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T. M. DE MURO

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ELECTRON DISCHARGE TUBE HAVING A DIODE BUILT THEREIN

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2 Sheets-Sheet 1

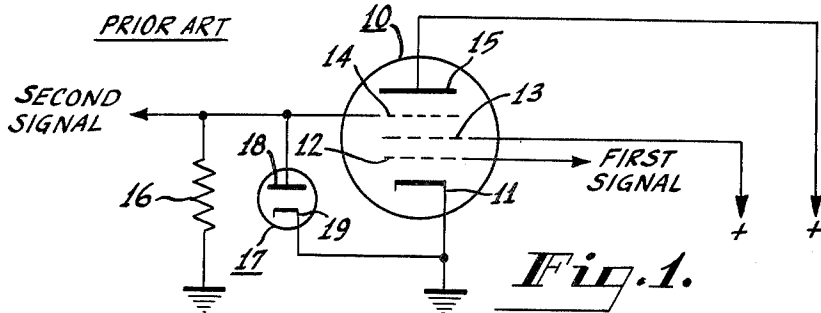
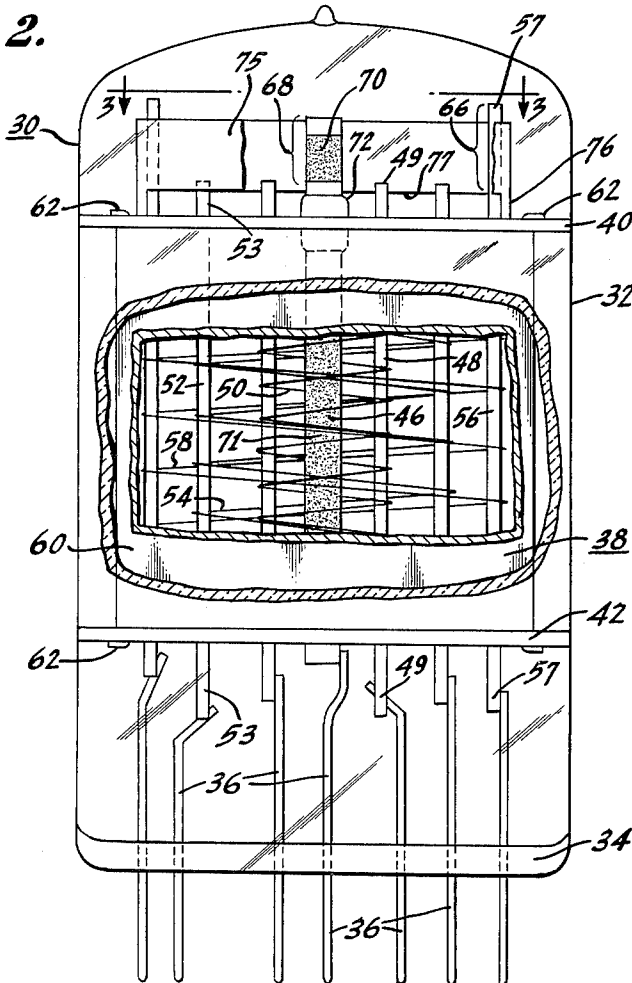


Fig. 2.



INVENTOR.

THOMAS M. DEMURO

BY

William A. Zaleski
Attorney

July 26, 1966

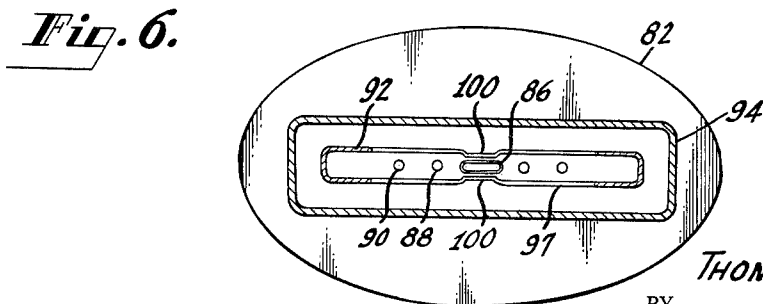
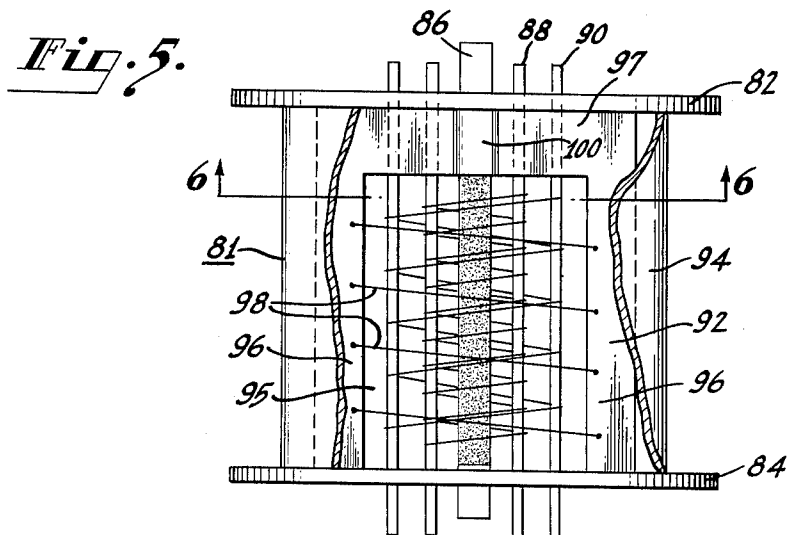
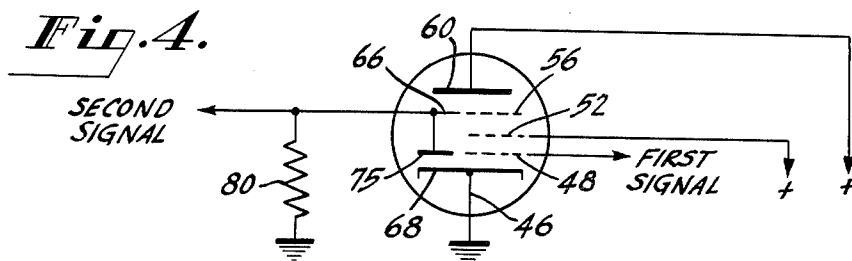
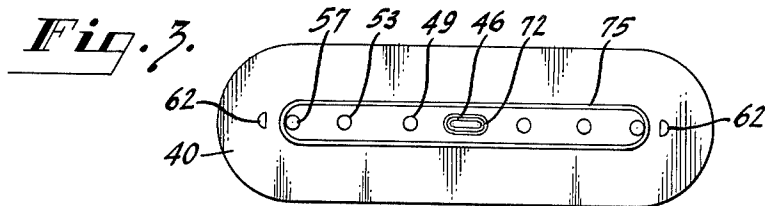
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INVENTOR.
THOMAS M. DEMURO

BY

William A. Ralesak
Attorney

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ELECTRON DISCHARGE TUBE HAVING A DIODE BUILT THEREIN

Thomas M. De Muro, New York, N.Y., assignor to Radio Corporation of America, a corporation of Delaware
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This invention relates to electron discharge tubes and particularly to electron discharge tubes used in circuit applications wherein the phenomenon known as "grid-blocking" is a problem.

In certain electron tube applications an electronic signal is applied to a grid of the electron tube which drives the grid positive for a short period of time. When the grid is made positive it is bombarded by electrons which cause an increase in temperature of the grid which may result in electrons being emitted from the grid. If the electron emission from the grid exceeds the number of electrons attracted to the grid, the current flow through the grid circuit is in a direction to cause a voltage rise across the grid circuit resistance. The increase in voltage at the grid attracts a greater flow of electrons to the grid which further heats the grid causing increased electron emission. The process stabilizes at some positive voltage on the grid when further increases of grid emission current are offset by equal increases of current flow to the grid. The positive voltage on the grid tends to remain on the grid thereby "blocking" or interfering with the normal operation of the electron tube.

The positive grid voltage is caused by the voltage rise across the grid circuit resistance caused by the flow of current through the grid. Thus, one means to prevent the build-up of a blocking positive grid voltage is to short circuit the grid circuit resistance during the positive voltage swing of the grid. This may be accomplished by connecting a diode in parallel with the grid circuit. That is, the positively driven grid is electrically connected to the anode of the diode and the cathode of the diode is electrically connected to the cathode of the tube containing the positively driven grid. Thus, when the grid swings positive, the diode begins to conduct and thereby provides a low resistance shunt across the grid circuit resistance. In this manner, build-up of the blocking voltage is prevented. The use of an extra diode for the purpose of shunting the grid circuit resistance, however, is an extra and undesirable expense.

An object of this invention is to provide an improved and inexpensive electron tube which automatically shunts out the resistance in the grid circuit of the tube during positive voltage swings of the grid of the electron tube.

Particularly, an object of this invention is to provide an improved and novel electron tube having a grid electrode and which provides a low resistance shunt across the resistance in the grid circuit of the tube during positive voltage swings of the grid for preventing the build-up of blocking voltages on the grid.

For achieving these objects in accordance with this invention, an electron tube may be provided including a cathode, at least two grids, one between the other and the cathode, and an anode. In circuit applications which may use the tube of this invention, the "other" grid, that is, a grid having one or more other electrodes disposed between it and the cathode, is positively driven. For preventing the build-up of blocking voltages on the other grid, the electrodes are so arranged that certain portions of the other grid are "exposed" directly to the cathode. That is, no other electrodes are disposed between these portions and the cathode. Since the exposed portions of the other grid are not obstructed from direct electron coupling with the cathode, the cathode emits electrons to the exposed portions of the other grid whenever a posi-

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tive voltage appears on the other grid. As will be described in greater detail hereinafter, the exposed portions of the other grid and cathode are in parallel to the resistance in the grid circuit of the other grid and shunt this resistance during positive voltage swings of the other grid. For increasing the conductivity between the exposed portions of the other grid and the cathode for more effectively shunting the grid circuit resistance, a conductive member (conductor or lead) may be connected to the exposed portion of the other grid which extends towards and closely adjacent the cathode.

In the drawings:

FIG. 1 is a schematic representation of a prior art arrangement of a pentode type electron tube having a diode shunt across the resistance in the grid circuit of the tube;

FIG. 2 is a side elevation of an electron tube which may be made according to this invention, parts being broken away to show details of construction;

FIG. 3 is a section along line 3-3 of FIG. 2;

FIG. 4 is a schematic representation of the tube shown in FIGS. 2 and 3, indicating the electrical connections to the electrodes of the tube;

FIG. 5 is a side elevation, partially broken away, of a modification of the cage assembly of the tube shown in FIG. 2 and made according to this invention; and,

FIG. 6 is a section along line 6-6 of FIG. 5.

The present invention may have utility in a variety of electron tubes containing at least one positively driven electrode and a further electrode which is disposed between the positively driven electrode and the cathode of the tube. For illustrative purposes, the present invention will be described in connection with a pentode electron tube having a cathode, a first control grid, a screen grid, a second control grid, and an anode.

Conventional pentode type electron tubes are often used in circuit applications wherein the second control grid is positively driven. FIG. 1 shows the electrical connections for the electrodes of a conventional pentode type electron tube 10 in a circuit application wherein the second control grid is driven positive. Details of the circuit are not shown since any number of circuits wherein the second control grid is or may be positively driven are well known. See, for example, Functional Circuits and Oscillators, Reich, Van Nostrand (1961), section 50.1.

The electron tube 10 includes a cathode 11, a first control grid 12 connected to have a first electrical signal applied thereto, a screen grid 13 connected to the positive source of voltage, a second control (third) grid 14 connected to have a second electrical signal applied thereto and which drives the grid 14 positive, and an anode 15 connected to a positive source of voltage. A resistance 16 is connected between the second control grid 14 and the cathode 11. For preventing the build-up of a positive blocking voltage on the second control grid 14, a diode 17 is connected in parallel with the second control grid circuit resistance 16. The anode 18 of the diode 17 is connected to the second control grid 14, and the cathode 19 of the diode 17 is connected to the cathode 11 of the electron tube 10. Elements connected to the screen grid and anode are not shown. Thus, when the second control (third) grid 14 swings positive with respect to the cathode 11 of tube 10, the diode 17 begins to conduct and provides a low resistance shunt across the grid circuit resistance 16 thereby preventing the build-up of a positive voltage across resistance 16.

An electron tube 30, as shown in FIGS. 2 and 3 may be provided in which the build-up of positive grid voltage on the third grid does not occur. Electron tube 30 comprises an envelope 32 closed at its lower end by a header 34 having conductive and support leads 36 extending therethrough in vacuum sealed relation. An electrode

cage assembly 38 is supported on the ends of the leads 36 within the envelope 32.

The cage assembly comprises a pair of spacer plates 40 and 42, usually of mica, for supporting the various tube electrodes and for providing the correct relative spacing therebetween. Mounted between spacer plates 40 and 42 are an elongated cathode 46, a first grid 48 having side rods 49 and a lateral winding 50, a second grid 52 having side rods 53 and a lateral winding 54, a third grid 56 having side rods 57 and a lateral wire 58, and a box-like anode 60. The lateral wire windings 50, 54 and 58 of grids 48, 52 and 56, respectively, extend lengthwise substantially the entire distance between spacer plates 40 and 42. Each of the ends of all the side rods of the grids and the ends of the cathode extend through properly spaced and sized apertures in the spacer plates 40 and 42. Anode 60 is provided with extending tabs or ears 62 which also extend through apertures in the spacer plates, some of the tabs 62 being bent over against the spacer plates to hold the cage assembly together. The lower ends of the cathode 46, grids 48, 52 and 56, and a tab 62 of the anode 60 are connected to the leads 36 which provide electrical connections with the various electrodes as well as providing support for the cage assembly 38.

As shown, all the side rod ends and the end of the cathode extend upwardly through the upper spacer plate 40. For reasons to be described, the side rods 57 of the third grid 56 extend an appreciable distance upwardly beyond the ends of the side rods 49 and 53 of first and second grids 48 and 52, respectively. Also, the end of the cathode 46 extends appreciably upward beyond the ends of side rods 49 and 53 of grids 48 and 52. As a result of this arrangement, extending end portions 66 of side rods 57 of third grid 56 are "exposed" to the extending portion 68 of cathode 46. That is, there are no other electrode portions disposed between the extending portions 68 and 66 of the cathode 46 and third grid 56, respectively. The extending portion 68 of cathode 46 is provided with a band 70 of an electron emitting material, such as the triple carbonates normally used for oxide coated cathodes. A similar coating 71 is also provided over substantially the entire length of the cathode between spacer plates 40 and 42.

To facilitate assembly of the electron tube shown and to prevent scraping of the emissive coating band 70 from the extending portion 68 of the cathode during assembly of the cathode between the spacer plates 40 and 42, cathode 46 may be provided with an enlarged cross-section 72 which is greater in extent than the cross-section of the coated extending portion 68 of the cathode. The cathode-receiving aperture through spacer plate 40 is also larger in size than the upper coated portion of the cathode, whereby the upper spacer plate 40 may be mounted over the extending portion 68 of the cathode without disturbing the coating thereon.

Welded to the extending portions 66 of side rods 57 of the third grid 56 is a shunting or auxiliary anode 75. The anode may be provided with downwardly extending tabs or legs 76 which engage the spacer plate 40 for automatically providing correct positioning of the anode 75 with respect to the spacer plate upon assembly of the anode 75 onto the cage assembly 38. The anode 75 is positioned to surround the upper coated band 70 of the cathode 46.

The electron tube 30 thus described comprises a pentode electron tube wherein an extension of the third grid is exposed to an electron emitting portion of the cathode. This is shown schematically in FIG. 4 wherein the extending portions 68 and 66 of the cathode 46 and third grid 56, and the auxiliary anode 75 secured to portions 66, are shown forming a diode separate from the other tube electrodes. Since neither of the other grid electrodes 48 and 52 is interposed between the extending portion 66 of grid 56, anode 75, and the extending cathode portion 68, the cathode portion 68 may emit electrons directly to

the extending portion 66 of the third grid 56 whenever a positive voltage appears on the third grid 56. Portion 66 of grid 56 and anode 75 are in parallel to the grid 56 circuit resistance 80 and provide a low resistance shunt across this resistance during the positive voltage swing of grid 56. Moreover, because no other electrodes are disposed between the extending portions of the cathode and the third grid and the anode connected to the third grid, conduction from the cathode portion 68 to the third grid portion 66 may occur even when electron emission from the cathode portion 71 between spacer plates 40 and 42 is cut off.

As known, the conductivity of an electron discharge device is dependent upon the space between the electron collecting electrode and the electron emitting electrode. Because of the presence of the first and second grids 48 and 52 between the cathode 46 and the third grid 56, the side rods 57 of the third grid may be spaced at such a large distance from the cathode that the conductivity between the extending portions 68 and 66 of the cathode 46 and the third grid 56, respectively, may be insufficient for effectively shunting the grid circuit resistance 80. For increasing this conductivity the supplemental or shunting anode 75 is electrically connected to the extending portions 66 of side rods 57, the anode 75 extend towards and closely adjacent the cathode. By selection of the length of the extending portions of cathode 46 and side rods 57, and the spacing between the shunting anode 75 and the cathode 46, the desired diode conductivity can be obtained.

In place of an auxiliary anode 75 welded to the side rods 57 of the third grid 56, the third grid may be formed with integral inwardly extending portions. An example of such construction is shown in FIGS. 5 and 6 wherein the cage assembly 81 includes a pair of oppositely disposed spacer plates 82 and 84 and a plurality of electrodes mounted between the spacer plates. The electrodes include a cathode 86, a wire wound first control grid 88, a wire wound screen grid 90, a box-like third or second control grid 92, and a box-like anode 94. The third grid 92 is substantially rectangular in shape and formed from flat metal stock, and has a pair of oppositely disposed openings or windows 95 therethrough, each defined by vertical sides 96 and one cross strap 97 at the upper end of the third grid. Extending across the windows 95 are a number of wires 98 secured to the vertical sides 96 of the windows, as by brazing.

The cathode 86 has an electron emissive coating extending substantially the entire length thereof between spacer plates 82 and 84. Control grid 88 and screen grid 90 have wires wound around the side rods of these grids only along the grid lengths within the projected area of the windows. By this arrangement, the cross straps 97 of the third grid 92 are directly exposed to the cathode 86. For increasing the conductivity between the third grid 92 and the cathode 86, the cross straps may be provided with inwardly extending bowed portions 100.

The operation of an electron tube utilizing the cage assembly 81 shown in FIGS. 5 and 6 is the same as the operation of the tube 30 shown in FIGS. 2 and 3, and the schematic representation shown in FIG. 4 applies to both tube constructions.

By way of example, the side rods 57 of the third grid 56 of a tube, as shown in FIGS. 2 and 3, are spaced 0.175 inch from the cathode 46. The extending portion 68 of the cathode 46 has an electron emitting area of 0.031 square inch, and the auxiliary anode 75 secured to the extending portions 66 of the third grid 56 is spaced 0.010 inch from the cathode. At 5 volts positive with respect to the cathode on the third grid 56 and auxiliary anode 75, the current is 5 ma., whereby the parallel shunt provided by the auxiliary anode 75, the extending portions 66 and 68 of the third grid 56 and cathode 46, respectively, has a resistance of 1000 ohms.

What is claimed is:

1. An electron discharge tube comprising a cage assembly including a pair of oppositely disposed spacer plates and a plurality of tubular electrodes mounted between said spacer plates, said electrodes being coaxial and including, in the order named, a centrally disposed cathode, a first control grid, a screen grid, a box-like second control grid having a window in a portion thereof between said spacer plates and lateral wires secured across said window, and an anode, said cathode having an electron emitting coating over a portion thereof having a length greater than the length of said window, and said first and said screen grids having wires along only the lengths of said two grids within the space defined by said window.

2. An electron discharge tube comprising a cage assembly including a pair of oppositely disposed spacer plates and a plurality of tubular electrodes mounted between said spacer plates, said electrodes being coaxial and including, in the order named, a centrally disposed cathode, a wire wound first control grid, a wire wound screen grid, a box-like second control grid including a cross strap and vertical sides defining a window located between said spacer plates, and wires secured to said vertical sides and extending across said window, and an anode, said cathode having an electron emitting coating covering substantially the entire length of said cathode between said spacer plates, said first and screen grids having wires along only the lengths of said two grids included within the space defined by said window, and said cross strap being bowed inwardly towards said cathode.

3. An electron discharge tube comprising a pair of oppositely disposed spacer plates and a plurality of tubular electrodes mounted between said screen plates, said electrodes being coaxial and including, in the order named, a centrally disposed cathode, a first control grid, a screen grid, a second control grid, and an anode, each of said electrodes having end portions extending through said spacer plates, said cathode having electron emitting coatings covering a portion of the cathode between said spacer plates and a portion of the end portion of said cathode extending beyond one of said spacer plates, all of said grids having lateral wires surrounding said cathode between said spacer plates, and an auxiliary anode secured to the end portion of said second control grid extending beyond said one spacer plate, said auxiliary anode surrounding and being directly exposed to said coated extending portion of said cathode.

4. An electron tube comprising a pair of oppositely disposed spacer plates, a cathode, and at least two electrodes surrounding said cathode, end portions of said cathode and said electrodes extending through said spacer

plates, one of said electrodes being disposed between said cathode and the other of said electrodes and having means at least partially shielding said cathode from said other electrode between said spacer plates, and the end portions of said cathode and said other electrode extending beyond one of said spacer plates and beyond said shielding means for directly exposing to one another the extending end portions of said other electrode and said cathode.

5. An electron tube comprising a pair of oppositely disposed spacer plates, a cathode, and at least two coaxial electrodes surrounding said cathode, end portions of said cathode and said electrodes extending through said spacer plates, one of said electrodes being disposed between said cathode and the other of said electrodes and having means at least partially shielding said cathode from said other electrode between said spacer plates, the end portions of said cathode and said other electrode extending beyond one of said spacer plates and beyond said shielding means for directly exposing to one another the extending end portions of said other electrode and said cathode, and a conductive member secured to said extending end portion of said other electrode extending inwardly towards and adjacent to said extending end portion of said cathode.

6. An electron discharge tube comprising a pair of spacer plates and a plurality of electrodes mounted between said spacer plates, said electrodes including, in the order named, a centrally disposed cathode having two portions thereof coated with electron emissive material, a grid electrode comprising a pair of side rods and a lateral wire helix wound around and between said side rods, and a further electrode having longitudinally extending sides and a strap extending transversely to said sides, said sides and strap defining a window, said window and said lateral wire helix being substantially longitudinally coextensive with one only of said coated portions of said cathode, and said strap being substantially longitudinally coextensive with the other only of said cathode coated portions.

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JOHN W. HUCKERT, *Primary Examiner*.

A. J. JAMES, *Assistant Examiner*.