Nov. 1, 1955 H. D. DOOLITTLE 2,722,624

ELECTRON TUBE

Filed April 21, 1952 2 Sheets-Sheet 1

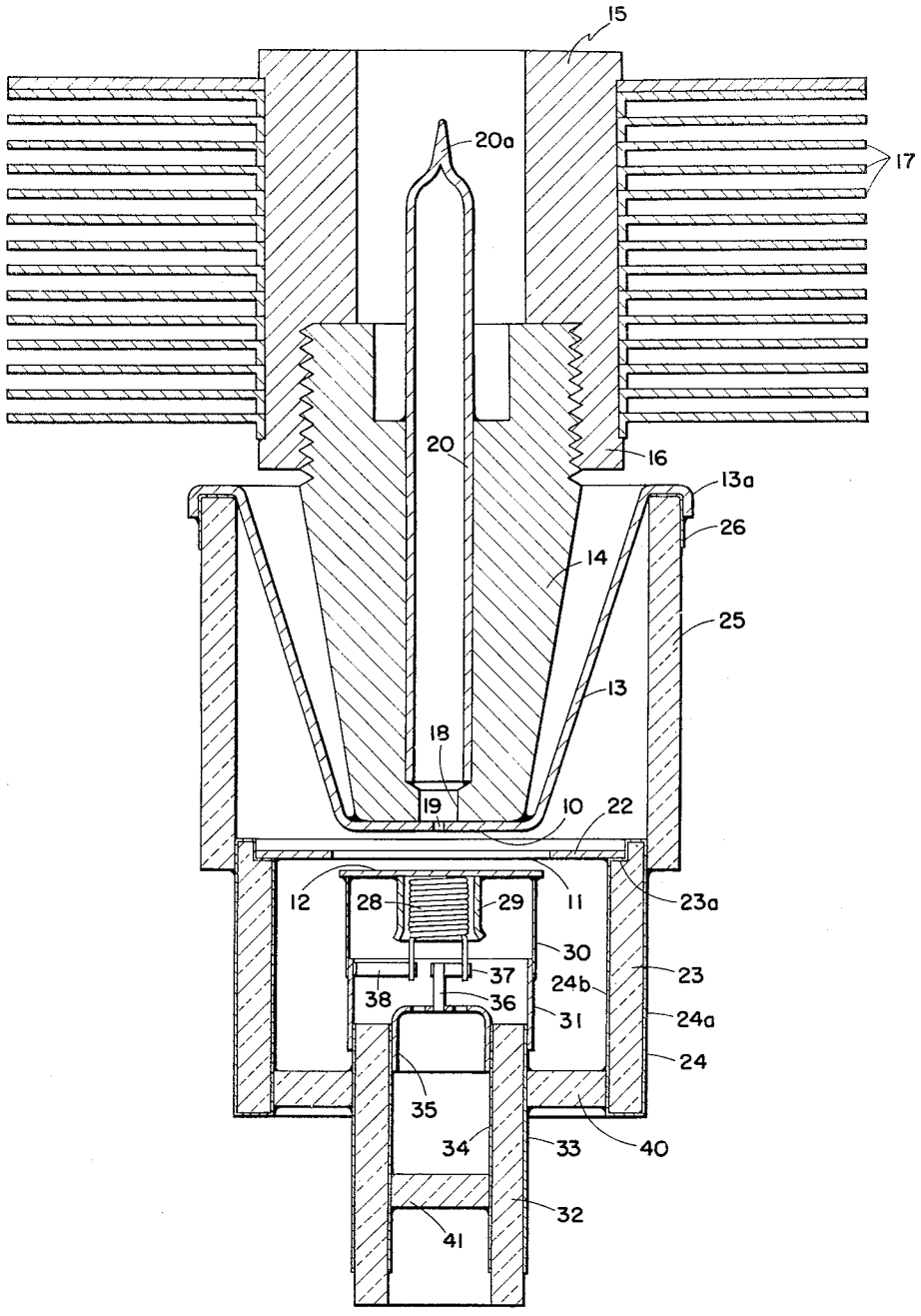


FIG. 1

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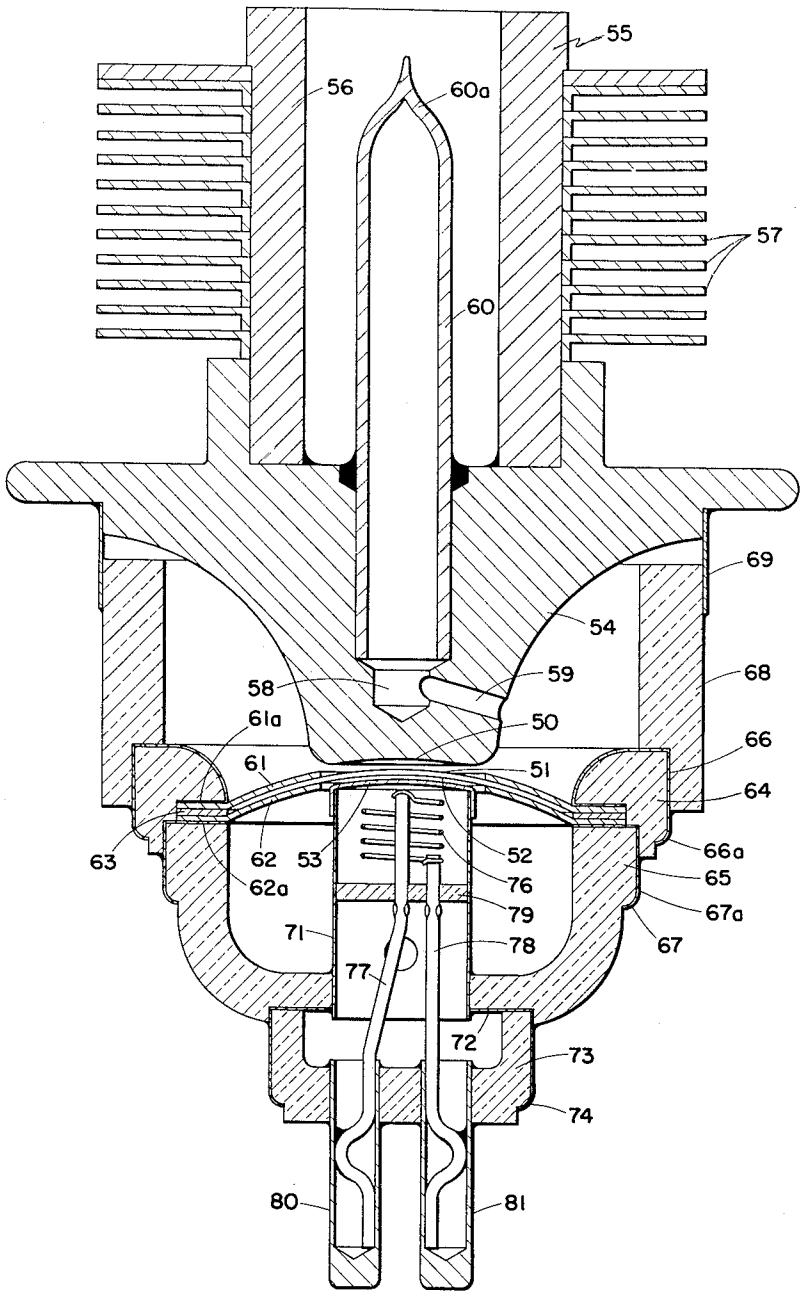


FIG. 2

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ELECTRON TUBE

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4 Claims. (Cl. 313—250)

This invention concerns an electron tube useful in high frequency applications having an envelope composed primarily of ceramic members whereon are formed coaxial terminals by metallizing processes. More specifically, this invention relates to an electron tube having various ceramic envelope portions wherein different parts of the metallic coating on one of the ceramic envelope members carry different currents.

The use of metallized surfaces on ceramic electron tube envelope members is taught by Passarge in his Patent No. 2,099,531, which extends to the use of such metallized surfaces as electrodes, conductors, lead through connections and terminals. Although Passarge does teach the use of the metallic joints uniting the ceramic members as lead-in conductors, he does not teach the use of a single one of his ceramic envelope members for the purpose of carrying two separate currents.

Different electric currents must ordinarily be isolated from one another if they are not to interfere with one another. Such isolation in conventional tube construction is accomplished by an insulator, such as glass. Where ring seals are employed in coaxial tube construction, the insulators must be carefully matched to metallic members from the standpoint of expansion and the matching metallic sections must be long enough so that metallic members to which they are in turn sealed will not modify their expansion at the glass. The length of these metallic glass-sealing members imposes a minimum limit on the size of the tube.

In high frequency applications it is desirable to keep the tube structure as small as possible. Furthermore, in a particular case it may be simply desirable to keep a pair of leads close spaced to one another. These ends are furthered by the close spacing which is possible between conductors in the tube structure of the present invention. If, in addition to using metallized areas as lead-through conductors, the ceramic surfaces are employed as terminal members, additional space is saved. Moreover, the use of metallized ceramic envelope portions minimizes the number of parts required and hence again makes a more compact structure possible. Obviously, a terminal member need not be confined to one ceramic member but may be arranged entirely or in part on any ceramic envelope member adjacent to the lead-through.

In some instances it is desirable to have separate electric currents flow to or from the same electrode or different parts of the same electrode along different paths. This is particularly the case in grid structures where the grid is coupled to both the input and output of the cavity circuit. In such a case it is desirable to put separate conductors between the opposite sides of the grid and the respective input and output circuits. This may be accomplished in various ways. A preferred way of accomplishing it, however, is by use of a single ceramic member which is metallized on all surfaces of its annular body since the grid is mounted on the metallic surface at some point and a cavity wall is mounted on the metallized surface at another point. One side of the cavity

wall is part of the input circuit and carries input currents and the other side of the cavity wall is part of the output circuit and carries output current. Thus, currents from one side of the grid flow to one side of the cavity wall and currents from the other side of the grid flow to the other side of the cavity wall along different portions of the metallized surfaces of said member.

For a better understanding of my invention reference is made to the following drawings:

Fig. 1 is a sectional view taken along the axis of a planar triode which employs my invention.

Fig. 2 illustrates, in a similar sectional view, a tetrode which has generally planar elements and in which my invention is employed.

Referring to Fig. 1 the structure shown is a modified form of a widely used conventional type of ultra high frequency triode. The active elements are an anode **10**, a grid **11** and a cathode **12**, all of which are mutually parallel and close spaced. The active anode **10** is the bottom of cup **13** which is advantageously composed of low expansion metal whose coefficient of expansion closely matches that of the envelope insulation. Affixed to the cup's bottom opposite its active surface is copper block **14** which conducts heat away from the active anode surface **10** out to a radiator element generally designated **15**. This radiator element may be conveniently affixed to the copper block **14** by means of its threaded engagement with heavy tubular radiator core member **16**. A plurality of annular fins **17** surround and are affixed to the outside of tubular core member **16** to provide a large surface area for the dissipation of heat. An axial duct **18** is formed through anode block **14**. A small hole **19** is made through the bottom of cup **13** at the active anode surface **10** adjacent one end of this duct to provide a passage from the outside to the inside of the tube for the purpose of evacuating the vacuum envelope upon completion of the electron tube. Size requirements for this opening **19** may be determined by a reference to my U. S. patent application Serial No. 197,040, filed November 22, 1950. A tubular member **20** is inserted into axial duct **18** and fixed vacuum tight therein so that, upon complete evacuation of the electron tube, the tubulation may be sealed off at **20***a* using processes known to the art.

Grid **11** may advantageously be composed of a mesh of refractory wire which is permanently affixed to the annular grid ring **22**. Grid ring **22** is supported on dielectric tubular envelope member **23** against a shoulder **23***a* formed adjacent one end of the tubular member. As shown, the whole surface of tubular member **23** is coated with conductive material **24**. Adjacent the end which supports grid support **22**, tubular member **23** is sealed vacuum tight to one end of tubular dielectric member **25** whose coefficient of expansion closely matches that of cup **13**. The lip of cup **13** is folded back in such a manner that it forms channel **13***a* which accommodates the end of member **25** opposite the end sealed to member **23**, and member **25** is sealed vacuum tight to the cup **13**. A conductive coating **26** may be applied to a portion of the outer surface of member **25** to form an anode terminal provided that this coating terminates in contact with lip **13***a* of the anode cup.

The cathode **12** is advantageously coated with oxide emitter material. The cathode **12** is indirectly heated by heater coil **28** which is surrounded by tubular heat shield **29** affixed at one end to the back of the cathode disk. The cathode itself is supported on a low conductivity foil collar **30**. The opposite end of foil collar **30** is affixed to conductive collar **31** which in turn is affixed to the outer surface of tubular dielectric member **32**. This outer surface of tubular dielectric member **32** is covered with a conductive coating **33** similar to that

found completely covering the surface of member **23**. The inner surface of dielectric member **32** is likewise coated with conductive material **34**. The ends of member **32** are left uncoated so that they provide a barrier between the two conducting surfaces. Cup-like conductor **35** is affixed within the tubular member **32** to contact the inner conductive coating at the end adjacent the cathode. Since a vacuum tight seal is not required between the cup **35** and dielectric member **32**, mere mechanical mounting is satisfactory. No matter how affixed, the cup **35** should be perforated in some manner similar to that shown in order to make possible the complete evacuation of the interior of the tube envelope. This cup-like member is connected to one side of heater **28** through rodlike axial lead **36** and conductive strip **37** respectively. The other side of heater **28** is connected through conductive strip **38** to tubular member **31**. The vacuum wall between tubular members **23** and **32** is completed by sealing annular dielectric member **40** between them. Similarly, disk-like dielectric member **41** completes the vacuum envelope when sealed within tubular member **32**.

It will be observed that the portions of the conductively coated surfaces of ceramic members **25**, **23** and **32** which are outside of the vacuum envelope provide excellent rigid terminals for the tube electrodes. Like all conductive coatings or layers of this invention, these are characterized by their vacuum tight bonding to dielectric surfaces. Since these coatings **26**, **24**, **33** and **34** are usually of highly conductive material, advantageously about 1 mil thick, they provide excellent terminals for high frequency applications where penetration of the current is rarely more than .001" into the surface of the conductor, and, where appropriate, they likewise provide more than adequate conductors of filament current. These terminals and the conductively coated surfaces of ceramic members which provide paths into the vacuum envelope to the active elements from these terminals may be produced by any conceivable method of affixing a conductive coating vacuum tight to a dielectric surface. My invention is not limited to any one of these methods but will be better understood by reference to a typical example. Typical of such methods are the so-called metallizing processes used in making ceramic-to-metal seals. For instance, a frequently used metallizing process applies molybdenum and a small amount of manganese to a ceramic surface by means of a so-called paint, which consists of fine powdered metal particles suspended in a suitable vehicle, such as amyl acetate. After application to the surface has been completed, the coated dielectric member is introduced into a furnace, which contains an inert atmosphere, and its temperature is sufficiently elevated to drive off the volatile components and at the same time to cause adhesion of the metal particles. Thereafter a thin ring of silver is placed atop the molybdenum-manganese layer. This assembly is placed in a furnace and fired to melt the silver in order to form a continuous conductive layer adhering vacuum tight to the dielectric surface. The silver also provides a convenient solder for joining the dielectric members in the tubes of my invention. It is possible to produce a high conductivity connection which extends between the element support within the tube and some terminal point on the outside of the vacuum envelope, while at the same time producing a vacuum seal between various envelope portions. Since similar techniques have been used to join ceramic and metal members in the prior art, a junction between the conductively coated dielectric members and metallic element supports may be accomplished using conventional means.

The particular tube structure of Fig. 1 offers many advantages. For instance, it reduces the number of precision parts which must be employed in the cathode stem and grid area and permits these structures to be simple and compact. Furthermore, its grid terminal construction is of great advantage in that it eliminates common coupling between the plate-to-grid and cathode-to-grid currents. In other words, by this construction plate-to-grid and cathode-to-grid radio frequency currents may flow in separate paths to opposite sides of the active grid area. Thus the plate-to-grid current will flow along coating *24a* on the outside surface of dielectric member **23**, and the cathode-to-grid current will flow along coating *24b* on the inside surface of dielectric member **23**.

Fig. 2 illustrates a generally planar type tetrode for use at ultra high frequencies. This tetrode contains an active anode **50**, a control grid **52**, a screen grid **51** and a cathode **53**. The active anode is located at one surface of a highly conductive metallic block **54** to which may be affixed cooler element, generally designated **55**. Cooler element **55** advantageously consists of a heavy tubular core member of conductive material **56** and a plurality of annular fins **57** surrounding tubular member **56** and affixed to its outer surface. An axial duct **58** is terminated short of the active anode surface and is joined with the interior of the vacuum envelope through port **59**. Tubular seal off **60** is soldered vacuum tight within duct **58** and serves to permit evacuation of the envelope after completion of the tube. After evacuation is completed, tubular member **60** is sealed-off at **60***a* using conventional means.

Screen grid **51** and control grid **52** are supported generally parallel to one another by parallel concave members **61** and **62** which have peripheral planar areas **61***a* and **62***a* respectively. The correct spacing and separation of the two grid supports **61** and **62** is accomplished by the interposition of annular dielectric member **63** between the planar peripheral portion **61***a* and **62***a* of the grid supports. These peripheral portions of the grid supports are held between opposed planar surfaces of dielectric members **64** and **65**. Surfaces of these dielectric members are coated with metal, as described in the case of the tube of Fig. 1, such that a conductive coating **66** on member **64** extends from the screen grid support **61** through the vacuum envelope to an outer surface of the dielectric member **64**. The conductive coating **66***a* on the outer portion of member **64** serves as the terminal for the screen grid. Likewise, a surface of member **65** extending from the control grid **52** through the vacuum envelope to the outside of member **65** may be coated with conductive material **67**. In this case the conductive surface area **67***a* outside the vacuum envelope serves as a terminal for the control grid. The members **64** and **65** may be fixed together using the conductive material **67** also as a soldering medium. Member **64** is also affixed to tubular member **68** which in turn is joined to anode block **54** through the metallic collar **69**.

The surface of cathode **53** is advantageously coated with oxide emitter material. The cap-like cathode is supported on tubular metallic member **71** which in turn may be joined to the end of dielectric member **65** remote from screen grid support member **62**. In this instance a metallic coating may be provided from metallic sleeve **71** over a portion of dielectric member **65**. This metallic layer **72** may be employed in joining dielectric members **65** and **73**. The outer surface of dielectric member **73** may also receive a metallic coating **74** which continues metallic coating **72** and provides a terminal for the cathode. Within the cathode and its support structure heater element **76** is connected at one end to conductor **77** and at the other end to conductor **78**. These conductors extend through a dielectric heat baffle **79** into cup-like prong members **80** and **81** respectively in which they are fixed by soldering or other conventional means. These cup members **80** and **81** are affixed vacuum tight adjacent their lips to ceramic member **73**.

The particular advantage achieved by the structure of Fig. 2 is extremely close spacing between the active control and screen grids and general accuracy in overall

tube and element spacing, together with a highly compact tube structure.

The tube structures described illustrate many of the advantages of my invention. Many other structures differing materially in appearance from the electron tubes described are within the scope of my invention, however. For instance, my invention is not confined to tubes of planar geometry nor is it confined to use in any particular portion of the tube structure or in connection with any particular tube element. In general, it is characteristic of my invention to provide the structural benefits of mechanical and thermal ruggedness at points where relatively weak dielectric-to-metal seals would normally be employed. It is likewise an advantage of my invention that strong rigid terminal members may be provided without producing undue strain on the tube structure in general and dielectric-to-metal seals in particular.

I claim:

1. A high frequency electron tube having an anode, a cathode and a grid within a vacuum envelope and respective terminals therefor externally of the envelope, the envelope being composed primarily of annular ceramic members mounted in stepped relationship in order to provide convenient cavity circuit coupling, wherein one of said annular ceramic members between the anode and cathode terminals has its entire surface covered with a metallic layer which metallic layer is electrically connected to the grid providing internal connecting leads to the grid, leads through the vacuum envelope and sealing means for the ceramic member composing said envelope.

2. A high frequency electron tube having an anode, an indirectly heated cathode and a grid within a vacuum envelope composed primarily of annular ceramic members mounted in stepped relationship in order to provide convenient cavity circuit coupling, wherein one of said annular ceramic members has its inner and outer surfaces covered with electrically separated metallic layers each of which metallic layers extends through the vacuum envelope thereby providing sealing means for the ceramic envelope members, lead through conductors connected respectively to opposite sides of the cathode heater, and terminals for the respective sides of the cathode heater.

3. A high frequency electron tube having planar anode, cathode and closely-spaced screen and control grid electrodes within a vacuum envelope composed primarily of annular ceramic members arranged in stepped relationship, support members of essentially the same shape and size for each of the grids, a low expansion dielectric annulus arranged between the grid supports which annulus provides the exact spacing required between the grid electrodes, a pair of ceramic envelope members receiving and supporting the grid supports, a surface of each of said ceramic envelope members being covered with a metallic layer which is in electrical contact with one of the grid supports, each of which metallic coatings constitutes a lead through the vacuum envelope and a terminal for the electrode it contacts.

4. A high frequency electron tube having anode, cathode, and grid electrodes within a vacuum envelope, and respective electrode terminals externally of the envelope, the vacuum envelope comprising annular members formed of ceramic material, one of the annular members bearing a metallic layer having two spaced portions separated by ceramic material of which the member is formed, the metallic layer being electrically connected to one of the electrodes and the two spaced portions thereof providing separate respective paths for two separate currents flowing between the electrode to which the metallic layer is connected and the terminals of the other two electrodes.

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