United States Patent

Beggs

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[54] ELECTRON BEAM FOCUSING BIPOTENTIAL CATHODE

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[73] Assignee: **General Electric Company**

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[51] **Int. Cl.**.....**H01j 1/20**, H01j 1/46, H01j 1/52

[58] **Field of Search**.....313/178, 346 R, 348, 355, 212

[56] **References Cited**

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[57] **ABSTRACT**

To increase selectively the electron emission from a cathode, a control grid is placed above the cathode and osmium or iridium is evaporated through the openings of the grid onto the cathode. On the resulting cathode the coated regions provide a value of work function which is lower than that of the uncoated regions.

5 Claims, 3 Drawing Figures

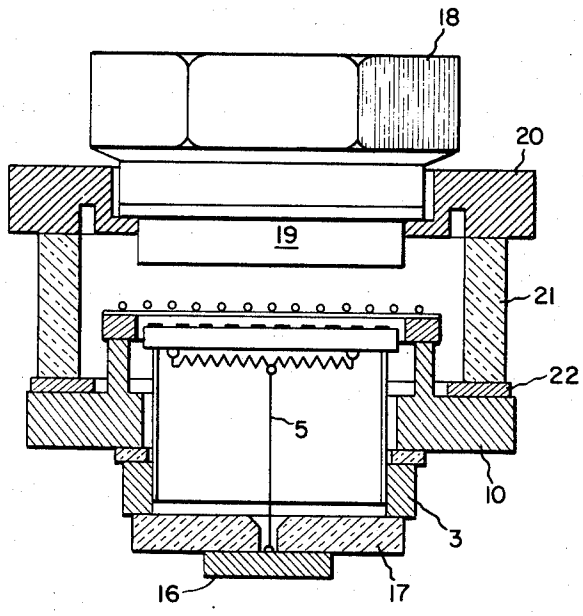
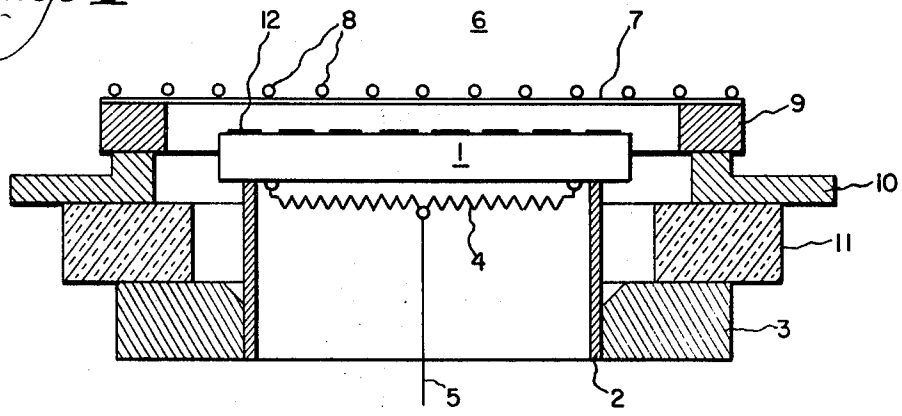


Fig. 1



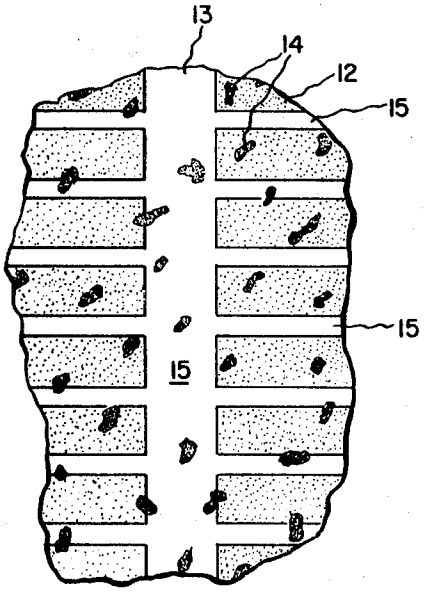


Fig. 2

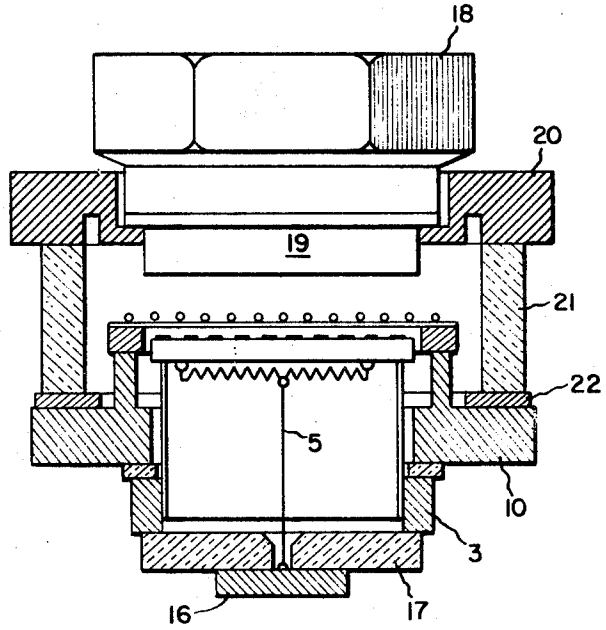


Fig. 3

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ELECTRON BEAM FOCUSING BIPOTENTIAL CATHODE

This invention relates to electron discharge devices and more particularly to a novel structure in such devices which provides electron beam focusing. The invention herein described was made in the course of, or under, a contract or subcontract thereunder, with the Department of the Army.

Power triodes for operation at microwave frequencies must necessarily have a large control electrode to anode spacing in order to minimize interelectrode capacitance. To obtain suitable electron current flow across such a wide gap necessitates operation of the control electrode at a relatively large positive potential. Operation at such large positive potential, however, tends to cause collection of current by the control electrode during the positive portions of the voltage wave applied to the control electrode.

In my U.S. Pat. No. 3,154,711, granted Oct. 27, 1964 and assigned to the assignee of the present invention, there is disclosed an electron discharge device in which electron beam focusing is achieved by employing a cathode having a self-biasing focusing electrode of small dimensions in relatively close proximity to the cathode and conductively interconnected therewith. The cathode electrode and focusing electrode have respective low- and high-work functions so as to establish a negative contact potential difference on the focusing electrode with respect to the cathode, the focusing electrode being maintained clean by operating it at or near cathode temperatures to produce the contact potential difference. The use of such a bipotential cathode has been found to be helpful for reducing to a low level the magnitude of current collected by a control electrode operating at a positive potential with respect to the cathode.

It is a principal object of my invention to provide a new and improved type of bipotential cathode.

It is another object of my invention to provide new and improved means and methods for focusing electron beams.

In accordance with my present invention, a bipotential cathode is formed in precise alignment with the control electrode structure by evaporation of material onto the cathode after the control electrode is mounted adjacent to it. The material evaporated on the cathode may be either osmium or iridium and on the resulting cathode, the coated regions have a value of work function which is lower than that of the uncoated regions. As a result, the deposited material on the surface of the cathode not only increases emission from the cathode but also provides a potential to aid in focusing electrons through the openings in the control electrode. In accordance with one aspect of my invention, the focusing potential is made more effective by spacing the control electrode closely to the cathode.

The novel features believed characteristic of my invention are set forth in the appended claims. The invention itself, together with further objects and advantages thereof, may best be understood with reference to the attached drawing in which:

FIG. 1 is an enlarged, cross-sectional side view of a portion of an electron discharge device employing a focusing electrode in accordance with the present invention;

FIG. 2 is a partial enlarged plan view of a portion of the bipotential cathode of FIG. 1; and

FIG. 3 is a cross-sectional side view of a triode electron discharge device incorporating the bipotential cathode of my present invention and showing electrode spacings exaggerated.

In the portion of the electron discharge device illustrated in FIG. 1, a cathode 1 is supported by a cylinder of foil 2 which in turn is connected to a cathode contact ring 3. Cathode 1 may be of a well-known type and comprises a porous tungsten body impregnated with a suitable electron-emissive material such as barium calcium aluminate or barium calcium tungstate. The cathode is raised to operating temperatures by means of a heater 4 bonded to the bottom surface of cathode 1, heater 4 being energized through a wire 5 and a cathode contact member 3. A grid electrode 6 of mesh construction is disposed closely adjacent cathode 1. Grid 6 may comprise relatively

fine wires 7 arranged in a first direction and heavier wires 8 arranged transverse to wires 7 to provide an orthogonal pattern of openings between the wires 7, 8. The mesh arrangement of grid wires is brazed to a grid ring 9 which in turn is welded to a grid support ring 10 which provides an external connection for the control grid. A ceramic insulator 11 is positioned between and sealed to cathode contact ring 3 and grid support ring 10 in a well-known manner.

In forming the cathode-control grid structure, the cathode is mounted by welding support cylinder 2 which may comprise hafnium foil or any other suitable material to cathode contact ring 3, with the cathode surface positioned at a predetermined distance above the upper surface of grid support ring 10. Grid ring 9 which is of sufficient thickness to support the mesh of grid wires slightly above the cathode's surface is then brazed to the grid support ring 10. In this manner, the grid is affixed securely in its desired final relationship with respect to the cathode prior to the formation of the bipotential cathode surface.

In accordance with my invention, coated regions 12 are deposited on the upper surface of cathode 1 in exact alignment with the control grid 6 by evaporating through the openings of grid 6 a material providing a work function which is lower than that of the surface of cathode 1. When a metal having such a high-work function and comprising, for example, osmium or iridium, is deposited onto the surface of the impregnated cathode 1, it is effective to reduce the work function of the cathode by approximately 0.2 volt. Accordingly, I evaporate such a material in a conventional manner by supporting a bead or piece (not shown) of the material above the control grid and heating it. This causes the material to descend in straight lines and be deposited through the openings in the control grid so that the respective portions of the coating are in exact alignment with such openings.

FIG. 2 is an enlarged partial plan view of cathode 1 after being coated with the material. In this figure the numeral 13 designates the porous tungsten structure of the cathode; 14 designating the impregnating electron emissive material, and the numeral 12 the rectangular regions of coating vapor deposited on the surface of cathode 1. In this structure, the uncoated regions 15 of the cathode between he grid wires maintain their original higher value of work function while the coated regions 12 assume the new lower value. For electron tubes where the spacing between the control grid and the cathode is very close, for example of the order of 0.001 inch or less, the 0.2 volt negative potential existing on the uncoated cathode surface beneath the grid wires provides a focusing capability sufficient to appreciably reduce current collection by the grid wires. Additionally, I have found that the electron emission from the coated regions is of the order of three or four times higher than that from the uncoated regions below the wires so that an additional advantage is gained by deposition of the surface coating on the cathode with the grid in position.

In accordance with my invention, in some instances it is desirable first to vaporize over the entire surface of the cathode, a material (not shown) which can maintain a clean surface when operating at elevated temperatures. Titanium, zirconium, platinum, or a nonemitting material, such as molybdenum carbide, are suitable for such coating material. Thereafter, when 1 evaporate osmium or iridium and deposit it through the openings in the grid structure, a much larger contact difference of a potential is achieved and even more effective focusing of the electron current results.

FIG. 3 shows a cross-sectional elevation of an electron discharge triode incorporating the foregoing features of my invention. In FIG. 3, heater lead 5 is connected to a heater contact button 16 sealed in a well-known manner to a ceramic insulator 17, in turn sealed to the bottom portion of contact ring 3. The relatively massive anode 18 having a planar surface 19 in opposed relation to cathode 1 is sealed to an anode contact ring 20 which in turn is spaced from grid support ring 10 by means of a ceramic insulator 21 sealed to metal ring 22.

In accordance with the foregoing, it is to be observed that the vapor deposition of iridium or osmium on the surface of the cathode not only increases its emission, but also provides a potential to aid in focusing the electrons through the openings in the control and screen grids. This is accomplished by depositing the material on the cathode with the grids already mounted in their final positions so that the material is deposited only on the cathode surface in the openings between the grid windings. By this procedure, the emission below the grid wires is less than that of the coated areas and a difference of potential of approximately 0.2 volt between the uncoated and coated areas is present and tends to deflect the electrons and form them in beams that more readily pass between the grid wires. Although the focusing potential is small, it becomes more effective as the grid is spaced more closely to the cathode.

While the present invention has been described by reference to particular embodiments thereof, it will be understood that modifications may be made by those skilled in the art without actually departing from the invention. I, therefore, aim in the appended claims to cover all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An apparatus comprising a planar cathode electrode comprising a porous metal member impregnated with an electron emissive material, a control electrode comprising a mesh of fine transverse wires and having a plurality of small apertures between said wires supported in closely spaced relation with said cathode electrode, said cathode electrode having on its surface adjacent said control electrode and in a pattern in exact alignment with the apertures in said control electrode a coating of a material which combines with the electron emissive material to provide a work function which is lower than that of the uncoated regions of said cathode electrode, the uncoated regions of said cathode electrode underlying said transverse wires and none of said wires overlying said coating material, whereby electrons emitted from said cathode are focused between said wires and through the apertures in said control electrode.

2. The apparatus of claim 1 in which the wires extending in one direction have a larger diameter than those extending in the transverse direction.

3. The apparatus of claim 1 in which the coating is selected from the group consisting of osmium and iridium.

4. The apparatus of claim 4 in which the coating comprises iridium.

5. The apparatus of claim 3 in which a material selected from the group consisting of titanium, zirconium, platinum and molybdenum carbide is interposed between the surface of the cathode member and said coating.

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