Aug. 17, 1954 R. C. BAILIN 2,686,885

INSULATED COATED GRID FOR ELECTRON DISCHARGE DEVICES

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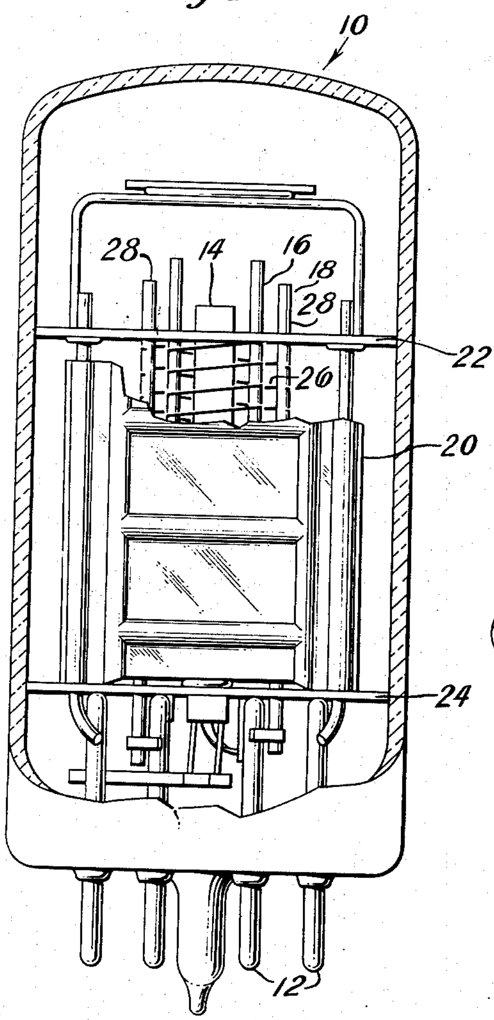
Fig. 1



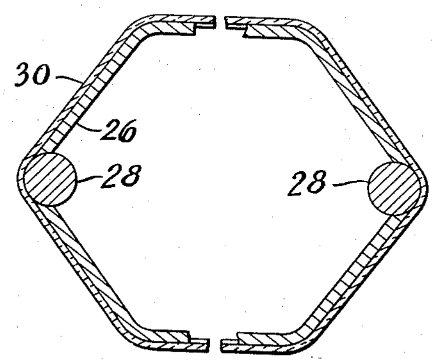


Fig. 2

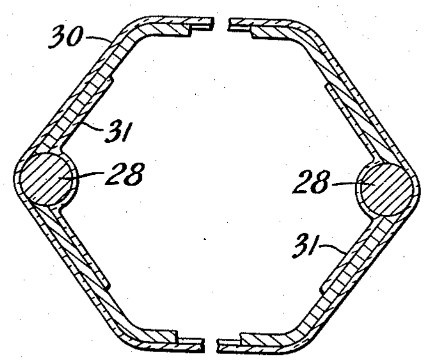


Fig. 3

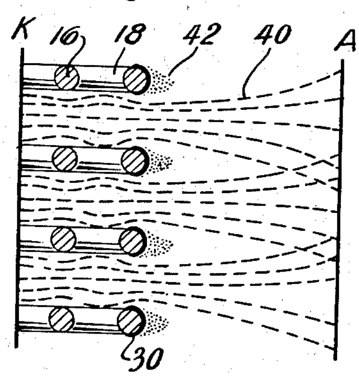


Fig. 4

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INSULATED COATED GRID FOR ELECTRON DISCHARGE DEVICES

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6 Claims. (Cl. 313—107)

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The present invention relates to electron discharge devices and more particularly to multi-grid vacuum tubes.

Another object of the present invention is the improvement of power type electron discharge tubes.

Another object of the present invention is the provision of a novel type of tetrode power tube. Another object of the present invention is the reduction of screen current in a tetrode power amplifier tube.

Another object of the present invention is the provision of an aligned grid tetrode thermionic discharge tube which is characterized over presently known tubes by lowered screen current, low distortion and low radiated noise. Other objects of the present invention include the reduction of mounting problems and of shrinkage in the manufacture of power-type electron discharge tubes.

The foregoing objects and others which may appear from the foregoing detailed description are attained in accordance with an aspect of the present invention by providing an electron discharge tetrode having lateral wires of the control grid and screen grid aligned. The lateral wires, at least of the screen grid, are coated with an insulating material on the side of the laterals most closely adjacent the anode. The alignment of the two grids causes the flow of electrons from the cathode to the plate to be directed in a beam formation such as to establish a potential minimum between the screen and plate. The insulating coating on the exterior surface of the laterals and in the area around the side rods of the screen grid causes a dense electron charge to be accumulated on the surface of the insulating material which is held firmly in place by the positive grid wires. This charge effectively neutralizes the positive grid potential in the screen to plate region and makes the potential gradient toward the plate increasingly positive. Thus any secondary electrons emitted from the plate encounter an increasingly negative potential gradient in their path away from the plate and consequently they will all tend to be returned to the plate. Thus the plate to screen current encountered in the conventional tetrode construction is substantially eliminated.

It has previously been recognized that the alignment of control grid and screen grid wires covers the electron stream to be somewhat formed into beams. The beaming tends to effect a dense space charge and a potential minimum in the region between the screen grid and anode. However in the case of a coated screen electrode

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the effect is substantially increased. The electron charge built up about the screen acts as a virtual cathode and causes convergence of the electron beams. The distance which this charge extends toward the plate controls the point at which the beam begins to diverge. At this point a potential minimum is effected and further suppression action is achieved.

The present invention will be more fully understood by reference to the following detailed description which is accompanied by a drawing in which Figure 1 illustrates in partial section an elevational view of a tube utilizing principles of the present invention while Figures 2 and 3 are enlarged transverse sectional views of the second grid of the tube shown in Figure 1 illustrating the coating applied to the grid, and Figure 4 is a diagram showing by means of dotted lines the direction of electron flow within the tube of Figure 1. This figure also illustrates the accumulation of a static electron charge on the insulating of the second grid which acts to converge the electron beams before they again diverge as they approach the anode.

Figure 1 shows an evacuated envelope 10 which is commonly constructed of vitreous material. The envelope is closed at its lower end by a header through which lead-in conductors 12 pass. If desired the evacuated envelope 10 may be made of a conductive material such as metal, in which case the lead-in conductors 12 may be suitably insulated from each other and from the envelope. The envelope 10 contains a cathode 14 which may be heated by a heater element (not shown). Coaxially arranged about the cathode 14 are a number of grids, the first grid 16 normally being operated as a control grid while the second grid 18 acts as an accelerating or screen grid. Around the outside of screen grid 18 is arranged a sheet metal anode 20. In the particular embodiment shown in Figure 1 the various electrodes are maintained in position by means of extensions at each end passing through insulating spacer members 22, 24. The grids 16 and 18 are preferably constructed by winding a thin lateral wire 26 in an open helix about a pair of spaced side rods 28. The lateral wire 26 is commonly secured to the side rods 28 by being swaged into notches on the outside surface of the side rods. Other methods such as welding may be used if desired. The particular manner of constructing the grids is not critical in the present invention.

As shown better in Figure 2 the screen grid lateral wire 26 (shown in this figure in cross section) is coated on its outer side only with a thin coating of insulating material 30. Preferably the coating is applied by placing the screen grid which has been degreased and fired according to the normal processing schedule on a special mandrel which acts to shield the inner surface of the grid laterals from a spray of the coating material. The grid side rods preferably rest in a well in a mandrel so that they also are shielded from the spray in the regions where welds are to be made when the mount is assembled. The insulating coating is applied as a wet spray for even distribution, uniform cohesion and complete coverage of the projected areas. A coating which has been tried and has proven satisfactory consists of a mixture of 50 cc. of 38-900 Alundum powder, 30 cc. of a ten percent dry binder and 20 cc. of distilled water. Alternatively powdered silica may be substituted for the Alundum. It is desirable that the particle size of the insulating material be as small as possible in order to be able to uniformly coat grid wires of small diameters. Also it is desirable that the spray give as smooth a surface as possible so that no bare spots appear on the grid wires. After the grid has been sprayed it is removed from the mandrel and dried in a conventional manner after which the tube may be assembled into the form shown in Figure 1.

Tests of tubes constructed according to the present invention reveal a slightly higher plate current and lower plate resistance than conventional beam power tubes of the same size. The mutual trans-conductance is about the same but there is a substantial drop in screen current, that is the coated grid tubes have a ratio of screen current to space current of about 2 percent against 3.14 percent for regular beam power tubes. A minor rise in grid to plate capacitance and a minor reduction in output capacitance is also noted. Dynamic tests of the tubes indicate a transfer characteristic with a slope of unity over the entire operating range and consequently a decrease in distortion over conventional tubes.

Life test comparisons between the coated grid tubes and standard beam power tubes of similar characteristics indicate almost identical life curve characteristics. It is thus unmistakably clear that coated grid tubes may be satisfactorily substituted for the more complicated beam power tubes and simultaneously they eliminate many of the more undesirable characteristics of beam tubes. The elimination of the physical suppressor of pentodes and the removal of the beam plates simplify construction of the tube and eliminate the possibility of shorts between these elements and the anode. It has been discovered that the manufacture of these tubes is simpler than is the case with previously known tubes because the light color of the coating material on the grid simplifies the alignment of the grids lessening fatigue and improving the efficiency of the operators constructing the tubes. A substantial decrease in manufacturing shrinkage due to misalignment is experienced. This alone results in a substantial cost reduction in manufacture.

When using the form of grid construction shown in Figure 2 some confining of the beam of electrons from the cathode to the plate is noted due to the action of the negative potential on the side rods of the control grid. If a more confined stream is required the modification shown in Figure 3 may be used. Here it will be noted that the insulating coating is applied not only to the exterior surface of the grid lateral wire 26 but an additional coating is applied, entirely covering the side rods 28 and extending to the desired extent along the interior surface of the lateral wires. This form of construction may be achieved by coating the entire grid as by dipping or similar methods of application and wiping the adherent coating material from the desired part of the inside of the grid lateral winding. In Figure 4 I have shown a partial view of the center section of a coated grid tube with an assumed plane electron emitting surface K directing a stream of electrons as indicated by the dotted lines 40 toward the anode surface A. The alignment between the lateral wires of control grid 16 and the screen grid 18 is clearly emphasized in this figure. Due to the presence of insulating material on the outside of the lateral wire of grid 18 a static electron charge as indicated at 42, tends to be built up on the outside surface of the coating. This charge is bound in place by the positive charge on the lateral wires of grid 18. When the tube is in operation the static electron charge is held in position on the insulating material by the repulsive action of the electron beams indicated by dotted lines 40. The actual screen current will thus be limited principally to low velocity electrons emitted by the cathode which are attracted to the lateral wires of grid 18 and any higher velocity electrons which tend to strike the lateral wires of grid 18 due to fortuitous misalignment between the lateral wires of grids 16 and 18.

It will be noted that the presence of the static electron charge as indicated at 42 causes the electron stream 40 to converge to a considerable extent in the space between the screen grid 18 and the anode surface A. Any secondary electrons emitted from the anode surface A therefore have a steeper potential gradient to overcome in their flight from anode A toward the screen electrode 18. Secondary emission characteristics tending to cause a dynatron kink in the operating characteristics of the tube are thereby substantially completely eliminated.

While I have shown and described several embodiments of the present invention, it should be clearly understood that my invention is not limited thereto but that modifications may be made. Thus the insulating coating on screen grid 18 may take the place of a physical suppressor grid in a pentode tube in the same way as it substitutes for beam confining plates in a beam power tube. The principles of this invention are applicable to multi-grid tubes generally.

What I claim is my invention is:

1. An electron discharge device including a cathode, a number of grids and an anode concentrically arranged about said cathode, one of said grids being adapted to have a positive potential applied thereto and means for preventing the flow of current from said anode to said grid including an insulating coating over the outer surface of said grid.

2. In an electron discharge device a grid including a number of side rod members carrying an open helical winding of grid lateral wire, said wire being coated with an insulating material on the outer surface of the winding only.

3. In an electron discharge device, a grid including a number of side rod members carrying an open helical winding of grid lateral wire, said wire being coated with an insulating material on the outer surface of the winding and said side rod members being coated with said insulating material.

4. In an electron discharge device, a grid in-

cluding a number of side rod members carrying an open helical winding of grid lateral wire, said grid lateral wire being coated with an insulating material on the outer surface of the winding and said side rod members and said lateral wire in the immediate vicinity of said side rods also being covered with said insulating material.

5. An electron discharge device including a cathode and an anode and a number of interposed grids having aligned lateral wires, the outermost of said grids having a coating of insulating material only on its side most closely adjacent said anode.

6. An electron discharge device including a cathode, a number of grids and an anode concentrically arranged about said cathode, said grids having aligned lateral wires, one of said grids being adapted to have a positive potential

applied thereto and means for preventing the flow of current from said anode to said grid including an insulating coating over the outer surface of said grid.

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