

July 4, 1939.

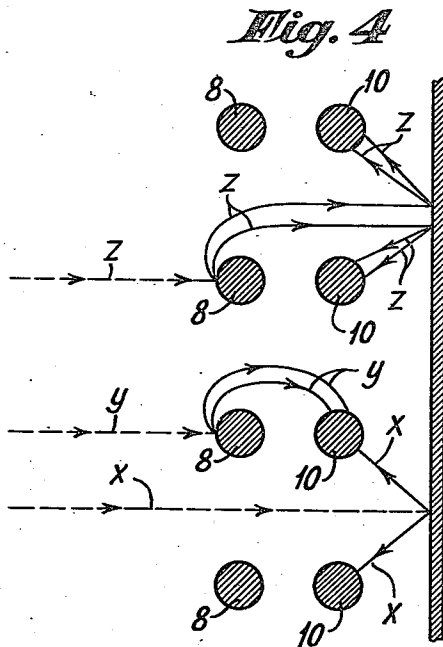
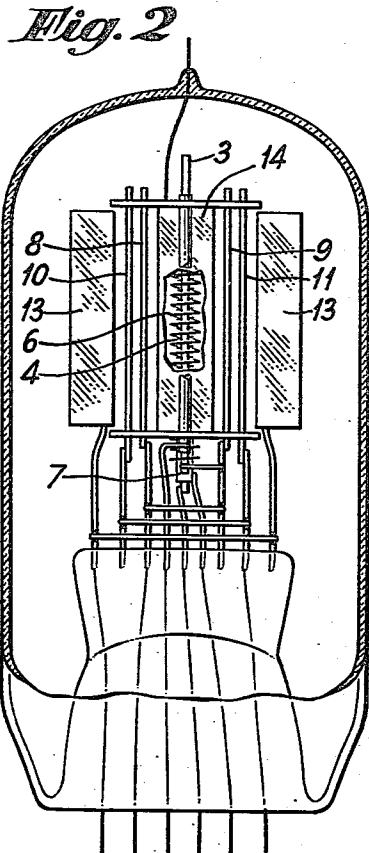
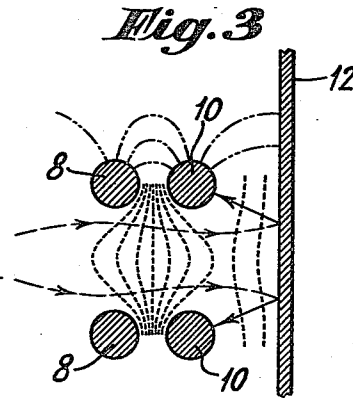
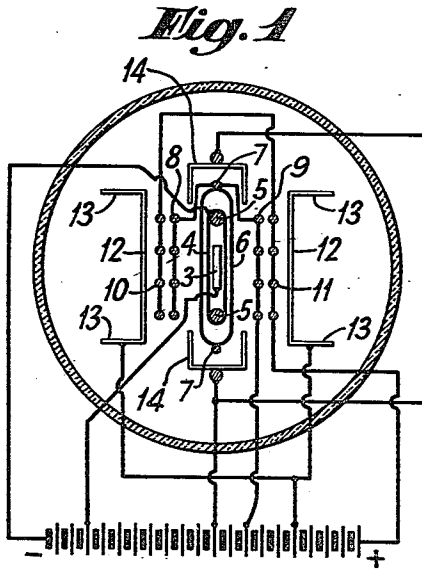
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2,164,892

SECONDARY EMISSION TUBE

Filed Feb. 23, 1939

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 5

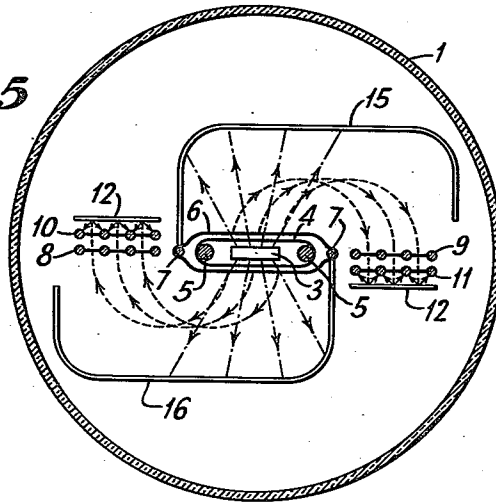
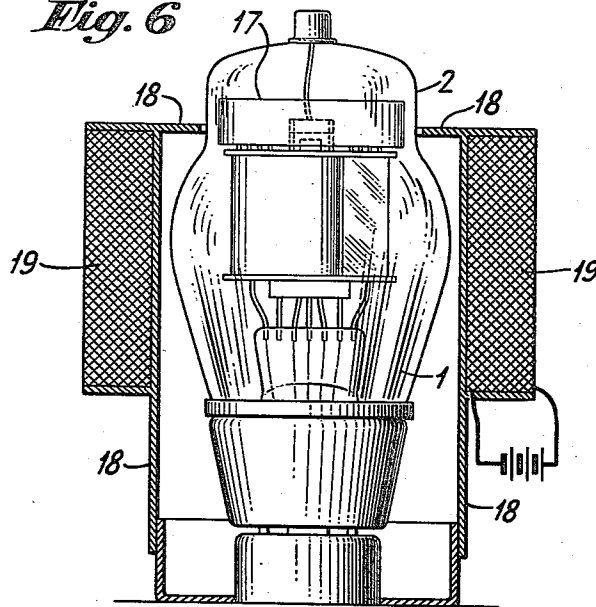


Fig. 6



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SECONDARY EMISSION TUBE

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6 Claims. (Cl. 250—174)

This invention relates to electron discharge devices and has for its object to provide improved electron discharge devices of the grid controlled type which have incorporated in them a secondary emission amplifier stage and which have high mutual conductance.

One object of the invention is to provide a grid controlled thermionic tube of the secondary emission amplifier type which is of maximum efficiency and is so constructed that all the primary electrons which pass through the grid control system strike the multiplying electrode.

Another object is to provide such a tube in which the output anode is in effect so close to the multiplying electrode that space charge effects do not prevent utilization of the full secondary emission, and all the primary electrons proceed to the multiplying electrode, which in use is at a considerably lower potential than the output anode.

A further object is to provide such a tube in which the multiplying electrode has a reasonably long life even when the thermionic cathode is of the barium activated type.

According to the invention an electron discharge device in which the electron stream to the output anode is a secondary electron stream emitted by an electron multiplying electrode which is bombarded by electrons from a primary cathode has a grid-like output electrode or anode interposed between the primary cathode and the multiplying electrode, and another similar grid-like electrode interposed between the output anode and the primary cathode, the output anode and said other grid-like electrode acting as parts of an electron lens system to direct electrons from the primary cathode through the apertures of the two grid-like electrodes to the multiplying electrode, the secondary electrons from which are collected by the output anode.

For a better understanding of the invention, reference is made to the accompanying drawings, which illustrate some embodiments of the invention and in which Figure 1 is a cross-section through the electrode system of one example of the invention; Figure 2 a side view of the electrode assembly, partly broken away to show details of construction; Figure 3 an enlarged fragmentary view indicating diagrammatically the flow of electrons; Figure 4 a similar view to indicate the electron flow when the lens grid emits secondary electrons; Figure 5 a cross-section of a form of tube with a barium activated cathode; and Figure 6 a side elevation of a tube constructed as shown in Figure 5.

Referring to the accompanying drawings the tube shown in Figures 1 and 2 has an evacuated bulb 1 enclosing an electrode assembly comprising a central rectilinear and preferably flattened cathode 3 which may be directly or indirectly heated and is positioned symmetrically within a closely adjacent control grid 4, preferably in the form of a flattened ellipse with two large grid rods or supports positioned in the plane of the cathode. Symmetrically surrounding the control grid is a similar attenuated elliptical screen grid 6 preferably also with its supports 7 in the common plane of the cathode and of the control grid supports. Placed symmetrically about the cathode and outwardly of the screen grid is a duplex lens grid comprising a pair of unipotential lens grids 8, 9, which are of very open mesh and which preferably consist of spaced rectilinear rods positioned parallel to the longitudinal axis of the cathode and electrically connected together. Outwardly of the duplex lens grid and again symmetrically arranged with respect to the cathode is a duplex output anode, comprising a pair of unipotential grids 10, 11, which are similar to the lens grids 8 and 9 and which have their conductors and apertures aligned with the corresponding conductors and apertures of the lens grids. Outwardly of the output anode grids and again symmetrically arranged with respect to the cathode is a duplex multiplying electrode, comprising a pair of secondary electron emitters or multiplying electrodes 12 connected together, each emitter being in the form of a metal plate sensitized on the face toward the cathode in some known manner to have high secondary electron emissivity and preferably provided with bent back cooling fins 13. These multiplying electrodes may, for example, be of copper, with their surfaces oxidized and sensitized with caesium, as such electrodes are found to be somewhat more robust than the caesium-on-silver type of multiplying electrode, though the caesium-on-silver type may be used, if desired.

The enlarged schematic view in Figure 3 best shows the alignment of the lens grids and the output grids, as each wire or rod 10 and 11 of each anode grid lies directly behind a corresponding wire or rod 8 and 9 of the adjacent lens grid, so that a line drawn through one rod in an anode grid and the corresponding rod in the adjacent lens grid will run normal to the emissive surface of the adjacent multiplying electrode 12 and to the operative faces of the screen and control grids which are not shown in this figure.

Preferably a shield electrode is mounted adjacent the screen grid to help form the electron discharge into two oppositely extending beams. The shield electrode may, for example, comprise a pair of trough like sheet metal members 14 mounted at the ends of the screen grid near the grid rods 7, with the open sides of these troughs facing the screen grid, and the sides of the troughs projecting slightly beyond the grid rods, which, as a result, are in effect inside the troughs. In use the open trough-like electrodes 14 act as beam shaping electrodes to constrain electrons from the primary cathode into two lateral phalanges which pass in turn through the control grids, the screen grids, the lens grids, and the anode grids to the multiplying electrodes, where several secondary electrons are released for one primary electron and return to the anode grids which constitute the output anode.

A convenient operating potential for the lens grids is that of the screen grid to which they may be connected, either outside or inside the tube. In use when suitable potentials are applied to the various electrodes most of the primary electrons in their outward courses from the cathode pass through the interstices of the lens and anode grids, without touching the grid conductors, and go to the multiplying electrode surfaces, as indicated in Figure 3, in which the broken lines with arrow heads represent primary electrons paths, the full lines with arrow heads represent secondary electron paths, and the dotted lines represent in the conventional manner equipotential lines and the chain lines represent in conventional manner lines of force.

External connection to the control electrode is preferably made through one end of the envelope opposite to that at which connection to the output anode is taken out, and if desired, an electrostatic screen may be provided across the electrode system at the end where the control grid lead is taken out in order to minimize capacity feed back effects.

With the constructions illustrated and described, most of the primary electrons will, in each case, pass through the lens grid to the multiplier electrode, but some primary electrons will impinge on the lens grid itself. If this lens grid is made of nickel, most of the impinging electrons will be lost, because of the high surface work function of this metal. It is in some cases desirable to make the lens grids of a high secondary electron emissivity; for example, by making the lens grids of silver or copper, oxidized on the surface, and coated with caesium. The result is a substantial increase of efficiency, an improvement of as much as 20-25% in mutual conductance. The way in which the improvement is obtained will best be seen from the accompanying Figure 4, in which the same reference numerals and electron path conventions are used as are employed in Figure 3, it being assumed, however, that in Figure 4 the lens grid is secondary electron emissive. The electron paths (x) at the bottom of Figure 4 represent the case where a primary electron passes through the lens grid, as will occur in the majority of cases; and the paths (y) and (z) represent two cases where a primary electron impinges on the lens grid. As will be seen, in neither case does such impingement represent loss, for in case (y) secondaries are emitted and pass direct to the output anode grid 10 and 11, while in case (z) secondaries are emitted which pass to the multiplier electrode surface 12 where

still more secondaries are emitted and pass back to the output grid 10 and 11.

The conventional cathode is coated with oxides of barium and strontium, and is therefore barium activated. It has been found that in a tube made as above described and having a barium activated cathode there is a tendency after considerable use, such as for 100 hours or more, for the performance to drop away as compared to what it was initially. This tendency seems to be caused by a diminution of the secondary emission ratio of the multiplying electrodes 12, apparently due to deposition of barium atoms from the barium activated thermionic cathode upon the multiplying electrodes 12. In accordance with the invention, the primary electron stream from a barium activated or similar primary cathode liable to emit atoms when in use and multiplied by secondary electron emission at a multiplier electrode is caused preferably by a magnetic field to follow electron paths which are curved instead of rectilinear, and the multiplier electrode is so positioned that it receives electrons following the curved paths but is out of the paths of particles or barium atoms ejected from the cathode, for the paths of such particles will be substantially rectilinear and unaffected by the magnetic field.

Figures 5 and 6 of the accompanying drawings illustrate an embodiment of the invention as applied to a tube in which the primary electron streams follow curved paths. In the tube shown in these Figures the envelope 1 has the usual dome top 2, and encloses an electrode assembly comprising a rectilinear thermionic barium activated cathode 3, surrounded by a flattened elliptical control grid 4 having large support rods 5, the control grid being closely surrounded by a similar screen grid 6 with support rods 7. Outwardly of the opposite ends of the screen grid 6 are two symmetrically positioned anode groups consisting of the lens grids 8, 9, associated anode-grids 10 and 11, and the emitter or multiplying electrodes 12, arranged as shown, the surfaces of the emitters being preferably of the complex caesiated type. Each anode group, consisting of a lens grid, output anode, and an emitter, all parallel to one another, is set edge on to the cathode and is behind a grid rod 5 which shields the anode group from particles emanating from the cathode and following straight paths away from the cathode. The discharge from the cathode is formed by the grid rods 5 into two beams which leave the cathode in opposite directions perpendicular to the plane of the grid rods and the anode groups. These beams are straight as they leave the cathode, and must be bent so as to follow a curved or semi-circular path if they are to reach the anode groups. In order to bend the beams and thus direct the discharge to the anode groups two curved sheet metal accelerating electrodes 15 and 16 are positioned parallel to the length of the cathode with their concave surface toward the cathode and the anode groups. When these accelerating electrodes are maintained at a potential positive with reference to the cathode as, for example, when they are connected to the screen grid, they will, in conjunction with a magnetic field extending through the tube parallel to the length of the cathode, cause the discharge to follow paths which curve around the cathode, as indicated in the drawings so that the discharge reaches the anode groups and passes through the lens grid and anode grid of each group in the same way as indicated in Figure 3.

An internal screen 17 may be provided to assist

in electrostatically screening the control grid circuit and preferably this screen is a sheet metal cylinder close to the wall of the dome of the bulb and connected to the screen grid. The screen is in effect continued outside the envelope by being brought close to the envelope wall opposite an external shield 18 of metal or some other good conduction material. This external shield may conveniently be formed with cheeks, as shown, and used as the bobbin for a coil 19 which in use is energized from some suitable D. C. source to produce a magnetic field which extends through the tube lengthwise of the cathode. With this construction, barium atoms evaporated from the cathode 3 do not strike the sensitized emitters 12, as appears from Figure 5, in which the curved broken lines with arrow heads represent primary electron paths, the short full lines with arrow heads extending from the emitters 12 represent secondary electron paths, and the straight chain lines with arrow heads represent cathode particle or barium atom paths. The particles or barium atoms move in straight lines from the cathode and fall upon the electrodes 15 which extend across the paths of these particles. The electrodes 15 and 16 are maintained at any suitable positive potential, and may conveniently be at screen grid potential, as illustrated in the drawings.

I claim:

1. An electron discharge device comprising a thermionic cathode, a secondary electron emitter having a high coefficient of secondary electron emission, means for producing a modulated primary electron stream from said cathode to said emitter, a grid-like output anode between said cathode and said emitter and extending across the path of said electron stream to said emitter, and an electron lens grid similar to said output anode mounted between said output anode and said cathode with its conductors and apertures aligned along the path of said electron stream with the corresponding conductors and apertures of said output anode to cooperate with said output anode as part of an electron lens system for directing the electron stream from said cathode through the apertures of said grid-like electrodes to said emitter.

2. An electron discharge device as defined in claim 1 in which the means for producing a modulated primary electron stream comprises a control grid surrounding the cathode, a screen grid surrounding the control grid, and a pair of elongated shield electrodes positioned parallel to and on opposite sides of the cathode and near the screen grid.

3. An electron discharge device as defined in claim 1 and comprising an elliptical control grid and an elliptical screen grid concentric with said cathode, and a pair of elongated shield electrodes of trough-like form mounted parallel to and on opposite sides of said cathode to overlap and partially enclose the opposite ends of the screen grid.

4. An electron discharge device comprising a rectilinear oxide coated thermionic cathode, means for concentrating the electron discharge from said cathode into a radial beam, a secondary electron emitter having high secondary electron emissivity mounted out of radial alignment with the portion of the beam at said cathode, a grid-like output anode mounted in front of said emitter, means for producing a magnetic field parallel to the length of said cathode for curving said beam about said cathode and directing said beam through said anode to said secondary electron emitter, and a lens grid electrode similar to said grid-like output anode mounted in front of said output anode with its conductors and apertures aligned along the path of said beam with the corresponding conductors and apertures of said grid-like output anode.

5. An electron discharge device comprising an evacuated glass bulb enclosing a rectilinear oxide coated cathode, a control grid and a tubular screen grid surrounding said cathode, one of said grids having a support rod parallel to the length of said cathode, a flat secondary electron emitter of high secondary electron emissivity mounted with its edge toward and parallel to the longitudinal axis of said cathode and behind said grid rod, a curved sheet metal accelerating electrode with its concave surface parallel to and facing said cathode and said emitter and extending from near said cathode to the vicinity of said emitter to direct the electron discharge to said emitter along a path curved around said cathode, and means for producing a magnetic field which extends through the discharge space of said device in a direction substantially parallel to the length of said cathode.

6. An electron discharge device as defined in claim 5 in which the screen grid carries a sheet metal cylinder with its wall close to the wall of the bulb, an external metallic shield surrounds the bulb and has at one end a hole with its edges adjacent and aligned with said metal cylinder, and a coil is wound on said shield to generate a magnetic field substantially parallel to the length of said cathode.

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