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ELECTRON DISCHARGE DEVICE

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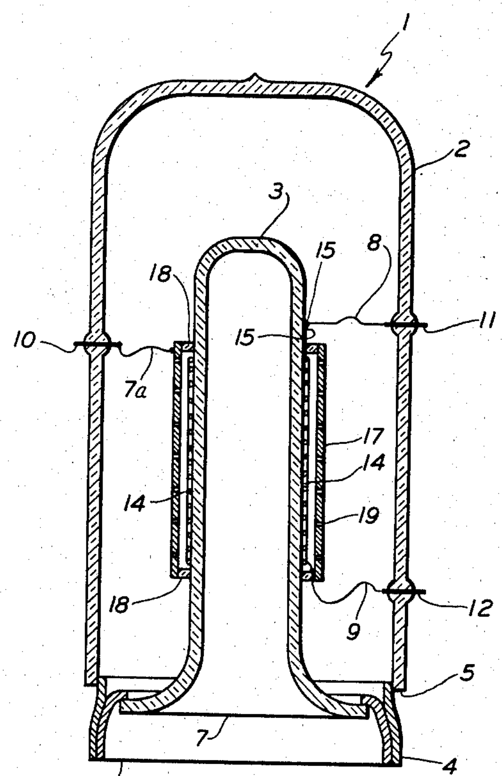

FIG. 1

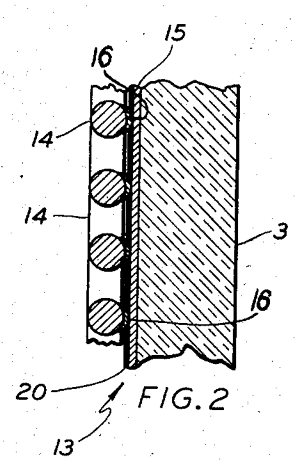

FIG. 2

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ELECTRON DISCHARGE DEVICE

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The present invention relates to an electron discharge device and method of making same, and more particularly to such a device which utilizes cathode and control grid electrodes mounted in close proximity to each other.

In conventional vacuum tube constructions, the electrodes comprising the tube, such as the cathode, control grid, and anode, are arranged in suitable geometrical relation with respect to each other to enable the effective control of electron flow from the cathode to the anode by means of the control grid which is interposed in a space between the cathode and anode. The cathode is electron emissive and may be constituted, for example, by photoelectric or thermally emissive materials, the electrons emitted by the cathode being collected by the anode after passing through the space partially occupied by the control grid. In triode tubes, for example, these electrons normally flow to the anode in accordance with the controlling effect of the control grid. The biasing potential normally applied to this grid is varied, in some circuits, to effect substantial current changes in the tube anode circuit. By use of the grid electrode, it is possible to use small control voltages for controlling relatively large quantities of power in the anode circuit, and the effectiveness of the grid in controlling this power, or the space current between the anode and cathode, may be represented by a mathematical expression characterized as grid-plate transconductance (mutual conductance). In certain applications of vacuum tubes, it has been found highly desirable to have the highest possible value of grid-plate transconductance, and it has been found that the position of the control grid with respect to the cathode plays an important part in obtaining the desired value of such transconductance.

In view of the foregoing, it is an object of this invention to provide an electron discharge device having an electrode structure conducing to the highest possible value of grid-plate transconductance.

It is another object of this invention to provide a vacuum tube construction in which the cathode and control grid electrodes are so arranged with respect to each other that the control grid exercises a maximum of control over the space discharge current flowing between the cathode and the anode.

It is still another object of this invention to provide a vacuum tube construction having cathode and control grid electrodes which are uniquely arranged so as to bring the two electrodes into extremely close proximity with each other while maintaining direct current electrical separation therebetween.

It is still another object of this invention to provide, in a vacuum tube construction having control grid and cathode electrodes, a physical relationship between the two electrodes which positions the control grid in the electron field adjacent the cathode where most effective control of the flow of these electrons may be obtained.

It is another object of this invention to provide a method for producing a photo-sensitive cathode in close proximity to a control grid whereby an insulating space between the cathode and control grid having an appreciably high resistance to leakage currents may be obtained.

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In accordance with the present invention, there is provided a vacuum tube construction comprised of a supporting member made of insulating material, a cathode surface provided on said supporting member, spaced conductive elements constituting a control grid provided on said cathode surface, and insulating spacer coating or elements adhered to the conductive elements for separating the grid from the cathode surface. The spacer elements are made to such negligible thickness as to provide almost contiguous mounting of the grid on the cathode surface to thereby position the grid where it will be most effective.

For a better understanding of the invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

In the accompanying drawings:

Fig. 1 is an axial section of an embodiment of the present invention; and

Fig. 2 is an enlarged fragmental section of a portion thereof.

Referring to the drawings, a high vacuum electron discharge device **1** is comprised of a glass or the like envelope **2** of conventional shape and construction and a transparent tubular reentrant supporting member **3** which may be made of glass or other suitable material as will appear hereinafter. An annular metal flange **4** made of some suitable material such as Kovar is affixed in the usual manner to the end **5** of the envelope **2** and another Kovar flange **6** is secured to a radially outwardly flaring lip **7** on the end of the support **3**. These flanges **4** and **6** are suitably secured together such as by seam welding so as to provide a supporting connection between the two members **2** and **3** and to position the member **3** centrally of the envelope **2**. The connections between the flanges **4** and **6** and the respective members **2** and **3** are such as to provide a hermetic seal for evacuating the space between the support **3** and the envelope **2**.

The electrode assembly of the tube, which is generally cylindrical in the illustrated embodiment, is securely mounted on the outer peripheral surface of the support **3**, and suitable wire leads *7a*, **8** and **9**, connect the electrodes of this assembly to terminal connections **10**, **11** and **12**, respectively, projecting through the glass envelope **2**.

The electron control electrode assembly, shown in enlarged detail in Fig. 2, is comprised of a cathode, generally indicated by the reference numeral **13**, and a control grid element **14**. The cathode itself is comprised of a first layer of metal **15** such as antimony or silver, which in the illustrated embodiment is thin enough to permit the passage of light therethrough. This layer **15** is adhered to the outer peripheral surface of the support **3** by the use of any of the usual processes, such as by evaporation. The control grid **14** is comprised of a wire mesh screen of approximately 500 mesh size, and this screen is preformed to a tubular shape so as to fit over the cylindrical layer **15**. Before assembling the grid **14** on the metallic layer **15**, insulating spacers **16** are adhered to the inner peripheral surfaces of the various crossed wires which make up the grid **14**. In the preferred arrangement, these spacers **16** are composed of either silicon monoxide or aluminum oxide, which materials may be applied to the wires by any of the well known techniques. Satisfactory results may be obtained by evaporating the silicon monoxide on the various surfaces, and aluminum oxide may be deposited on the wires by the process known as "electro-phoresis."

The spacers **16** are of negligible thickness but adequate to provide the necessary electrical insulation between the cathode base **15** and the grid **14**. In the preferred arrangement, it is desired to locate securely the grid **14** as close to the surface of the cathode base **15** as possible. With the spacers **16** properly secured to the inner periphery to the grid **14**, the grid is telescoped over the support and located axially thereof as shown in Fig. 1. Preferably, the inner diameter of the grid **14** determined by the thickness of the spacers **16**, is substantially coextensive with the outer diameter of the metallic layer **15** to provide a snug, secure fit.

The anode **17** is tubular in shape and is centered both axially and coaxially over the grid electrode **14** by glass or the like spacers **18**. A plurality of tiny perforations **19** are provided in the wall of the anode **17** for a purpose which will be explained more fully hereafter.

As will be seen in Fig. 1, the terminal connection **10** is conductively connected to the anode **17**, the cathode base **15** is connected to the terminal **11**, and the grid **14** is connected to the terminal **12**.

In the assembly of the construction thus far described, the cathode base **15**, the grid **14**, and the anode **17** are assembled onto the support **3**. It is important, however, that the grid **14** be cleaned of oxides (by means of hydrogen furnace or the like) before its assembly onto the tube. This assembly may be accomplished in the open atmosphere, the importance of which being explained more fully hereinafter. The support **3** with its electrode assembly is now located within the envelope **2** as shown in Fig. 1, and the flanges **4** and **6** are seam-welded to provide a vacuum tight container. The tube is next evacuated in the customary manner.

As a final step in the method of fabricating this tube, cesium vapor is introduced into the tube by the use of the conventional techniques for depositing on the cathode base **15** (via the perforations **19**), within the elemental areas **20** bordered by the various spacers or coating **16**, a coating of cesium for making the cathode photosensitive. Irradiation of the elemental areas **20** will result in the emission of electrons which is directed radially outwardly through the grid openings.

In fabrication, it is important that the surface of the grid **14** be such as will not permit the adherence thereto or chemical reaction therewith of the cesium vapor, and as a corollary, the conductive material of the cathode base **15** must be of such constituency (such as antimony oxide) as will combine with the cesium vapor so as to provide the electron emissive areas **20** as previously described. With the cathode base **15** being comprised of either silver oxide or antimony oxide, and the grid **14** being composed of a material such as copper or nickel cleaned of its oxide surface, the cesium will adhere and react only with the cathode base.

This precleaning of the grid is important because in the photoelectric tube, if the cesium adheringly deposits onto the grid **14**, the grid becomes electron emissive which would defeat the normal function of the vacuum tube. By following the preceding procedure, only the cathode base will be made electron emissive thereby providing the normal physical relationship between the cathode and control grid electrodes.

As mentioned earlier, the spacers or coatings **16** are of minimum thickness, that is, the spacers **16** are of such thickness as to position the grid **14** almost directly upon the surface of the cathode base **15** yet thick enough to provide electrical separation therebetween. It has been found that the control grid is most effective when the electric field of the grid is located immediately adjacent the emitting surface of the cathode, and from the description of the foregoing, it will be seen that such field is positioned as close to the emitting surface of the cathode as appears to be possible.

In operation, electrons are emitted from the cathode surface, and those which possess sufficient velocity to pass beyond the negatively charged grid are accelerated

toward the anode. Most effective control of this flow of electrons is achieved by positioning the control grid as closely to the cathode surface as possible.

As mentioned earlier, the electrode assembly is mounted on the support tube **3** in the open atmosphere. The proper treatment of the grid material, as explained hereinbefore, makes this arrangement of assembly possible, the cesiation step in the method of fabrication serving to sensitize only the elemental areas **20** on the cathode base **15** and no other portion of the assembly.

In other prior art tube arrangements, silver oxide usually constitutes the surface upon which the cesium is deposited, the silver oxide coating usually covering both the grid and cathode base materials. Thus, when the cesium vapor is introduced into the evacuated envelope, both the grid and cathode surfaces are sensitized thereby reducing the operating efficiency of the finished tube. With the present arrangement, deposition of cesium takes place only on the base material **15**.

From the foregoing it will be apparent that the grid electrode has negligible but adequate spacing with respect to the cathode **13**, and that the grid is mounted rigidly with respect to the cathode. Such rigid mounting reduces the tendency of the grid to move relative to the cathode and to thereby develop "microphonics." Also, it is obvious that the present tube will withstand severe jarring and vibration which causes conventional tubes to be noisy.

In the operation of the foregoing described embodiment, a lamp or similar light source is introduced in to the reentrant support **3** to irradiate the photoelectric areas **20** from which electrons flow radially outwardly through the openings in the grid **14** to the anode **17**. While a photoelectric tube has been illustrated and described, it will appear obvious to those skilled in the art that the base **15** may be composed of silver treated in any well known manner to make it thermally emissive.

While there has been described what is at present considered the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims, to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An electron flow-controlling assembly for an electron discharge device comprising an insulating support, a layer of conductive material provided on said support, a conductive control-grid element supported on said layer and comprising a screen-like member having apertures, insulation adhered to one side only of said screen-like member, said insulation contacting said layer and constituting a support and spacer for said screen-like member, and electron-emissive material provided only on the elemental areas of said layer which are not contacted by said insulation thereby providing intimately close but insulated spacing between such areas and said control-grid element.

2. An electron-flow-controlling assembly for an electron discharge device comprising an insulating support, a layer of conductive material provided on said support, said conductive material being selected from the group consisting of antimony and silver, a control-grid element supported on said layer and comprising a series of conductively connected spaced metallic wire-like elements, said elements being formed of metal selected from the group consisting of copper and nickel, insulating spacers separating said wire-like elements from said layer, said spacers contacting said layer at points directly beneath said wire-like elements, the elemental areas of said layer which are not contacted by said spacers only being electron emissive thereby providing intimately close but insulated spacing between such areas and said control-grid element.

3. The method of fabricating an electron discharge control assembly in the atmosphere comprising the steps of providing a base of conductive material on a supporting member, adhering an insulating material to one side of a control-grid element, mounting said control grid element on said supporting member with said insulating material directly contacting said conductive material, and activating the elemental areas of said conductive material which are not contacted by said insulation material to render said areas only electron-emissive.

4. The method of fabricating an electron discharge control assembly in the atmosphere comprising the steps of providing a base of conductive material on a supporting member, adhering an insulating material to one side of a control-grid element, treating the control-grid element to remove oxide coating therefrom, mounting said control-grid element on said supporting member with said insulating material directly contacting said conductive material, and the elemental areas of said conductive material which are not contacted by said insulation material to render said areas only electron-emissive.

5. The method of fabricating an electron discharge control assembly in the atmosphere comprising the steps of providing a base of conductive material on a supporting member, said conductive material being one of the group of antimony and silver, adhering an insulating material to one side of a control-grid element, said control grid element being composed of a material selected from the group of copper and nickel, treating the control-grid element to remove oxide coating therefrom, mounting said control-grid element on said conductive material whereby the insulating material separates the two, and subjecting the assembly to casium vapor, said cesium vapor adhering to said base but not to said element thereby rendering said base electron-emissive.

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