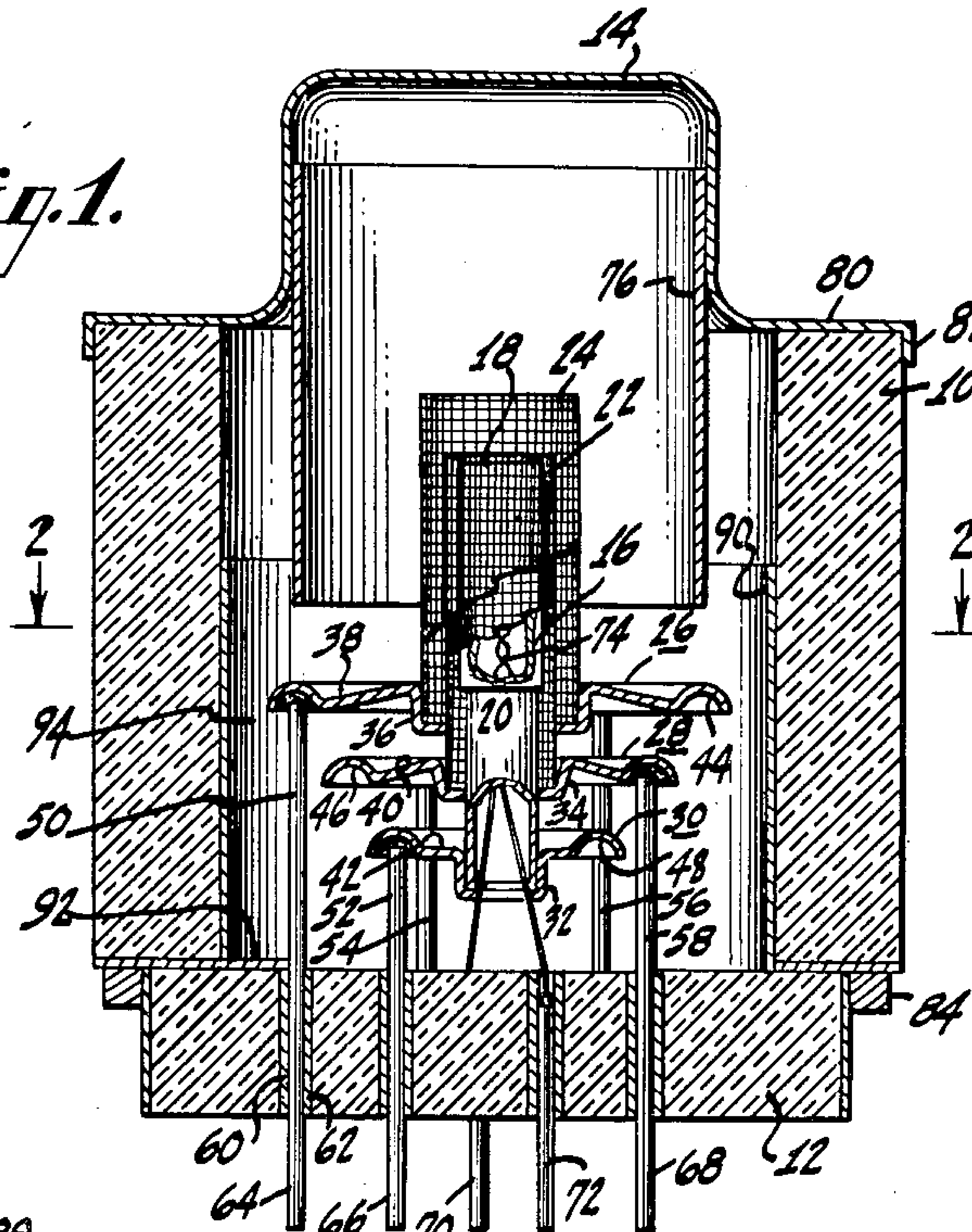
Aug. 8, 1961 O. H. SCHADE, SR 2,995,673

SFLF-SHIELDED ELECTRON TUBE

Filed Nov. 7, 1958

Fig. 1.



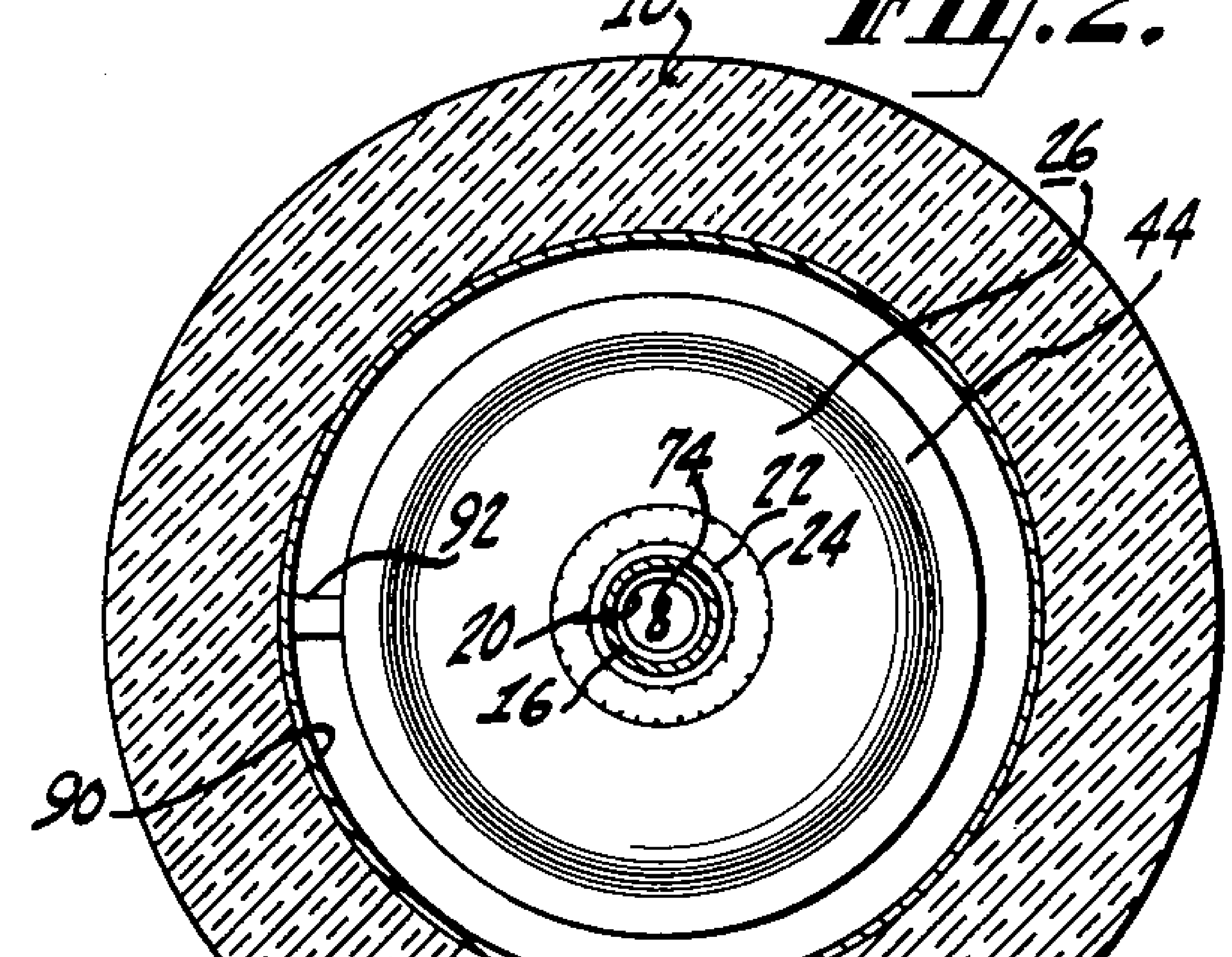


Fig. 2.

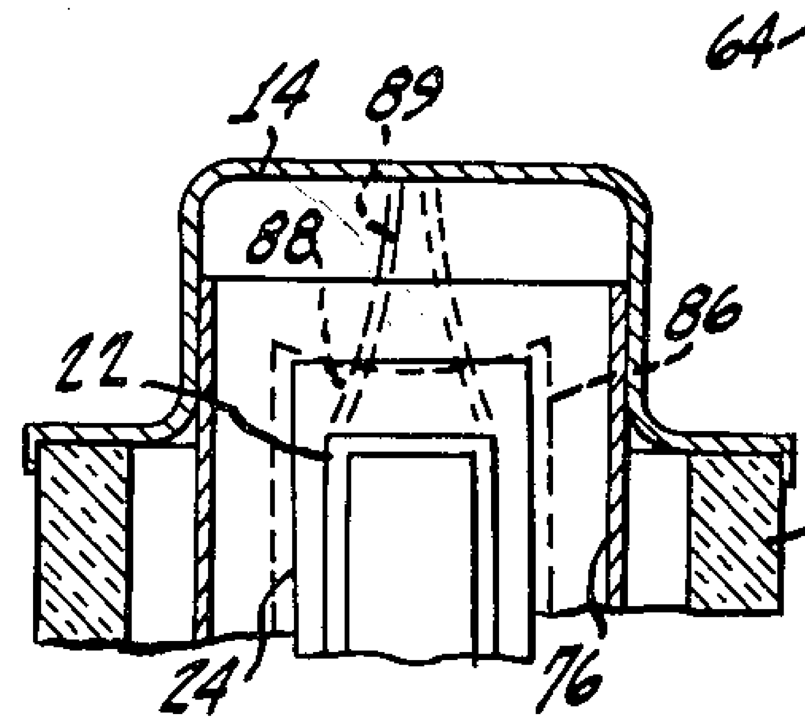


Fig. 3.

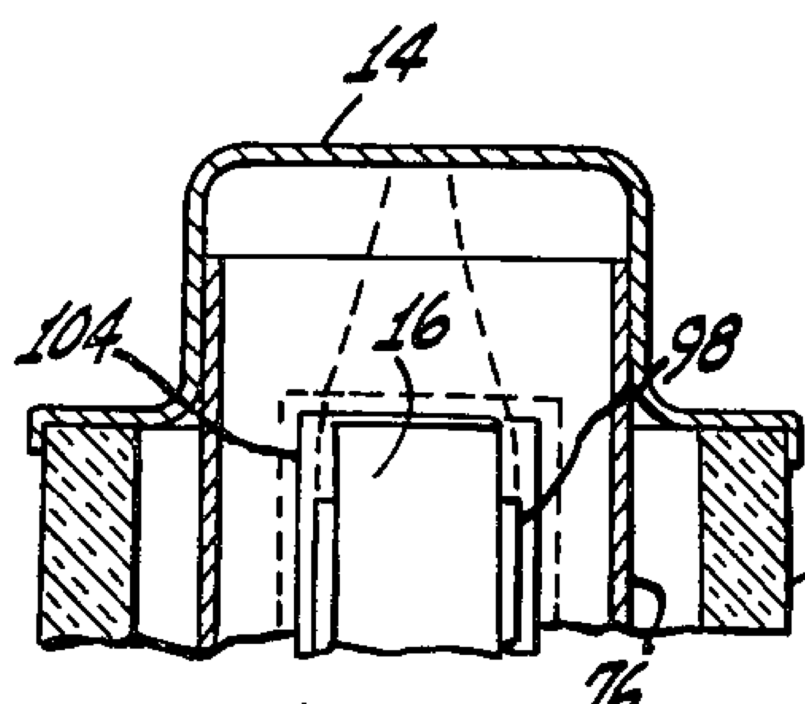


Fig. 4.

INVENTOR.
OTTO H. SCHADE, SR.

BY

L A Larsen

ATTORNEY

United States Patent Office

2,995,673

Patented Aug. 8, 1961

2,995,673

SELF-SHIELDED ELECTRON TUBE

Otto H. Schade, Sr., West Caldwell, N.J., assignor to Radio Corporation of America, a corporation of Delaware

Filed Nov. 7, 1958, Ser. No. 772,450
9 Claims. (Cl. 313—265)

The present invention relates to electron tubes having improved shielding features at radio frequency operation and particularly to a tube having self-shielding properties.

The term "self-shielding" is intended to describe a feature wherein structural elements of a tube designed primarily to perform functions other than shielding, also serve as effective shields.

One element of an electron tube that is particularly sensitive to conditions for which shielding is desirable, is the control grid. At frequencies within the standard broadcast band potential fields may be generated within a tube which are of such type as to produce unwanted electron charges and resultant potential changes on the control grid included in the tube. Such unwanted potential changes seriously impair the signal fidelity in the output of the tube.

While many solutions to the problem of adequate shielding of the control grid have been presented in the past, such solutions are characterized by the need to employ tube elements designed primarily for shielding purposes. Such elements, therefore, involve added expense in tube manufacture.

Accordingly, it is an object of the invention to provide an improved self-shielded tube.

It is another purpose of the invention to provide an electron tube including parts having a structure determined primarily by considerations remote from shielding but which also exhibit effective shielding properties.

One embodiment of the invention may comprise a tetrode type of electron tube having a cathode and control and screen grids supported at one end of an envelope, and an anode supported at the other end. In the aforementioned embodiment, the screen-grid is intermediate the control grid and anode. While the screen-grid in such arrangement screens the control grid from the anode to a certain extent, additional shielding value is realized according to the invention, by extending one end of the screen-grid beyond the adjacent end of the control grid and by associating the other end of the screen-grid with a support structure and metallically coated bulb portion which intercept the lines of force between the anode and the other end of the control grid. This additional shielding value is obtained without the need for special parts intended primarily for shielding purposes.

In a structure of the type referred to incorporating the invention, a certain equipotential surface characteristically generated between the anode and control-grid of a tetrode type of electron tube, extends relatively close to the active portion of the screen-grid. However, lines of force extending from semi-exposed end regions of the control grid to the anode and in normal relation to the surface referred to, have an appreciable length intermediate the control grid regions referred to and the aforementioned equipotential surface. In this way, the control grid is isolated effectively from this equipotential surface.

Further objects and features of the invention will become apparent from a consideration of the following and more detailed description of an embodiment thereof, taken in connection with the accompanying drawing, wherein:

FIG. 1 shows a sectional elevation of a tetrode type of electron tube in which the invention is incorporated;

FIG. 2 is a transverse sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a schematic representation of an equipotential surface and force lines, present in a tube of the type shown in FIG. 1; and

FIG. 4 is a schematic showing of an equipotential surface and force lines present in a modified form of electron tube according to the invention.

Reference to the drawing will reveal in FIG. 1 thereof a tube structure of the tetrode type in which the invention is embodied. The tube structure referred to includes an envelope constituted by a bulb **10**, which may be cylindrical and made of a ceramic material such Forsterite, a wafer **12** closing one end of the bulb and also made of a ceramic material such Forsterite, and a metallic cap **14**, which may be made of a suitable metal such as nickel or a ceramic material such as Forsterite.

Mounted within the envelope aforementioned are two groups of coaxial tubular electrodes. One of these groups is supported on the wafer **12** and comprises a tubular cathode member **16** having a closed end **18** and fixedly telescoped over a tubular cathode support **20**, a control grid **22**, surrounding the cathode member **16**, and a screen grid **24** surrounding the control grid. Adjacent end portions of the electrodes referred to are brazed to the inner walls of centrally disposed tubular portions of support collars **26**, **28**, **30**, by means of a suitable brazing material such as copper. Thus, as shown in FIG. 1, the lower end of the cathode support **20**, is fixed to the tubular portion **32** of support collar **30**, the lower end of the control grid **22** is fixed to the tubular portion **34** of support collar **28**, and the lower end of the screen grid **24** is fixed to the tubular portion **36** of support collar **26**.

The support collars aforementioned, in addition to the tubular portions **32**, **34** and **36**, include radially extending flanges **38**, **40** and **42**. Adjacent to the peripheries of the flanges **38**, **40**, **42** are formed annular troughs **44**, **46**, **48**, coated with a suitable brazing material, such as copper, and having a function to be described.

For supporting the structure comprising the three electrodes referred to, the tubular cathode support and the support collars, a plurality of wires, some of which **50**, **52**, **54**, **56** and **58** are shown in FIG. 1, extend through the wafer **12** and have their upper ends brazed to the annular troughs **44**, **46**, **48** referred to. The wires may be made of a refractory metal, such as molybdenum, and may have a coating thereon of copper, for example. Preferably, three wires equidistantly spaced around the axis of the wafer **12** are utilized for engaging each of the collars **26**, **28** and **30** at their troughs **44**, **46** and **48**, for providing a relatively rugged tripod support for each collar.

The three wires constituting the support for each collar **26**, **28**, **30**, extend into openings **60** in the wafer **12** and are brazed by means of the aforementioned copper coating thereon to metallic coatings **62** on the inner walls of the openings referred to. The coatings **62** may be molybdenum.

In one embodiment, only one wire in each tripod array extends beyond the outer surface of the wafer **12**, for service as a control prong. Thus, external prongs **64**, **66** and **68** constitute parts of wires **50**, **52** and **58**, respectively, connected to different electrodes. Wires **54** and **56** do not extend beyond the outer surface of wafer **12** and serve solely as support elements.

Additional wires **70**, **72** extend only from the outer face of the wafer aforementioned, and serve as external contact prongs for a heater **74** positioned within the cathode support **20** and to the legs of which the inner ends of the wires **70**, **72** are brazed by a suitable material, such as copper.

The other of the two groups of electrodes mounted within the envelope aforementioned, comprises a tubular anode **76** pressed into cap **14**, as viewed in FIG. 1. The upper end surface of cylinder **10** may have a metal coating thereon, of molybdenum, for example, and the inner face of flange **80** may have a coating thereon of a suitable brazing material, such as copper, for fixing flange **80** to the cylinder **10** in a hermetically tight joint.

The flange **80** may be provided with a cylindrical annulus **82** so that the annulus is adapted to engage the outer side wall of cylinder **10** for centering the cap **14** with respect to the cylinder.

By means of a suitable jig, not shown, the wafer **12** may be centered with respect to the cylinder **10**. When so centered, the wafer **12** may be fixed to the lower end of cylinder **10**, as shown in FIG. 1, by means of a suitable metallic coating, such as molybdenum, on the lower end surface of the cylinder and on the periphery of the wafer **12**, to which coating on both the cylinder and wafer may be brazed a suitable material **84**, such as NIORO solder which includes nickel and gold.

The electrodes of any electron tube form an electrostatic system, each electrode acting as one plate of a capacitor. The resultant interelectrode capacitances can seriously influence tube operation, particularly at high radio frequencies. The most important of these capacitances on tube performance is that between the anode and control grid. If the tube is used as an amplifier at radio frequencies, and if this capacitance exceeds a certain value, sufficient energy may be fed back to cause undesirable oscillation.

The electrostatic system in a tetrode is characterized by equipotential surfaces, one of which is designated **86** in FIG. 3, illustrating a potential field condition existing between the anode **76** and the control grid **22** and adjacent to the screen grid **24**.

According to the invention, one end portion of the control grid **22** is isolated from the electrostatic field of the anode by extending the screen grid **24** axially beyond the free end of control grid **22**, as shown in FIGS. 1 and 3. This disposes the free end of the control grid in a relatively deep well in which it is effectively shielded from the anode field. The capacitances between grid to anode can be calculated as follows: A capacitance exists between the upper portion of the control grid **22** to the aforementioned potential surface **86**. The force lines **88** and **89**, in FIG. 3, indicate the distance and effective annular surfaces determining such capacitance. This capacitance is in series with a second capacitance between the potential surface **86** and the cap **14** connected to the anode **76**. The resultant series capacitance should not exceed a small value to prevent harmful feedback.

The distance that the screen grid **24** is made to extend axially beyond the upper end of the control grid **22**, controls the value of the series capacitance referred to, according to the invention, and is determined by performance factors of the tube. Applicant has found that good results are obtained if the distance aforementioned is at least as large as one-half the diameter of the cathode **16**.

While the upper end portion of the control grid **22** is thus effectively shielded from the electrostatic field of the anode **76**, the lower end portion of the control grid is also desirably shielded according to the invention. The shielding of the lower end portion of the control grid is effected by the support collar **26** supporting the screen grid, and the lower portion of the inner wall of the ceramic envelope cylinder **10** having a metallic coating **90** thereon, such as of molybdenum. The metallic coating **90** may be connected to prong **64** serving the screen grid **24** by means of a coating strip **92**, shown in FIGS. 1 and 2, interconnecting the coating **90** and the coating **62** to which lead **64** is brazed. If it should be desired to have the coating **90** impressed with a different potential than that of the screen grid **24**, it is feasible to have

the strip **92** connect the coating **90** to another lead-in, such as cathode prong **66**.

It will be noted that in the foregoing structure a relatively narrow annular space **94** is provided between the periphery of the screen grid collar support **26** and the coating **90**. This space is appreciably separated from the lower exposed region of the control grid. The small size of the space aforementioned precludes any significant penetration of the anode field below the screen-grid collar **26**. Consequently, the capacitance of the lower portion of the control grid to the anode is of negligible magnitude. For best results, the coating **90** should extend upwardly, at least to the plane of collar **26**. It should extend downwardly, at least to the plane of control grid collar **28**. When the lower end of coating **90**, as viewed in FIG. 1, is spaced from the wafer **12**, a suitable metallic coating strip, not shown, may be provided on the inner wall of cylinder **10**, interconnecting the coating **90** with metallic coating strip **92** aforementioned.

It is evident the tetrode tube construction described, provides desired shielding of a control grid from the anode field without special shielding elements. Thus, the screen-grid itself, at its upper end portion, effectively shields the upper end portion of the control grid, as viewed in FIG. 1, and no additional shielding element is required at this end. In like manner, the collar **26** supporting the screen-grid **24** effectively cooperates with a coated portion of the inner wall of cylinder **10**, for shielding the lower portion of the control grid. The intermediate portion of the control grid is, of course, adequately shielded by the screen-grid. This accomplishment of a desired shielding function, according to the invention, without the need for special shielding members, contributes to reduced cost of an electron tube.

FIG. 4 shows a modified arrangement of a control grid and screen-grid in a tetrode type tube. In this arrangement the control grid **98** terminates short of the upper end of cathode **16**, and the screen-grid **104** is coextensive with the cathode. The upper end portion of the control grid, as in the previously described embodiment, is disposed in a well between the cathode and screen-grid, in which it is effectively shielded from the anode. The capacitance between the control grid upper end and the anode thus can be reduced to a negligible value. Applicant has found that in the example shown in FIG. 4, the free end of the screen-grid **104** should extend above the free end of the control grid **98** a distance at least as great as the radial distance from the cathode **16** to the control grid referred to, for good results. The cathode **16** in this arrangement should be free of emitting coating at the upper portion thereof above the control grid **98**.

While the structure of FIG. 4 produces more effective shielding for a given differential in the magnitude of upward extents of the screen and control grids, it is characterized by the disadvantage that the upper portion of the cathode must be free from appreciable electron emission. However, in certain applications, this disadvantage may be more than balanced by the resultant improved shielding.

It will be appreciated that instead of metallic end cap **14**, a ceramic wafer, made of Forsterite, for example, and having an annular coating band of a metal, such as molybdenum, may be used and which coating is adapted to be brazed to the upper end of cylinder **10**, as viewed in FIG. 1.

What is claimed is:

1. In an electron tube of the tetrode type having an envelope an anode, a control grid, a screen grid coaxial with said control grid, all within said envelope a first flanged support engaging one end of said control grid, a second flanged support engaging the adjacent end of said screen grid, said first and second supports being spaced axially of said grids, whereby said one end of

said control grid extends beyond said adjacent end of said screen grid, and the end portion of said control grid including said one end is exposed by said screen grid, said second flanged support having a larger transverse extent than said anode and being disposed between said anode and said exposed end portion of said control grid, said control grid and said screen grid being of substantially equal length, whereby a portion of said screen grid adjacent to the other end thereof extends beyond the other end of said control grid, said second flanged support and said last named portion of said screen grid shielding the end portions of said control grid from the anode field produced during operation of said tube, said envelope having a wall portion of conducting material extending from below the first flange to the end of the anode closest to said second flange, and a ceramic wafer member closing the envelope adjacent the wall portion of conducting material and supporting said cathode, said control grid and said screen grid within said envelope.

2. A self-shielded electron tube comprising an envelope including a bulb portion made of insulating material and closed at one end by a wafer and at the other end by a conducting closure member, a plurality of coaxial electrodes within said bulb portion and including a cathode, a heater for said cathode, and two grids, and an anode supported by said conducting closure member and surrounding said plurality of coaxial electrodes, lead-ins extending outwardly from said wafer and connected to said electrodes and heater, a flanged support engaging one end of the outer of said grids, and coaxial with said electrodes, the inner of said grids having an end portion adjacent to and extending beyond said one end of the outer grid, whereby said end portion is exposed by said outer grid, said flanged support having a transverse extent to dispose its periphery in relatively closely spaced relation with respect to the inner wall of said bulb portion, said inner wall having a metallic coating therearound, extending at least from a plane transverse of said bulb and including the free end of said anode to said wafer, for shielding said exposed end portion, and means electrically connecting said coating to one of said lead-ins.

3. A self-shielded electron tube comprising an envelope including a cylindrical bulb portion made of insulating material, electrodes within said envelope and concentric with said bulb portion and with each other, said electrodes including an anode, a control grid and a second grid, a first flanged support engaging one end of said control grid, a second flanged support engaging one end of said second grid, said supports being coaxial with said bulb portion and spaced along the axis thereof, a portion of said control grid being exposed by said second grid between said supports, the inner wall of said bulb portion having a metallic coating extending from the plane of one of said supports to the plane of the other of said supports, said coating being electrically connected to said second grid, said second support having a larger transverse extent than said anode and extending relatively close to said coated bulb portion, said second support being intermediate said anode and said exposed portion, whereby said second support and said coated bulb portion shield said exposed portion of the control grid from the field of said anode during operation of said tube, and a ceramic wafer member closing the envelope adjacent the bulb portion having the metallic coating thereon and supporting said control grid and said screen grid within said envelope.

4. A self-shielded electron tube comprising a cathode, a tubular first grid concentric with said cathode, a second grid surrounding said first grid and concentric therewith, and a tubular anode concentric with and surrounding at least adjacent end portions of said first grid and said second grid, said end portions of said grids being wholly open said first grid being spaced a predetermined radial distance from said cathode, the free end of said end portion of said second grid and the adjacent end

of said cathode being disposed substantially in a common plane, the free end of said end portion of said first grid being disposed in a plane intermediate the ends of said second grid and spaced from said common plane a distance at least as great as about one-half of said radial distance, for shielding said free end of said first grid from the field produced by said anode during operation of said tube.

5. In a tetrode type of electron tube, a control grid assembly, a screen grid assembly coaxial with said control grid assembly, and a bulb of insulating material enclosing said assemblies, said control grid assembly including a control grid and a support, said screen grid assembly including a support and a grid coaxial with said control grid, said control grid being telescoped partly only, within said screen grid, whereby adjacent ends of said grids are offset axially of the grids, one group of said adjacent ends comprising an end portion of said control grid exposed by said screen grid, said supports engaging said one group of adjacent ends, whereby said supports are spaced axially of said bulb a distance equal to the length of said exposed end portion of the control grid, said bulb having an annular metallic coating band coaxial therewith and axially coextensive with said exposed end portion, said support for said screen grid having a periphery in relatively close proximity to said coating band, and an anode surrounding said cathode and grids, said support for said screen grid and said coating band being intermediate said anode and said exposed end portion of the control grid for shielding said end portion, and a ceramic wafer member closing the envelope adjacent the bulb portion having the annular metallic coating thereon, and supporting said control grid and said screen grid within said envelope.

6. A self-shielded electron tube comprising an envelope including a bulb portion made of insulating material and conducting material, said bulb portion being closed at one end by an insulating wafer and being closed at the other end by an inverted cup-shaped member of conducting material, a tubular anode received within and supported by said cup-shaped member and extending toward said wafer, a plurality of coaxial electrodes supported by said wafer within said bulb portion and including a cathode, a control grid and a screen grid, all of said plurality of coaxial electrodes extending within and coaxial with said tubular anode, the end of the screen grid within said anode being wholly open, a first flange-like member secured to the end of said screen grid remote from said anode and extending radially to closely adjacent the conducting material of said bulb portion, a second flange-like member of smaller diameter connected to and supporting said control grid, the first flange being positioned between the end of the anode and said second flange, said first flange extending beyond the periphery of said anode and toward and being in close proximity to said conducting material, said conducting material extending between said flanges and to adjacent said anode whereby the lower end of said control grid and its flange support are shielded from said anode, said screen grid extending beyond the free end of said control grid within said anode a distance at least as great as the radial distance between the cathode and the control grid for shielding the upper end of the control grid from said anode.

7. A self-shielded electron tube comprising an envelope including a bulb portion made of insulating material and conducting material, said bulb portion being closed at one end by an insulating wafer and being closed at the other end by a conducting cup-shaped member extending outwardly from said bulb portion, a tubular anode received within and supported by said cup-shaped member and extending within said envelope toward said wafer, a plurality of coaxial electrodes supported by said wafer within said bulb portion and including a cathode, a control grid and a screen grid, all of said

plurality of coaxial electrodes extending within and coaxial with said tubular anode, a first flange-like member secured to the end of said screen grid remote from said anode and extending radially to closely adjacent the conducting material of said envelope, a second flange-like member of smaller diameter connected to the end of the control grid remote from said anode and supporting said control grid, the first flange-like member being positioned between the end of the anode and said second flange-like member, and said conducting material of said bulb portion extending between said anode and said wafer whereby the lower end of said control grid and its flange support are shielded from said anode.

8. A self-shielded electron tube comprising an envelope including a bulb portion made of insulating material and conducting material, said bulb portion being closed at one end by an insulating wafer and being closed at the other end by a conducting cup-shaped member extending outwardly of said bulb portion, a tubular anode having one end received within said cup-shaped member and supported thereby and extending inwardly of said envelope toward said wafer, a plurality of coaxial electrodes within said bulb portion and supported by said wafer and including a cylindrical cathode, a control grid and a screen grid, all of said plurality of coaxial electrodes being supported at one end by said wafer and having their free ends extending within and coaxial with said tubular anode, the end of said screen grid within said anode being wholly open, a first flange-like member secured to the end of said screen grid remote from said anode and extending radially outward and closely spaced from said conducting material, a second flange-like member of smaller diameter connected to the end of said control grid remote from said anode and supporting said control grid, said first flange being positioned between the end of the anode and said second flange, said first flange extending beyond the periphery of said anode, said conducting material extending from adjacent the inner end of said anode to said wafer whereby the lower end of said control grid and its flange support are shielded from said anode, said screen extending beyond the free end of said control grid within said anode a distance at least as great as about ½ the diameter of the cathode.

9. A self-shielded electron tube comprising an envelope including a bulb portion made of insulating material and conducting material, said bulb portion being closed at one end by an insulating wafer and being closed at the other end by a conducting cup-shaped member extending outwardly of said bulb portion, a tubular anode having one end received within said cup-shaped member and having its free end extending inwardly of said envelope toward said wafer, a plurality of coaxial electrodes supported by said wafer within said bulb portion and including a cylindrical cathode, a control grid and a screen grid, all of said plurality of coaxial electrodes being supported at one end by said wafer and having their free ends extending within and coaxial with said tubular anode, a first flange-like member secured to the end of said screen grid remote from said anode and extending radially outward and closely spaced from said conducting material, a second flange-like member of smaller diameter connected to the end of said control grid remote from said anode and supporting said control grid, said first flange being positioned between the end of the anode and said second flange, said conducting material extending from adjacent the free end of said anode to said wafer, whereby the lower end of said control grid and its flange support are shielded from said anode, said screen grid being completely and fully open at its free end within the anode and extending beyond the free end of said control grid for shielding the free end of said control grid.

References Cited in the file of this patent

UNITED STATES PATENTS

2,175,880	Crawford	Oct. 10, 1939
2,697,796	Eitel et al.	Dec. 21, 1954
2,794,933	Sorg et al.	June 4, 1957
2,814,750	Polese	Nov. 26, 1957
2,879,429	De Santis et al.	Mar. 24, 1959