

April 3, 1951

W. G. SHEPHERD
SECONDARY EMISSION AMPLIFIER

2,547,142

Filed Nov. 27, 1948

2 Sheets-Sheet 1

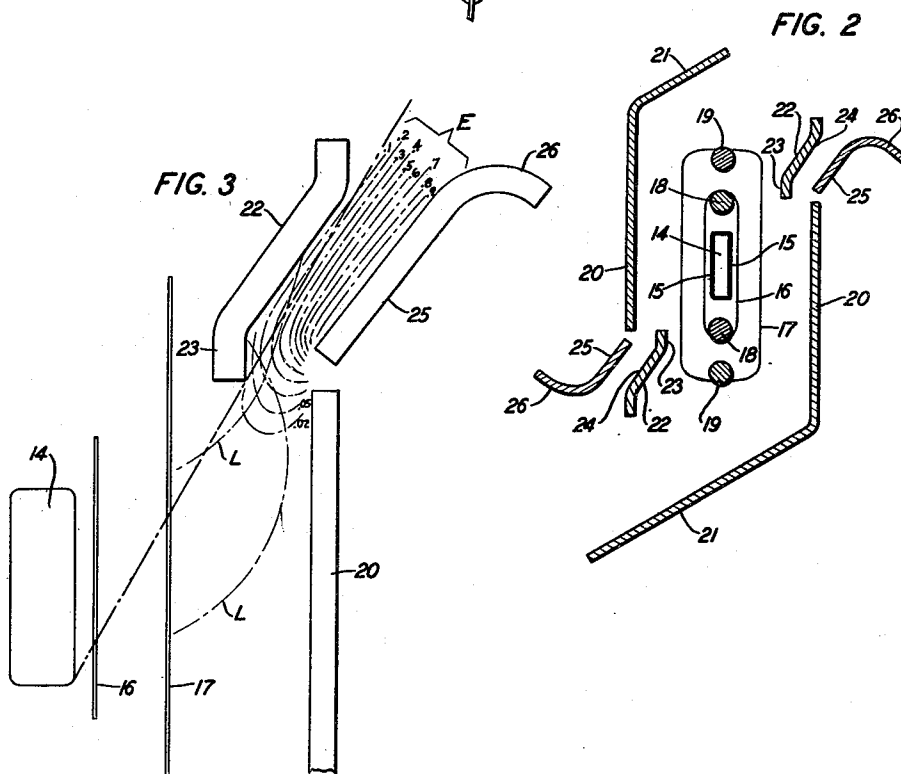
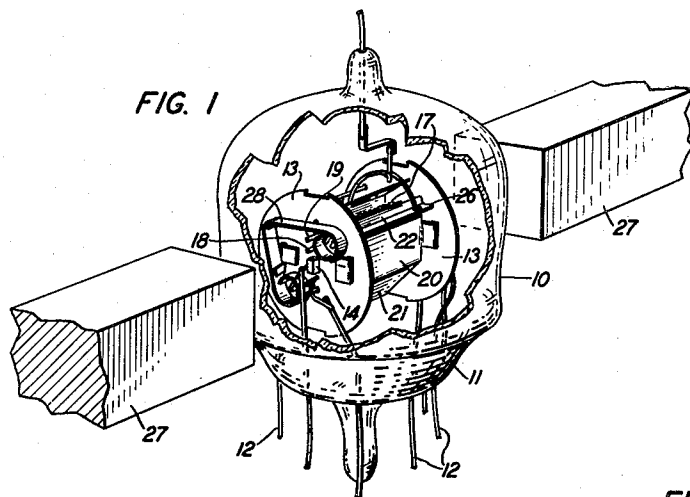
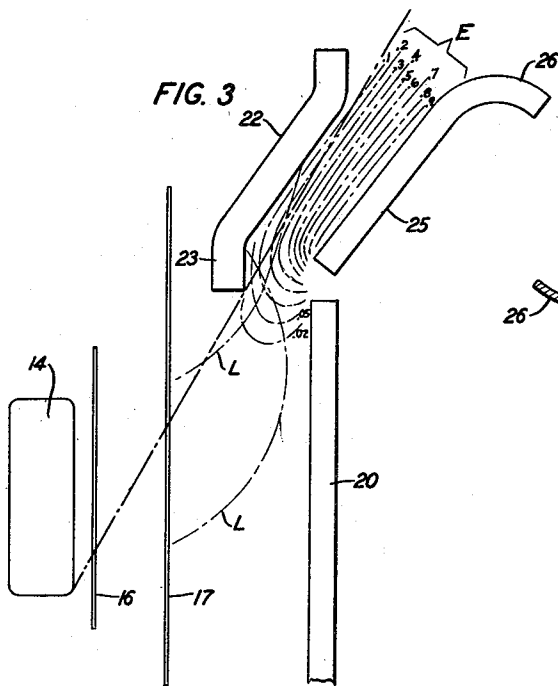


FIG. 3



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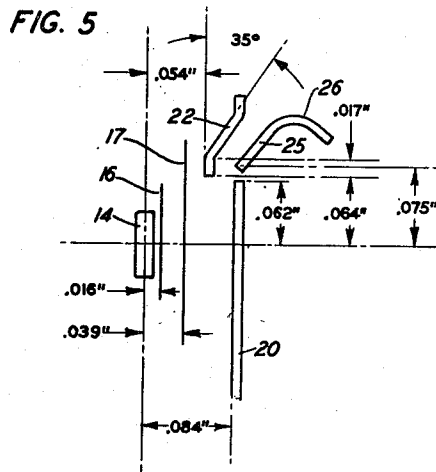
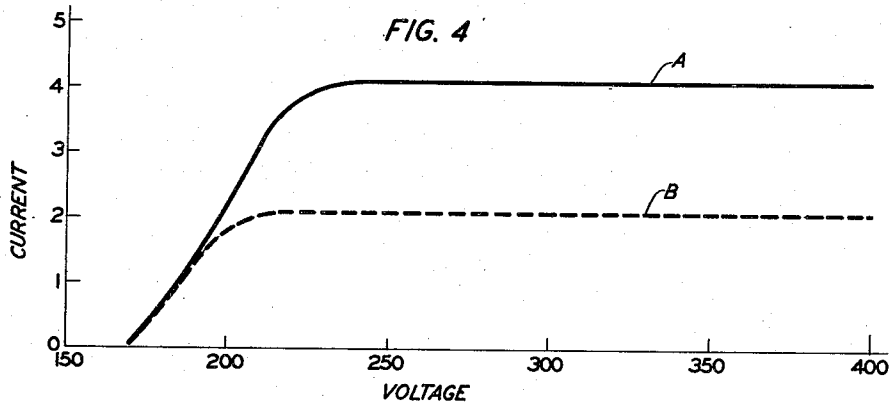
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UNITED STATES PATENT OFFICE

2,547,142

SECONDARY EMISSION AMPLIFIER

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Application November 27, 1948, Serial No. 62,396

6 Claims. (Cl. 250-174)

1

2

This invention relates to electron discharge devices and more particularly to such devices including a secondary electron emissive electrode and particularly suitable for use as amplifiers.

In secondary electron emission type amplifiers, in general, a primary electron stream of intensity variable by a control grid is directed against a target electrode, the surface of this electrode upon which the primary electrons impinge having a coefficient of secondary electron emission greater than unity whereby a current multiplication is obtained. Secondary electrons emanating from this surface are drawn to a collector electrode or output anode. In one known form of device, the direction of the primary electron stream is effected by the use of cooperating electric and magnetic fields of relative magnitude such that the trajectories of the primary electrons from the cathode to the target are curvilinear.

It has been found that in devices of the general construction indicated hereinabove, at some and particularly at relatively high output anode or collector electrode voltages some of the primary electrons may flow directly to the collector electrode so that they do not contribute to the desired electron multiplication effects. It has been found also that within the practical range of operating voltages for the device, at none are essentially all of the secondary electrons emanating at the target collected by the output anode. Consequently, the output or collector electrode current varies substantially with the voltage of the collector electrode, the voltages of the other electrodes being fixed. Hence, the output impedance of the device is relatively low.

One object of this invention is to improve the operating characteristics of electron discharge devices including secondary electron emissive electrodes.

More specifically, one object of this invention is to obtain a high output impedance for secondary emission-type amplifiers.

Another object of this invention is to decrease the electron transit times in secondary emission-type electron discharge devices.

In one illustrative embodiment of this invention, an electron discharge device comprises a cathode, control grid and screen or accelerating grid having juxtaposed, substantially plane parallel surfaces and correlated to project a large current primary electron stream. A target electrode having a secondary electron emissive surface is mounted to one side of the cathode and control and accelerating grids and has opposite

to the emissive surface thereof a collector electrode or output anode. The primary electrons are directed against the emissive surface of the target electrode by crossed magnetic and electric fields. An auxiliary electrode is mounted opposite the screen grid and laterally opposite the target electrode. The auxiliary electrode advantageously is operated at the same potential as the accelerating or screen grid thereby to produce a substantially electrostatic field free space between these two electrodes.

In accordance with one feature of this invention, the target and collector electrodes are so constructed and arranged that the primary electrons are directed to the emissive surface of the target electrode and traverse but a short distance in the field due to the output anode or collector electrode so that flow of primary electrons to the collector electrode is prevented.

In accordance with another feature of this invention, the target and collector electrodes have their opposed surfaces plane and parallel and closely spaced whereby secondary electrons emanating from the target electrode may be drawn to the collector electrode with but a low potential upon this electrode relative to the target electrode and all of such secondary electrons are collected.

In accordance with a further feature of this invention, the target electrode is provided with a shield portion to prevent the deposition of cathode material upon the secondary emissive surface of the target electrode.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a perspective view of an electron discharge device illustrative of one embodiment of this invention, portions of the enclosing vessel being broken away to show details more clearly;

Fig. 2 is a sectional view, to an enlarged scale, of the electrode assembly of the device shown in Fig. 1;

Fig. 3 is a diagram showing the configuration and relation of the electrodes in the device illustrated in Figs. 1 and 2 and showing also typical primary electron trajectories and the form of the electric field between the target and collector electrodes;

Fig. 4 is a graph illustrating typical operating characteristics for a device of the construction illustrated in Figs. 1 and 2; and

Fig. 5 is a diagram, similar to a part of Fig. 2, with dimensions for a typical device given.

Referring now to the drawing, the electron discharge device illustrated in Figs. 1 and 2 comprises an evacuated enclosing vessel 10, for example of vitreous material, having a stem or base 11 from which a unitary electrode assembly is supported by rigid conductors 12 sealed in the stem or base. The electrode assembly includes a pair of parallel insulating members 13, for example, mica discs, between which an equipotential or heater-type cathode 14 extends, the cathode being rectangular in cross section and having its opposite surfaces 15 plane and parallel and coated with electron emissive material. The cathode is encompassed by a control grid 16 and a screen or accelerating grid 17, the grids being mounted by pairs of support rods 18 and 19 respectively, extending between the insulating discs 13. As shown clearly in Fig. 2, the major portions of the two grids 16 and 17 are planar and parallel to the emissive surfaces 15 of the cathode.

Opposite each of the faces 15 of the cathode is an auxiliary electrode having a plane portion 20 parallel to the cathode surfaces 15 and having also a wing or shield portion 21.

A pair of target electrodes are mounted near the sides of the screen or accelerating grid, each of the target electrodes having a plane portion 22 and a shield portion 23 the function of which will be pointed out presently. The target electrodes are inclined with respect to the parallel faces of the screen grid and the surface 24 of each target electrode is coated or treated to have a secondary emission coefficient greater than unity. Extending from immediately adjacent each of the auxiliary electrodes is an output anode or collector anode having a plane portion 25 closely adjacent and parallel to the emissive surface 24 of the respective target electrode and having also an outwardly bent portion 26.

In operation of the device, a magnetic field is produced in the interelectrode regions, the lines of the field being parallel to the cathode, that is normal to the plane of the paper in Fig. 2. This field may be produced by a permanent or electromagnet having axially aligned pole-pieces 27 opposite the ends of the cathode. Also in operation of the device, the screen grid 17, auxiliary electrodes 20, 21 and target electrodes 22, 23 are maintained positive with respect to the cathode. Particularly advantageously, the auxiliary electrodes 20, 21 are operated at the same potential as the screen or accelerating grid 17 so that the regions between this grid and these electrodes is substantially electrostatic field free. Conveniently and advantageously, the target electrodes are maintained at the same potential as the screen or accelerating grid. The collector electrodes or output anodes 25, 26 are biased positive with respect to the target electrodes. Corresponding electrodes of the pairs may be tied together electrically as by conductors 28, only two of which are shown.

Under the influence of the accelerating potential upon the screen grid 17 and of the magnetic field, the primary electrons emanating from each surface 15 of the cathode are directed along curved paths at the emissive surface 24 to one of the target electrodes, whereby secondary electrons are released at the target electrodes. The secondary electrons emanating from each surface 24 flow to the associated collector electrode or anode 25, 26.

As has been pointed out heretofore, in accordance with one feature of this invention the electrodes are constructed and arranged so that all of the primary electrons reach a target electrode and the secondary electrons from each target electrode are collected by the respective output anode. The relationships are shown in Fig. 3 which is to scale. It will be noted from Fig. 3 that the shield portion 23 of each target electrode is parallel to the portion 20 of the adjacent auxiliary electrode and extends into the region between the grid 17 and the portion 20 so that it intercepts all straight lines which can be drawn from a target surface 24 to the respective emissive surface 15 of the cathode. Thus the portions 23 prevent deposition of any coating material from the cathode upon the emissive surfaces 24 and thus prevents contamination, with consequent loss in emitting efficiency, of the surfaces 24.

In the major part of the region between the screen grid 17 and the portions 20 of the auxiliary electrodes the electron paths are substantially segments of circles, inasmuch as the grid 17 and auxiliary electrodes are at the same potential and, therefore, the major part of the regions noted are electrostatic field free. However, in the vicinity of the end of each target electrode toward the respective auxiliary electrode, a component of electrostatic field is introduced by virtue of the fact that the potential of the collector electrode is somewhat higher than that of the adjacent target and auxiliary electrodes. The equipotential field lines in this region and between the target electrode and the corresponding collector electrode are indicated by the broken lines E in Fig. 3. The values on these lines represent fractions of the total voltage difference between the target electrode and its associated collector anode. The outer limits of the primary electron paths are indicated by the broken lines L. All the primary electron trajectories are within these limits.

Two important factors are to be noted especially in Fig. 3. First, any primary electron traverses only a short portion of the region in which the field due to the collector electrode or anode obtains. Secondly, the primary electron paths through this region are in parts thereof where the anode field is relatively weak. Consequently, substantially all of the primary electrons flow to the target electrodes.

Each collector electrode is closely spaced with respect to the corresponding secondary electron emissive surfaces 24. Because of this and the form of the electric fields in the target-collector regions, substantially all of the secondary electrons from each surface 24 can be drawn to the respective output anode with a relatively small voltage on the anode.

In a specific device, the dimensions of the electrodes and the spacings may be as given in Fig. 5. Typical electrode voltages will be given hereafter.

The output current-collector electrode voltage characteristics for a device of the construction illustrated in Figs. 1, 2 and 3 is shown in Fig. 4, wherein the ordinates are collector electrode current and the abscissae are collector electrode voltage. For the device represented by the graph A of Fig. 4, the control grid was biased at 2 volts negative and the screen grid, auxiliary electrode and target electrode were biased 175 volts positive, both relative to the cathode. For graph B, the primary electron current was reduced by biasing the control grid at 3.5 volts negative; the other

5

values of potential remaining the same as for curve A. It will be noted that the output current approaches saturation at a relatively low collector electrode potential and that the current remains substantially constant above this potential. Thus, the device exhibits a high output impedance.

Although a specific embodiment of this invention has been shown and described, it will be understood that it is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention.

What is claimed is:

1. An electron discharge device comprising a cathode having a substantially plane electron emissive surface, an accelerating grid opposite said surface and parallel thereto, an auxiliary electrode opposite said grid and electrically connected thereto to define a substantially electric field free region therewith, a secondary electron emissive target electrode laterally adjacent said region and inclined with respect to said emissive surface, a collector electrode opposite said target electrode and extending from immediately adjacent the edge of said auxiliary electrode nearest said target electrode, and means adjacent said region for producing a magnetic field in said region substantially perpendicular to the path of the electrons from said cathode plane electron emissive surface to said face of said target electrode, to direct electrons from said emissive surface to the face of said target electrode toward said collector electrode, said collector electrode being positioned so that it is not in the path of the electrons emitted from said plane electron emissive surface and directed to the face of said target electrode.

2. An electron discharge device in accordance with claim 1 wherein said target electrode includes a shield portion extending into said region and intercepting all straight lines between said emissive surface and said face of said target electrode.

3. An electron discharge device in accordance with claim 1 comprising a control grid adjacent said plane electron emissive surface.

4. An electron discharge device comprising an electron permeable electrode, an auxiliary electrode opposite said electron permeable electrode and electrically connected thereto to define a substantially electric field free region therewith, first means opposite said electron permeable

6

electrode for projecting an electron stream there-through and into said region, a target electrode having a secondary electron emissive surface adjacent and laterally beyond said region, said surface being inclined relative to the direction of projection of said stream, a collector electrode opposite said surface, and second means for directing said stream against said surface including means adjacent said region for producing a magnetic field in said region, said magnetic field being substantially perpendicular to the path of said electron stream from said first means to the surface of said target electrode, and said collector electrode being positioned outside of the path of the electrons emitted from said first means and directed to the face of said target electrode.

5. An electron discharge device comprising a cathode having a plane emissive surface, a target electrode to one side of said emissive surface and having a plane secondary electron emissive face at an obtuse angle relative to said emissive surface, a collector electrode having a portion opposite and substantially parallel to said face, and means for directing electrons from said surface to said face comprising an accelerating grid opposite said surface, an auxiliary electrode opposite said grid, extending from immediately adjacent said collector electrode and connected to said grid to define a substantially electric field free region therewith and means adjacent said region for producing in said region a magnetic field having its lines of force substantially parallel to said surface and substantially perpendicular to the path of the electrons from said cathode to said emissive surface of said target electrode, said collector electrode being positioned outside the path of the electrons emitted from said cathode and directed to the face of said target electrode.

6. An electron discharge device in accordance with claim 5 wherein said target electrode includes a shield portion positioned to intercept all straight lines from said surface to said face.

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