Feb. 11, 1941. H. MÜLLER 2,231,676

ELECTRIC AMPLIFIER

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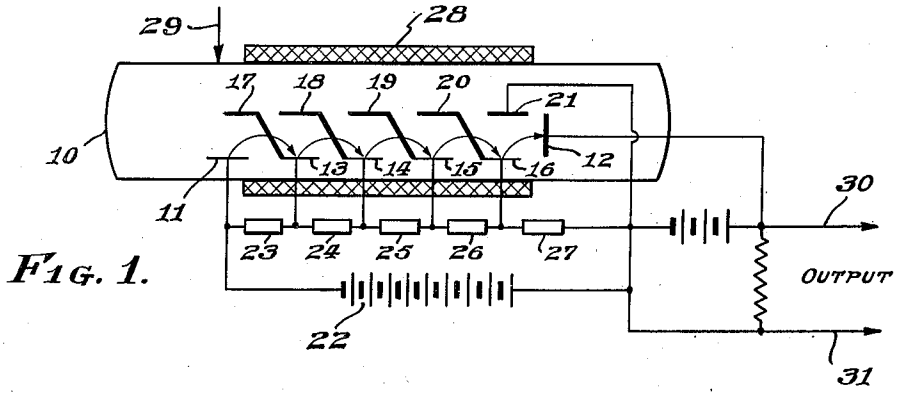

FIG. 1.

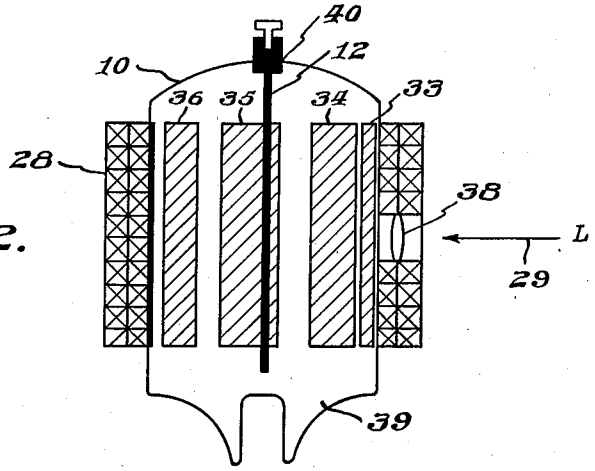

FIG. 2.

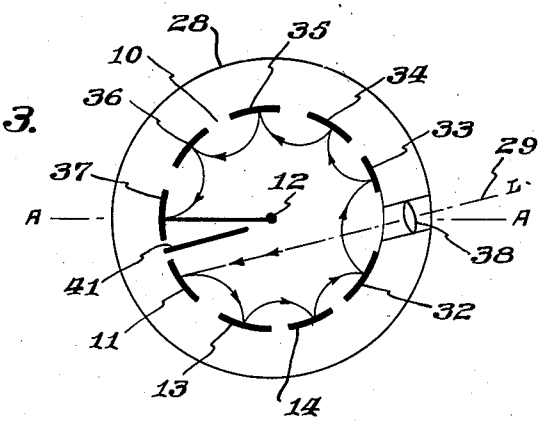

FIG. 3.

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FIG. 4.

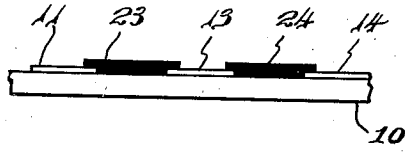


FIG. 5.

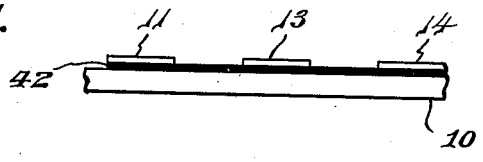


FIG. 7.

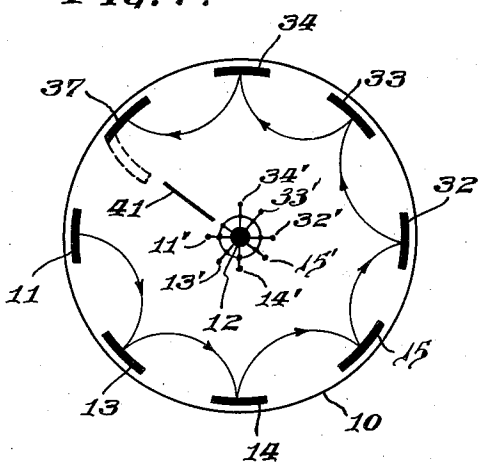
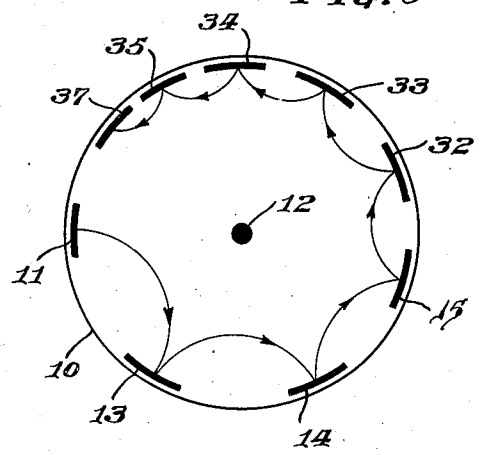


FIG. 6



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UNITED STATES PATENT OFFICE

2,231,676

ELECTRIC AMPLIFIER

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Application August 10, 1937, Serial No. 158,375
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2 Claims. (Cl. 179—171)

This invention relates to electric amplifiers of the type which function through a plurality of secondary electron emissive electrodes immersed in suitable electromagnetic and electrostatic control fields to increase the amplitude of the impulses which it is desired to amplify, and has for its principal object the provision of an improved apparatus and method of operation whereby such amplifiers are simplified in structure and rendered more reliable in operation.

Various types of secondary electron emission amplifiers, commonly designated as electron multipliers, are known. Such amplifiers ordinarily include a plurality of suitably spaced secondary electron emissive electrodes which are mounted in an evacuated container and are subjected to electrostatic and magnetic fields for controlling the path of the electrons between the various electrodes or stages. The magnetic control field may be produced by a permanent or electromagnet surrounding the evacuated container. The electrostatic control field is commonly applied between the secondary electron emissive electrodes and associated control or deflecting electrodes which do not receive the electrons but serve to accelerate them to the next successive secondary electron emissive electrode. In the operation of such amplifiers, each successive emissive electrode is subjected to a higher potential and receives the electrons emitted by the previous electrodes and the electron output from the last electrode is delivered to the utilization circuit.

In order to establish the required electrostatic field within the container, it has been customary to (1) mount the secondary electron emissive electrons in one plane, (2) mount the control or deflecting electrodes in another plane, and (3) provide a bleeder resistor external to the container for applying the different potentials required between the various pairs of emissive and deflecting electrodes.

In accordance with the present invention, the amplifier is improved and simplified by the provision of a cylindrical container wherein an axially mounted accelerating electrode is surrounded by a plurality of cylindrically-arranged emissive electrodes which may be spaced circumferentially by distances dependent on their operating voltages or may be interconnected through resistance material applied to the inner surface of the container. Alternatively, the emissive electrodes may be spaced circumferentially by equal distances and each associated with a different supplementary accelerating electrode element mounted on a central or axial support.

The invention will be better understood from the following description when considered in connection with the accompanying drawings and its scope is indicated by the appended claims.

Referring to the drawings,

Figure 1 illustrates an amplifier or electron multiplier of prior art construction,

Figs. 2 and 3 are respectively vertical and horizontal sectional views of the improved amplifier,

Fig. 4 illustrates an arrangement wherein both the electron emissive electrodes and their interposed resistance elements are applied directly to the interior surface of the container.

Fig. 5 illustrates an arrangement wherein the electron emissive electrodes are mounted on a resistance layer applied to the inner surface of the container,

Fig. 6 illustrates the emissive electrodes as differently spaced about the inner surface of the container, and

Fig. 7 illustrates the emissive electrodes as equally spaced circumferentially about a plurality of accelerating electrode elements.

The prior art device of Fig. 1 includes an evacuated container 10 within which is mounted a cathode 11 from which electrons are transmitted to an anode 12 through a path which includes the emissive surfaces of a plurality electrodes 13, 14, 15 and 16. Associated respectively with the cathode 11 and the emissive electrodes 13 to 16 are a plurality of control or accelerating electrodes 17 to 21 each illustrated as connected to the next following emissive electrode. Thus the accelerating electrode 17 which is paired with the cathode 11 is connected to the electrode 13, etc. For accelerating the emitted electrons, potential is applied from a source 22 through a plurality of resistors 23 to 27 to the various electrodes. For causing the electrons to follow the path indicated by the curved arrows, there is provided an electromagnet 28 or other suitable means for producing a magnetic field which is substantially parallel with the longitudinal axis of the container 10. The impulses to be amplified may be applied to the cathode 11 in the form of light as indicated by the arrow 29 and the amplified output may be derived at the output terminals 30 and 31.

The improved device of Figs. 2 and 3 includes a container 10 which is surrounded by an electromagnet 28 or is provided with other suitable means for producing a magnetic field which is substantially parallel to the container axis. Mounted axially of the container 10 is an accelerating electrode 12 surrounded by a plurality

of cylindrically arranged electron emissive electrodes 11, 13, 14, 15, 32, 33, 34, 35, 36 and 37 which are preferably attached to the inner surface of the container. As shown more clearly in Fig. 3, the electrode 12 in this case is connected to the electrode 37, which is the last electrode in point of electron travel.

Assuming that the electrode 11 is connected to the negative terminal of the source 22 (Fig. 1) and that the electrode 37 is connected to the positive terminal of this source, the electrodes 11, 13, 14, and 32 to 37 are subjected to successively greater potentials, each electrode adds its quota of secondarily emitted electrons and the total output may be derived from a suitable connection as indicated in connection with Fig. 1. The impulses to be amplified may be applied to the electrode 11 in the form of light 29 which is transmitted through a lens 38 mounted in an aperture of the electromagnet 28. It will be apparent that suitable leads are provided in the base 39 of the container 10 for applying potential to the various electrodes and that the accelerating electrode may be brought out at the container top as indicated at 40. Also it is desirable that a shield 41 be interposed between the electrodes 11 and 37.

As indicated by Figs. 4 and 5 the resistance units 23, 24, etc., may be made in the form of a resistive coating which is applied to the inner surface of the container between the electrodes or alternatively the electrodes 11, 13, 14, etc., may be suitably mounted on a resistive coating 42 (Fig. 5) applied to the inner surface of the container. These electrode-resistor arrangements have the obvious advantage that they render possible a more sturdy and compact unit which is especially desirable in connection with sound reproducers and the like.

Fig. 6 illustrates a modified electrode assembly wherein the spacing between the electrodes decreases as the interelectrode potential increases. This arrangement has the advantage that the electrode spacing is somewhat accommodated to the strength of the electrostatic field which becomes progressively weaker with each successive electrode starting at the negative terminal. In order to realize the same voltage drop from electrode to electrode, it is of course necessary that each successive resistive coating be made thinner or that different resistance materials be utilized for the different interelectrode coatings.

As indicated by Fig. 7, the central accelerating electrode 12 may be divided into accelerating electrodes 11', 13', 14', 15', 32', 33', and 34'. In this case, the arrangement is so made that the center part 12 of the accelerating electrode arrangement is metallic or consists of an insulating material. In a convenient way, a metal is employed for this. Accelerating electrodes 11', 13', etc., are attached on this supporting body 12 in an insulated arrangement. The individual accelerating electrodes can be wires or the like. Attention should be paid to the fact that they have an arrangement, insulating them against supporting body 12 and the individual accelerating electrodes. Furthermore, it is important that the construction is stable, so that accelerating electrode elements can not move out of their stationary portion. The voltage of the individual accelerating electrode elements is so selected that the voltage of accelerating electrode 11' is identical to the voltage of multiplying electrode 13, and that the voltage of accelerating electrode 13' is identical to the voltage of multiplying electrode 14, etc., i. e., the individual accelerating electrodes, consequently, possess the potential of the immediately following electrode. Now, one must imagine that the magnet is placed around the glass cylinder shown, and in this case it is quite obvious that under the influence of the electric field and of the magnetic field the electrons must follow the course, as illustrated by the arrows. The last electrode 37 is advantageously designed in the style indicated by dotted lines. A screen 41 which has a zero potential may be provided to prevent the high voltage of anode 37 from acting on electrode 11. According to the invention, it is not necessary to design the accelerating electrode 12 with the small dimensions shown, but it can be chosen considerably larger, and it must only be taken care that there is a hole for the passage of the light in electrode 12. If center part 12 of this multi-part accelerating electrode is then supplied with ground potential, one can be sure that the voltages of the individual parts of the electrodes have no injurious influence on one another. Furthermore, it is possible, according to the invention, to use, instead of the partial accelerating electrodes shown, only a few that are correctly distributed on the circumference of part 12 and to which the voltage is so assigned that the electrons again follow the prescribed correct course.

It will be apparent that the mounting of the emissive electrodes and their resistive coating connection on the surface of the container is a feature which is readily applicable to any of the various types of such devices including both those of this invention and those of the prior art.

I claim as my invention:

1. An electron-multiplier comprising a container, an accelerating electrode mounted axially of said container, a plurality of spaced apart electron emissive electrodes and an anode mounted in successive array around the inner surface of said container and substantially equal distances from said accelerating electrode, means for causing successively higher potentials to be applied to said emissive electrodes and anode as determined by the direction of electron travel said emissive electrodes and said anode being progressively spaced closer together in accordance with said increased voltage.

2. An electron multiplier comprising a container having a central axis, a plurality of electron emissive electrodes and an anode mounted in spaced circumferential relation around the inner surface of said container, a plurality of accelerating electrodes paired with said emissive electrodes mounted parallel to and at equal radial distances from said central axis, means for causing successively higher potentials to be applied to said emissive and anode electrodes as determined by the direction of electron travel, and means for causing each of said accelerating electrodes to be subjected to a voltage corresponding respectively to the voltage of the emissive electrode of the following pair.

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