesirable increases in inter-electrode capacitance and inductance caused by the increased lengths. Since the final seal is provided at 67, it is possible to eliminate the usual sealing rings between the anode and the adjacent envelope ceramic 66. Instead a butt seal is provided between the anode and the ceramic 66. In order to make such a butt seal withstand the forces caused by the different expansion characteristics of the copper and ceramic, the anode is recessed at 75 to provide a weakened or reduced thickness wall section 76. The end of the reduced section is brazed to the ceramic wall 66 which is metalized for that purpose.

It will be noted from the prior description that a very simple and extremely rugged arrangement is provided for securing the heater in the cathode, and also for securing the cathode and grids together, the latter in a manner which minimizes undesirable capacitance and adds to desirable capacitance. In addition, very simple and extremely rugged means are provided for connecting the control grid to the four terminal pins.

Further, it will be noted that a cathode-screen grid bypass capacitor has been built into the tube in a very simple and rugged manner. More specifically, it should be noted that the by-pass capacitor forms part of the vacuum envelope and that the relatively fragile thin ceramic wafer 63 is protected from damage by metal rings 21 and 64. It is of course necessary to provide a substantial voltage hold-off distance, or air gap, between the metal ring 21 and the metal rings 62, 64. This has been accomplished by making ring 62 of smaller outside diameter than ring 21, and further where necessary by deflecting ring 64 upwardly away from ring 21. Obviously, a substantially equivalent electrical characteristic and protection for the ceramic wafer 63 can be achieved if ring 64 is replaced by ring 62 extended in diameter and bent upwardly like ring 64. However, in some cases such construction reduces the yield of vacuum tight tubes because the heat of a final seal made between ring 65 and the described modification of ring 62 is too well conducted through copper ring 62 and tends to damage the seals between pins 28 and 35 and the header ceramic 34. This problem has been solved by the introduction of ring 64 having a lower coefficient of thermal conductivity than copper. It should also be noted that the location of the final seal adjacent the by-pass capacitor area makes it possible to employ a simple butt seal for the anode and also makes it very convenient to reach the necessary connecting points before the preassembled anode and cylinder 66 and ring 65 are lowered into place for final seal; such connecting points are for example the spot welds between 19 and 16, and between 27 and 31, and the positioning of screws 61.

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

1. An electron tube comprising cylindrical electrodes including a cathode, a control grid, a screen grid and an anode; a heater in said cathode comprising a ceramic cylinder, a heater wire wound on the outside of said cylinder, and a metal sleeve abutting the inside of said cylinder and rigidly connected to said cathode; terminals for said electrodes including pins spaced around a circle and projecting through the bottom of the electron tube, means conecting said control grid to said pins inside the tube and comprising an annular metal member brazed to said pins; means electrically separating and physically connecting the ends of said cathode and said grids and comprising metal end caps for said cathode and said screen grid and a ceramic end cap for said control grid, and a pin structure projecting through all three of said end caps; said terminals further comprising a metal ring projecting outside said tube and connected internally to said cathode, a completely metal ring structure projecting outside said tube and connected internally to said screen grid; a thin ceramic ring-shaped wafer sandwiched between said ring and ring structure in abutting relationship and forming therewith a by-pass capacitor; the external diameter of each of said ring and ring structure being at least as great as that of said wafer, and the minimum air gap between said ring and ring structure being greater than the thickness of said wafer; and said metal ring structure comprising two rings joined together by the final seal for the tube.

2. An electron tube comprising cylindrical electrodes including a cathode, a control grid, a screen grid and an anode, terminals for said tube comprising a metal ring projecting outside said tube and connected internally to said cathode, a completely metal ring structure projecting outside said tube and connected internally to said screen grid, a thin ceramic ring-shaped wafer sandwiched between said ring and ring structure in abuting relationship and forming therewith a by-pass capacitor, the external diameter of each of said ring and ring structure being at least as great as that of said wafer, and the minimum air gap between said ring and ring structure being greater than the thickness of said wafer.

3. An electron tube as claimed in claim 2 in which said ring structure comprises a first ring abutting said wafer and having a smaller diameter than said wafer, and a second ring separated from said wafer by said first ring, said second ring having a larger diameter than each of said cathode ring and said wafer.

4. An electron tube as claimed in claim 3 in which said ring structure further comprises a third ring on the side of said second ring remote from said first ring, and a final seal for said tube joining said second and third rings.

5. An electron tube comprising a cathode, a control grid, a screen grid and an anode, said tube having an envelope comprising a ceramic header disk at one end and a side wall ceramic cylinder, terminals for said electrodes comprising pins projecting through said header and brazed in metalized apertures therein, means connecting said pins to said control grid inside said tube, said terminals further comprising a metal cathode ring and a completely metal ring structure projecting outside said envelope, said metal cathode ring being connected to said cathode and hermetically bonded to said header, said ring structure being connected to said screen grid, a thin ring-shaped ceramic wafer sandwiched between said ring and ring structure in abutting relationship and forming therewith a by-pass capacitor, said ring structure comprising a first metal ring of copper directly abutting said wafer, a second metal ring of lower thermal conductivity than copper abutting said copper ring, and a third metal ring hermetically bonded to one end of said ceramic cylinder, the outer diameter of said cathode ring being at least as great as that of said wafer, the outer diameter of said copper ring being less than that of said wafer, the outer diameter of said second ring being greater than that of said cathode ring, a hermetic final seal between said second and third metal rings, and a butt seal directly between said anode and the other end of said ceramic cylinder.

6. An electron tube as claimed in claim 5 in which said butt seal comprises a ledge on the outer periphery of said anode abutting said other end of the ceramic cylinder, and anode comprises a rim portion projecting from said ledge along the inside of said ceramic cylinder.

7. An electron tube as claimed in claim 5 in which said anode is a metal cup-shaped member having a relatively thick wall portion forming part of the tube envelope, and said wall thickness being reduced adjacent said butt seal.

8. An electron tube comprising cylindrical electrodes including a cathode, a control grid, a screen grid and an anode, terminals for said tube comprising a metal ring projecting outside said tube and connected internally to said cathode, a completely metal ring structure projecting outside said tube and connected internaly to said screen grid, a thin ceramic ring-shaped wafer sandwiched between said ring and ring structure in abutting relationship and forming therewith a by-pass capacitor, the outer diameter of each of said ring and ring structure being at least as great as that of said wafer, and said ring structure being step-shaped so that it abuts the inner portion of said wafer and is spaced from the outer portion of said wafer.

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JOHN W. HUCKERT, *Primary Examiner.*

DAVID J. GALVIN, *Examiner.*

R. SANDLER, *Assistant Examiner.*