

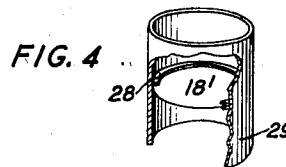
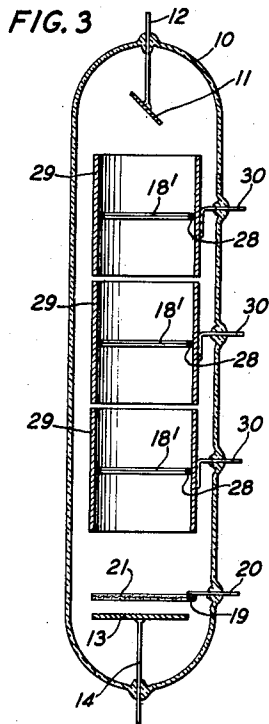
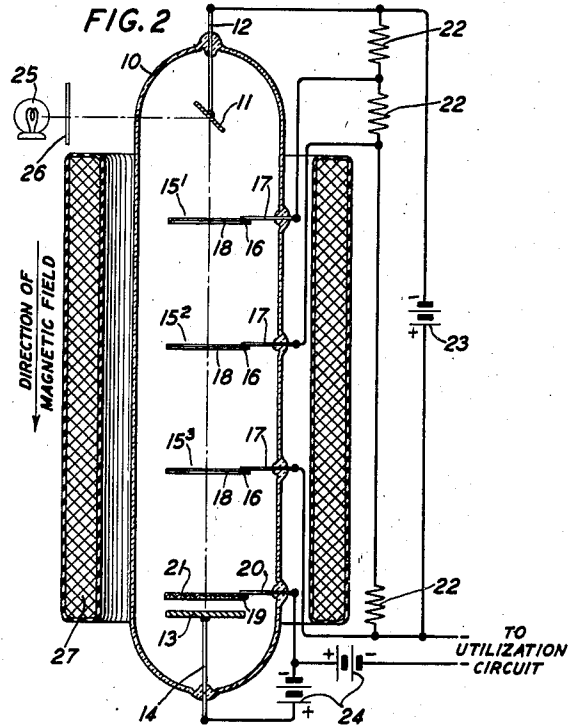
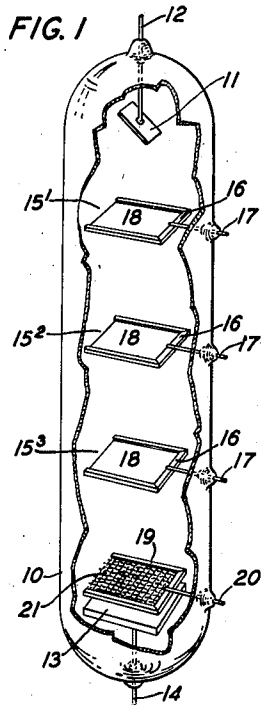
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ELECTRON DISCHARGE APPARATUS

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ELECTRON DISCHARGE APPARATUS

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5 Claims. (Cl. 250—175)

This invention relates to electron discharge apparatus and more particularly to such apparatus including multistage electron multipliers.

One object of this invention is to expedite the manifold amplification of electric currents.

Another object of this invention is to improve the efficiency of multistage electron multipliers.

In one illustration embodiment of this invention, an electron multiplier comprises a primary cathode, an anode or collector electrode spaced from the cathode, and a plurality of secondary or auxiliary cathodes between the primary cathode and the collector electrode or anode. The successive secondary or auxiliary cathodes may be operated at progressively increasing positive potentials with respect to the primary cathode so that the electrons emanating from each cathode are attracted to and impinge upon the next following electrode toward the anode or collector electrode.

In accordance with one feature of this invention, the secondary cathodes are composed of thin metallic sheets or films mounted parallel to one another and in alignment with the primary cathode and the collector electrode or anode. One or both faces of the metallic sheets or films may be sensitized to render them capable of copious emission of secondary electrons.

In accordance with another feature of this invention, means are provided for concentrating or guiding the electron streams emanating from each of the cathodes so that the streams from each cathode impinge upon the next succeeding cathode or the anode. The concentrating or guiding means may be, for example, a cylindrical coil encompassing the electrodes and producing a strong concentrated magnetic field adjacent and parallel to the axis of alignment thereof. Alternatively, the concentrating or guiding means may include a plurality of coaxial metallic tubular members each of which encompasses a corresponding one of the secondary or auxiliary cathodes and may have a suitable potential applied thereto.

The invention and the foregoing 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 view in perspective of an electron multiplier illustrative of one embodiment of this invention, a portion of the enclosing vessel being broken away to show the electrodes more clearly;

Fig. 2 is a view partly in cross section and partly diagrammatic of electron discharge apparatus

including an electron multiplier of the construction illustrated in Fig. 1 and an electromagnetic coil for concentrating the various electron streams;

Fig. 3 is a view in cross-section of an electron multiplier illustrative of another embodiment of this invention, wherein tubular concentrating members are provided for the electron streams, and

Fig. 4 is a detail view in perspective and partly broken away of one of the cathode-guide structures included in the device shown in Fig. 3.

Referring now to the drawing, the electron discharge apparatus shown in Figs. 1 and 2 comprises an elongated, cylindrical enclosing vessel 10 housing a primary cathode 11 mounted at one end of the vessel by a rigid leading-in conductor 12 and an anode or collector electrode 13 mounted at the opposite end of the vessel 10 and in alignment with the cathode 11, by a rigid leading-in conductor 14.

As shown clearly in Fig. 2, the primary cathode 11 may be a plate disposed at an angle, for example, 45 degrees, to the longitudinal axis of the vessel 10. The inner or lower face of this plate, that is, the surface thereof directed toward the anode or collector electrode 13, may be treated to render it photoelectrically active.

Disposed between the primary cathode 11 and the anode or collector electrode 13 and in alignment therewith are a plurality of auxiliary or secondary cathodes 15¹, 15² and 15³. Each of these cathodes comprises a rigid, metallic U-shaped frame 16 supported by a leading-in conductor 17 sealed in the side wall of the enclosing vessel 10 and extending therefrom. Each of the frames 16 carries a thin film or sheet of metal 18, the several sheets or films preferably being parallel to one another and to the anode or collector electrode 13. The sheets or films 18 may be, for example, of a precious metal such as gold leaf or silver and the faces thereof toward the anode or collector electrode 13 may be sensitized to assure copious emission of secondary electrons therefrom. For example, these surfaces may be treated with an alkali metal such as caesium, a negative element such as oxygen, and a metal such as silver to produce a matrix or coating containing caesium oxide, silver, and some free caesium.

A suitable screen electrode may be provided adjacent the anode or collector electrode 13 to shield the end secondary cathode 15³ from potential variations upon the anode or collector electrode. The screen electrode may comprise a rigid me-

tallic frame 19 supported by a rigid leading-in conductor 20 sealed in and extending from the side wall of the vessel 10, and a mesh portion 21 disposed parallel to the anode or collector electrode 13.

During operation of the device, as shown in Fig. 2, the secondary cathode 15¹ may be maintained at a positive potential, for example, of the order of 100 volts, with respect to the primary cathode 11, the cathode 15² may be maintained of the order of 100 volts positive with respect to the cathode 15¹ and, similarly, the cathode 15³ may be maintained of the order of 100 volts positive with respect to the cathode 15². The requisite potentials may be obtained, for example, from a potentiometer including suitable resistances 22 in shunt with a source such as a battery 23. The anode or collector electrode 13 and the screen electrode 21 may be maintained at suitable positive potentials, for example, of the order of 300 volts and 150 volts, respectively, with respect to the final secondary electrode by sources such as batteries 24. An output or utilization circuit may be connected between the cathode 11 and anode or collector electrode 13 as shown.

The primary cathode 11 may be energized or activated to produce a stream of electrons, as by a light beam emanating from a source 25 and focussed upon the photoelectrically active surface of the cathode 11 by a suitable lens, not shown. The intensity of the light beam, and hence the intensity of the electron stream emitted from the cathode 11 may be varied in accordance with the impulses to be translated or amplified, by a sound film 26.

Under the influence of the potential upon the secondary or auxiliary cathode 15¹, the electrons emitted by the primary cathode 11 flow with relatively high velocities toward the film 18 of the cathode 15¹ and impinge upon the surface thereof facing the cathode 11. As a result of this impingement of electrons, secondary electrons are released from the surface of the film 18 of the cathode 15¹ facing the next secondary or auxiliary cathode 15². It has been found that the secondary electron current emanating from the cathode 15¹ is many times greater than the impinging primary electron current. Consequently, in effect an electron multiplication and hence an amplification of the primary current is obtained.

The secondary electrons released from the cathode 15¹ travel at fairly high velocities toward the cathode 15² and impinge upon the film 18 thereof as a result of which other secondary electrons are released and an electron multiplication occurs. Similarly, the secondary electrons released from the film 18 of the cathode 15² flow to the next succeeding cathode 15³ and still other secondary electrons are produced and further multiplication occurs. The secondary electrons released from the cathode 15³ flow to the anode or collector electrode 13 and constitute the output current of the apparatus which is greater than the current emitted by the primary cathode 11.

In order to prevent dispersion of the electron streams flowing between the cathodes and thereby to insure the impingement of substantially all of the electrons emitted from the surfaces of the cathodes toward the anode or collector electrode, upon the next succeeding cathode or the anode, means are provided for concentrating or focussing the several electron streams. As shown in Fig. 2, this concentrating or focussing means

may include an elongated coil 27 encompassing the enclosing vessel 10 and mounted coaxial with the electrodes therein. The coil 27 is energized in a suitable manner to provide a strong concentrated magnetic field along the axis of alignment of the electrodes, the field having the direction indicated in Fig. 2.

In the embodiment of this invention illustrated in Fig. 3, the several sheets or films 18', of the secondary cathodes suitably sensitized as described heretofore, may be circular and, as shown more clearly in Fig. 4, may be carried by rigid metallic rings or frames 28. Each of the rings or frames 28 is affixed within a tubular metallic sleeve 29, preferably midway between the ends of the sleeve. The several sleeves 29 preferably are of the same diameter and are mounted coaxially with one another by rigid leading-in conductors 30 sealed in and extending from the side wall of the enclosing vessel 10. The various electrodes may be connected in the same manner as illustrated in Fig. 2.

Each of the tubular sleeves 29 is at the same potential as the corresponding film 18' carried thereby and serves, both mechanically and electrically, to minimize dispersion of the electron streams emanating from the cathodes so that the electrons from each cathode are concentrated and are focussed upon the next succeeding cathode or upon the anode or collector electrode.

Although specific embodiments of the invention have been shown and described, it will be understood, of course, that various modifications may be made therein. For example, although three secondary or auxiliary cathodes have been indicated in the specific embodiments shown and described, a greater or lesser number may be employed. Also, although the primary cathodes 11 have been illustrated as of the photoelectric type, they may be of the thermionic type, directly or indirectly heated, and a grid may be provided thereadjacent to vary the intensity of the primary electron stream. Likewise, although the concentrating sleeves 29 have been shown as cylindrical in form, they may be of other forms, for example, frusto-conical and tapered toward the next succeeding electrode. Other modifications may appear to those skilled in the art without, however, departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. Electron discharge apparatus comprising a primary cathode, a collector electrode, a plurality of imperforate parallel secondary cathodes mounted one behind another and between said primary cathode and said collector electrode, each of said secondary cathodes having the surface thereof toward said collector electrode sensitized to emit secondary electrons, and means electrically integral with and encompassing said secondary cathodes for concentrating the electrons emitted from each of said secondary cathodes.

2. Electron discharge apparatus comprising a primary cathode, a collector electrode, a secondary electron emitting cathode between said primary cathode and said collector electrode, and a tubular metallic member supporting and encompassing said secondary cathode, and mounted in alignment with said primary cathode and said collector electrode, said secondary cathode being mounted intermediate the ends of said tubular member.

3. An electron multiplier comprising a primary cathode, a collector electrode, a plurality of secondary cathodes mounted one behind another

between said primary cathode and said collector electrode, and a plurality of coaxial tubular members each encompassing a corresponding one of said secondary cathodes, each of said secondary cathodes being mounted remote from both ends of the corresponding one of said tubular members.

4. An electron multiplier comprising a primary cathode, a collector electrode in alignment with said primary cathode, a plurality of spaced coaxial tubular members between said primary cathode and said collector electrode, and a secondary electron emitting cathode within each of said tubular members and carried thereby, each secondary cathode being mounted substantially mid-way between the ends of the tubular member by which it is carried.

5. An electron multiplier comprising a primary cathode, a collector electrode in alignment with said primary cathode, a plurality of metallic tubular members between said primary cathode and said collector electrode, said members being coaxial and mounted end to end in alignment with said primary cathode and said collector electrode, and a plurality of metallic film electrodes each mounted within a corresponding one of said tubular members, said film electrodes extending transversely of said tubular members and having the surface thereof toward said collector electrode sensitized to emit secondary electrons.

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