March 15, 1938. R. WARNECKE 2,111,256

ELECTRON DISCHARGE TUBE

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Fig. 1

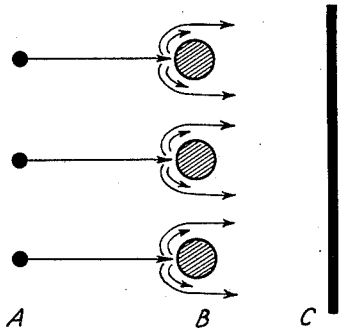


Fig. 2

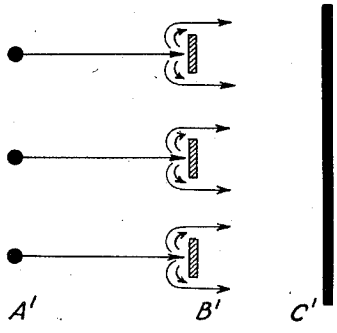


Fig. 3

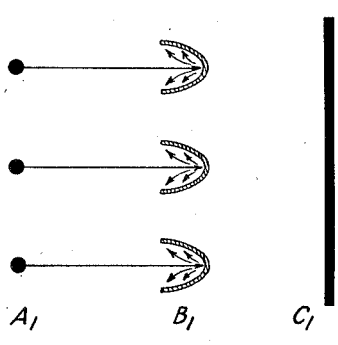
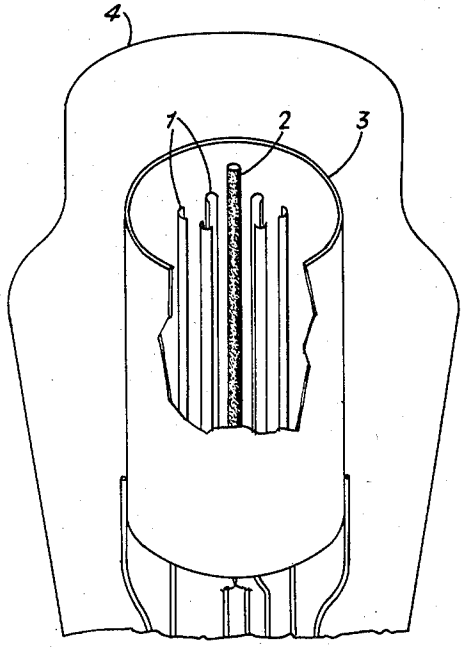


Fig. 4



Fig. 5



INVENTOR.
ROBERT WARNECKE

BY Charles McClair

ATTORNEY.

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Fig. 8

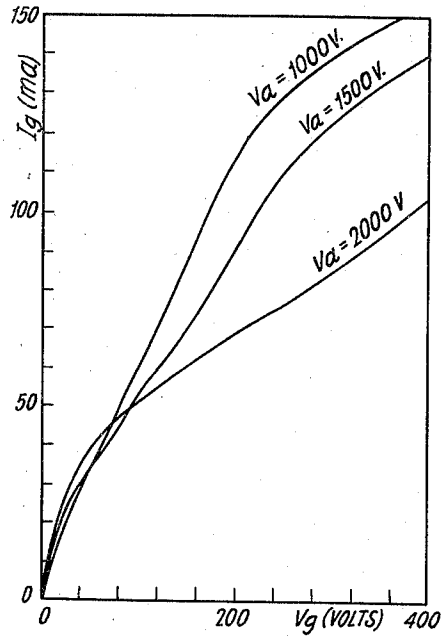


Fig. 10

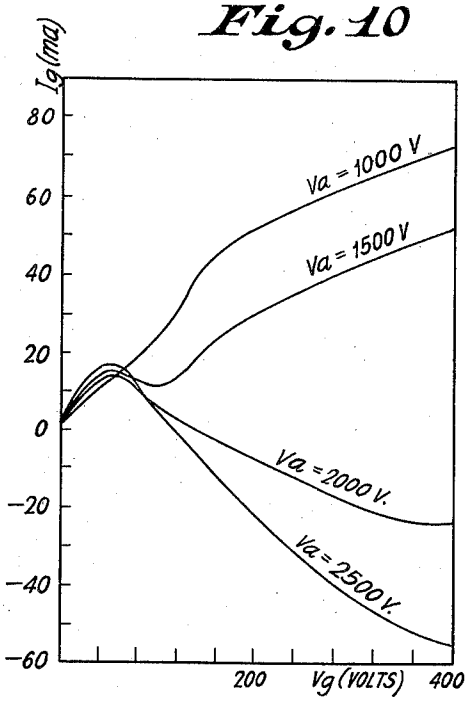


Fig. 9

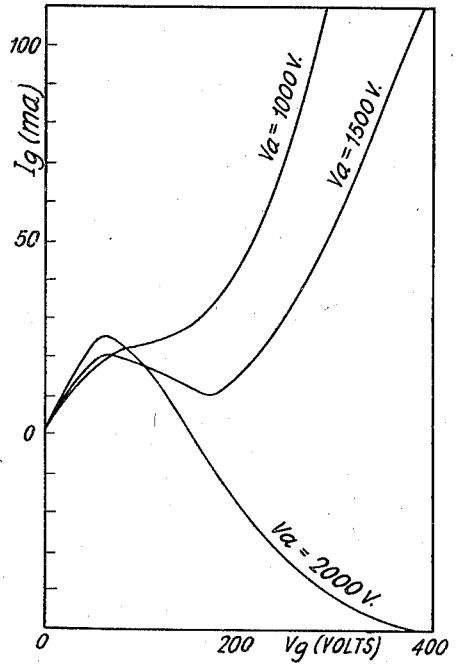


Fig. 6

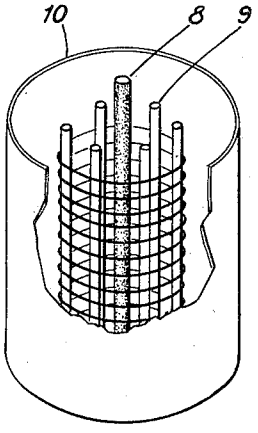
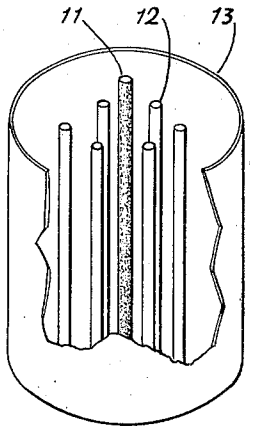


Fig. 7



INVENTOR.
ROBERT WARNECKE

BY Charles McClair

ATTORNEY.

Patented Mar. 15, 1938 2,111,256

UNITED STATES PATENT OFFICE

2,111,256

ELECTRON DISCHARGE TUBE

Robert Warnecke, Paris, France, assignor to Compagnie Generale de Telegraphie Sans Fil, Paris, France

Application September 27, 1935, Serial No. 42,424
In France October 26, 1934

6 Claims. (Cl. 250—27.5)

My invention relates to electron discharge tubes having a plurality of electrodes and particularly to improvements of the electrodes in such tubes.

It is well known that emission of secondary electrons from the electrodes of electron discharge tubes is troublesome and causes undesirable results. In the past this has been remedied principally in different ways. One consists in adding electrodes such as grids known as suppressor grids which are adapted to overcome the effect of secondary emission from an electrode, though this advantage is purchased at the cost of complication of the electrode arrangements and manufacture of the tube. The other method consists in forming on the surface of the electrode giving rise to the emission of secondary electrons, a chemical compound comprising metal of the electrode itself or some other substance which will reduce the number of secondary electrons. This last mentioned method is open to the objection that it is unstable when the electrode gets heated and results in variations in tube characteristics. Furthermore, this method in most instances is incompatible with perfect outgassing of the electrode in question which will in part destroy the superficial compound on the electrode.

The principal object of my invention is to reduce or eliminate the secondary emission given off from an electrode by constructing such an electrode so that it will recapture or recover the most of the secondary electrons emitted by it.

Briefly in accordance with my invention I make the surface of the electrode from which it is desired to reduce secondary emission concave in the direction from which the primary electrons flow and I have found that secondary emission will be so much smaller, the more concave the surface giving rise to secondary emission in respect to the direction of the primary bombardment.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawings in which Figures 1, 2, and 3 graphically show secondary emission from electrodes of different cross section; Figure 4 is an enlarged sectional view of a portion of a triode made in accordance with my invention; Figure 5 is a perspective view with parts broken away to show details of construction of an electrode mount assembly made in accordance with my invention; Figures 6 and 7 are perspective views with parts broken away showing electrode assemblies of conventional design and Figures 8, 9, and 10 are graphs showing the tube characteristics having the electrode assemblies shown in Figures 5, 6, and 7 respectively.

In Figures 1, 2, and 3 the primary electrons from source A, A^1, or A_1, which may be a filament type cathode, bombard the electrodes B, B^1, and B_1 which give off secondary electrons the paths or trajectors of which are indicated by the small arrows and which may be collected by the electrode C, C^1, and C_1. The directions of emission of secondary electrons approach a plane tangent to the point of impact, this effect being attributable to the space charge formed by the electrons. As shown in Figure 4 the secondary electrons given off by the electrode **6** are collected or gathered by the electrode itself due to its concave shape. The electrodes **5**, **6**, and **7** for instance represent the cathode, the grid and the anode of a triode.

According to the invention the electrode which is susceptible of giving off secondary electrons is given a concave cross sectional shape so that the primary electrons will impinge upon the electrode at points where its surface is concave with reference to the direction of impact of the primary electrons.

In Figure 5 is an electron discharge tube having a grid made according to my invention in which the rod-like elements **1**, have a concave sectional form turned towards the electron-emitting cathode **2**, the anode **3** surrounding the cathode and grid rods. The distinction between the present grid and those used in the prior art is clearly brought out by reference to Figures 6 and 7. In Figure 6 a helical grid **9**, which is the form most commonly employed, surrounds a cathode **8** and is in turn surrounded by anode **10**. The rod-like type of grid **12** in Figure 7 surrounds cathode **11** and is in turn surrounded by anode **13**.

The investigations made by the applicant have demonstrated the merits inherent in an electrode according to this invention, and the results obtained with such an electrode are graphically shown in typical curves in Figure 8. It is known that the secondary electron emission of an electrode, such as a grid in a triode, manifests itself by the fact that the current of this electrode with increasing positive potentials on the same, and with the voltage on the anode as well as the other electrodes maintained constant becomes irregular or decreases or even reverses. Hence, investigations were directed toward the develop-

ment of tubes with identical characteristics in which the grids were made from the same metal, but of forms such as shown in Figure 5, according to the invention, and Figures 6 and 7, known type grids. The variations in grid current of these tubes as a function of their potential were then measured with all of the other conditions of filament and plate remaining unchanged. The results are plotted graphically in Figures 8, 9, and 10 which represent the curves of variation of the grid current with grid voltage with different anode potentials for the grids shown in Figures 5, 6, and 7 respectively. In these figures I_g represents the grid current, V_g the grid voltage, and V_a the plate voltage.

The advantages residing in the invention are clearly brought out by a comparison of curves 8 and the others. It will be clearly seen that there is no longer any reversal of the grid current taking place and that the emission of secondary electrons from the electrode has been sufficiently diminished so that in the case of a grid covered by Figure 8 the curves indicate very little if any secondary emission.

It will be understood that while the principle underlying the invention has been here described only in connection with a special instance, the same is applicable and useful in other cases, that is in tubes using multi-strand cathodes, grids of helical form made of wires or strips concave towards the cathode.

The same principle is likewise useful in connection with an electrode other than the grid. In fact, the invention has been more particularly described in connection with a grid because in most instances it is the emission of secondary electrons from the grid that has proved most troublesome in practice. The invention at the same time provides a form of grid that is very rugged from a mechanical viewpoint. It also offers the great advantage that it presents no rough edge turned towards the anode, and this means a reduction in the chances of an inter-electrode discharge in high voltage tubes.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:—

1. An electron discharge device having a thermionic cathode for emitting electrons and a plurality of other electrodes including a grid and anode positioned adjacent said cathode and adapted to receive electrons from said cathode, said grid being positioned between the anode and cathode and including an element having a deep concave surface with reference to the movement of the electrons from said cathode to said other electrodes for suppressing secondary emission.

2. An electron discharge device having a thermionic cathode for emitting electrons radially from said cathode and a plurality of other electrodes including a grid and anode positioned around said cathode, said grid being positioned between the anode and cathode and including an element having a deep concave surface with respect to the direction of emission from said cathode for suppressing secondary emission.

3. An electron discharge device having a straight thermionic cathode for emitting electrons, a grid and an anode for receiving electrons from the cathode, said grid comprising a plurality of rod-like members parallel to said cathode, each of said rod-like members having a deep concave surface with respect to the path of an electron from said cathode to the anode.

4. An electron discharge device having a straight thermionic cathode for emitting electrons and a concentric grid and an anode for receiving electrons from said cathode, said grid comprising a plurality of straight rod-like members parallel to said cathode and each of said rod-like members having a surface deeply concave with respect to the line of travel of an electron from said cathode to said anode.

5. An electron discharge device having a cathode for emitting electrons, and an anode for receiving said electrodes, and a grid between said cathode and said anode comprising elements having deep concave surfaces with respect to the direction of impact of electrons from said cathode in movement from the cathode to said anode.

6. An electron discharge device having a cathode for emitting electrons, an anode for receiving a flow of electrons from said cathode, a grid electrode between said cathode and said anode in the path of said flow of electrons and having a surface deeply concave to said flow where the electrons strike said grid electrode for suppressing secondary emission.

ROBERT WARNECKE.