

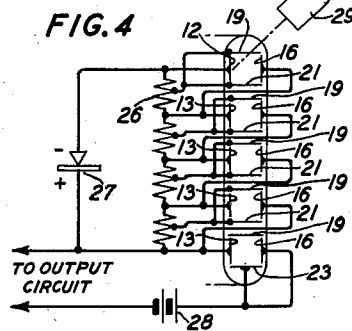
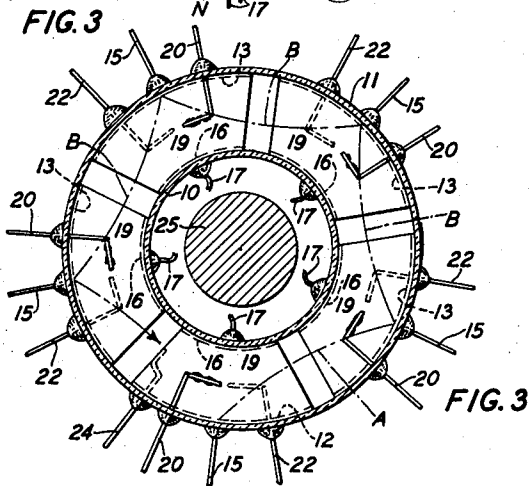
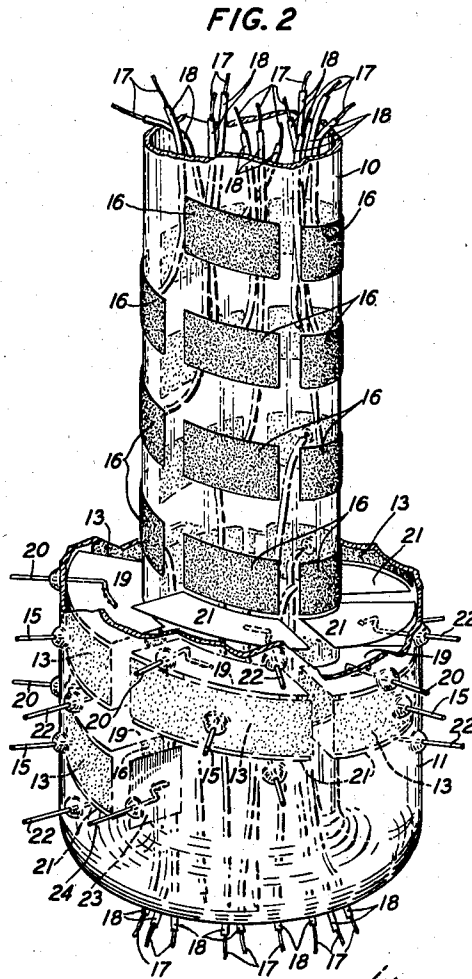
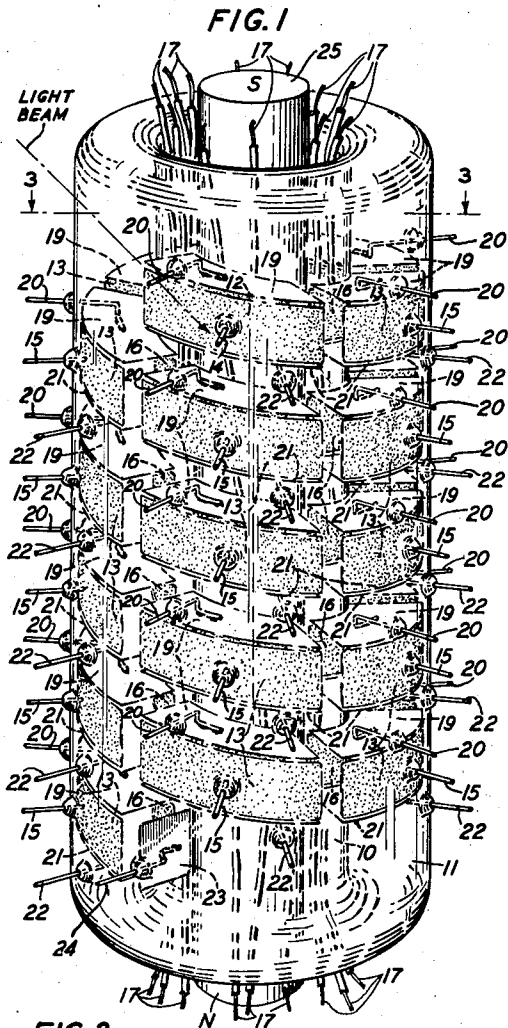
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ELECTRON DISCHARGE DEVICE

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## ELECTRON DISCHARGE DEVICE

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This invention relates to electron discharge devices and more particularly to such devices having a plurality of secondary electron emitting electrodes and commonly known as electron multipliers.

One object of this invention is to expedite the manifold amplification of relatively weak electrical signals.

Another object of this invention is to simplify the construction of electron discharge devices having a multiplicity of electrodes and thereby to facilitate the fabrication of such devices.

A further object of this invention is to improve the efficiency and operating characteristics of electron multipliers.

In one illustrative embodiment of this invention, an electron multiplier comprises a primary cathode, which may be of the photoelectric type, a collector electrode or anode remote from the primary cathode, and a plurality of successively arranged auxiliary electrodes or secondary cathodes between the cathode and the collector electrode and adapted to emit secondary electrons.

In accordance with one feature of this invention, the auxiliary electrodes or secondary cathodes are arcuate members mounted edge to edge and in helical formation, the first of the secondary cathodes being in proximity to the primary cathode and the last in the series of secondary cathodes being in cooperative relation with the collector electrode or anode.

In accordance with another feature of this invention, a second series of auxiliary electrodes is provided, these electrodes also being arranged in helical formation and in juxtaposition to the secondary cathodes. These auxiliary electrodes may be utilized during the operation of the device to provide electrostatic fields assisting in the determination of the trajectories followed by the electrons emanating from the primary and secondary cathodes.

In accordance with still another feature of this invention, means are provided for concentrating the electron streams emanating from the various cathodes and confining the streams to desired paths. In one form such means may comprise a plurality of plate members arranged in pairs at opposite extremities of the cathodes and defining enclosures with the cathodes and the auxiliary or field electrodes.

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 an elevational view in perspective of

an electron discharge device illustrative of one embodiment of this invention;

Fig. 2 is a fragmentary view showing particularly the form and relation of one series of auxiliary electrodes and the association of the leading-in conductors therewith;

Fig. 3 is a view in cross-section along line 3-3 of Fig. 1; and

Fig. 4 is a diagrammatic view showing one illustrative electrical association of the electrodes in the device shown in Fig. 1.

Referring now to the drawing, the electron discharge device illustrated therein comprises an evacuated enclosing vessel having vitreous, inner and outer cylindrical walls 10 and 11 respectively, which preferably are coaxial and substantially coextensive. Mounted upon the inner surface of the outer wall 11 are a primary cathode 12 and a plurality of arcuate, generally rectangular, auxiliary electrodes or secondary cathodes 13 arranged side by side in helical formation and uniformly spaced. Each of the cathodes 12 and 13 may comprise a metallic base or film deposited upon the inner surface of the wall 11 and homogeneously adhering thereto, the inner surface of each base or film being coated or sensitized so that the inner surface of the primary cathode 12 is photoelectrically active and the inner surface of each of the secondary cathodes 13 has good secondary electron emitting properties. For example, the bases or films may be of silver and treated with oxygen and caesium to form on the inner surface thereof a matrix or coating including silver, caesium oxide, and some free caesium.

Electrical connection to the primary cathode 12 may be established through a leading-in conductor 14 sealed in the wall 11 and contacting with the base or film comprising this cathode. Similarly, electrical connection to the secondary cathodes 13 may be established through conductors 15 sealed in the wall 11 and contacting with the secondary cathode bases or films.

Mounted upon the inner cylindrical wall 10 are a series of arcuate, generally rectangular, auxiliary electrodes 16 equal in number to the primary and secondary cathodes and arranged in helical formation. The auxiliary electrodes 16 are spaced in the same relation as the cathodes 12 and 13 so that the first auxiliary electrode 16 is in radial alignment with the primary cathode 12 and each of the other electrodes 16 is in radial alignment with the corresponding one of the secondary cathodes 13. The various electrodes 16 may be constituted by metal films, for example, films of silver, deposited upon the wall 10. If

desired, these films may be sensitized similarly to the films of the secondary cathodes 13 so that they have good secondary electron emitting characteristics. Electrical connection to the auxiliary electrodes 16 may be established through leading-in conductors 17 sealed in the wall 10 and contacting with the films 16. The conductors 17 extend from the ends of the wall 10 and all but the end portions thereof preferably are encased in insulating sleeves 18.

Disposed above each of the corresponding cathodes 12 and 13 and electrodes 16 and co-extensive therewith is an arcuate metallic non-magnetic plate 19, supported by a rigid leading-in conductor 20 sealed in and extending from the outer wall 11, the several plates 19 being substantially parallel to and slightly above the upper edges of the corresponding electrodes. A series of other metallic, non-magnetic plates 21, supported by leading-in conductors 22 sealed in and extending from the outer wall 11, are positioned parallel to the lower edges of the corresponding cathodes 12, 13 and electrodes 16. The plates 21 are substantially coextensive with the cathodes 12, 13 and electrodes 16 and are substantially parallel to the corresponding plate 19. Preferably, as indicated in Fig. 3, each of the plates 19 and 21 extends to immediately adjacent or contacts with the walls 10 and 11 so that the plates together with the cathodes and electrodes 16 define a series of axially aligned enclosures or canals of rectangular section.

An anode or collector electrode 23, which may be a rectangular metallic plate, is mounted adjacent and parallel to one end of the enclosure or canal defined by the lowermost plates 19 and 21 and electrodes 13 and 16, and is supported by a rigid leading-in conductor 24 sealed in and extending from the wall 11.

Extending through the opening defined by the inner wall 10 is a cylindrical bar magnet 25, which is strongly magnetized and produces a strong magnetic field between the inner surfaces of the cathodes 12 and 13 and the auxiliary electrodes 16 and parallel to the longitudinal axis of the enclosing vessel. Preferably the magnet 25 extends an appreciable distance beyond the ends of the enclosing vessel so that a field of substantially uniform intensity is produced throughout the length of the enclosing vessel.

During operation of the device, as indicated in Fig. 4 wherein by way of illustration but five of the sets of electrodes 16 and 12 or 13 are shown, the successive secondary cathodes 13 are operated at uniformly increasing positive potentials with respect to the primary cathode 12. For example, each secondary cathode may be maintained of the order of 50 volts positive with respect to the next preceding cathode. The necessary potentials may be obtained from a potentiometer device 26 connected across a suitable source such as a rectifier 27. Each of the auxiliary electrodes 16 may be connected to the next succeeding cathode so that it is at a positive potential with respect to the cathode in juxtaposition thereto. Corresponding plates 19 and 21 may be maintained at a potential, for example of the order of 5 volts, positive with respect to the cathode corresponding thereto. The collector electrode or anode 23 is maintained positive, for example of the order of 150 volts, with respect to the last of the secondary cathodes 13 through a source, such as a battery 28, in circuit therewith as shown in Fig. 4.

The primary cathode 12 may be energized to

cause the emission of electrons therefrom, by a beam of light emanating from a suitable light source 29 and focussed upon the primary cathode. Under the influence of the magnetic field produced by the magnet 25 and the potentials upon the auxiliary electrode 16 in juxtaposition thereto and the next succeeding secondary cathode 13, the electrons emanating from the cathode 12 will traverse paths such as indicated by the dotted line A in Fig. 3 and flow to and impinge upon the next succeeding cathode. The corresponding plates 19 and 21 serve to focus the electrons and confine them to paths along the center of the enclosures or canals formed by the associated electrodes.

The electrons impinging upon the secondary cathode 13 nearest the primary cathode cause the emission of secondary electrons from this secondary cathode and these electrons are attracted and guided to, and impinge upon the next secondary cathode 13, the secondary electrons traversing paths as indicated approximately by the dotted line B in Fig. 3. The secondary electrons thus liberated flow to and impinge upon the next secondary cathode to cause the emission of other secondary electrons therefrom. Inasmuch as the secondary cathodes are sensitized as described heretofore, the electron current emanating from each of the secondary cathodes is greater than the primary or secondary current flowing thereto. Consequently, in effect, an electron multiplication and an amplification of the original current occurs at each of the secondary cathodes.

The secondary electrons emanating from the last of the secondary cathodes 13 flow to the anode or collector electrode 23 and constitute the output current of the device. The magnitude of this current will be dependent upon the intensity of the light beam focussed upon the primary electrode 12 and will vary in accordance with variations in the intensity of the light beam.

As pointed out heretofore, the auxiliary electrodes 16 may be of such construction as to have good secondary electron emitting characteristics. If desired, these electrodes may be utilized as the cathodes in which case the polarity of the magnet 25 should be opposite to that shown in Fig. 1 and the connections illustrated in Fig. 4 should be changed so that the electrodes 16 are at successively increasing positive potentials and the electrodes 12 and 13 have the relative potentials indicated for the electrodes 16 in Fig. 4.

Although a specific embodiment of the invention has been shown and described, it will be understood, of course, that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electron discharge device comprising a primary cathode, a collector electrode spaced from said cathode, and a plurality of electrically separate, substantially rectangular secondary electrodes mounted side by side and in helical formation between said primary cathode and said collector electrode, said secondary electrodes having corresponding surfaces thereof adapted to emit secondary electrons.

2. An electron discharge device comprising a plurality of arcuate cathodes mounted in helical formation in a cylindrical boundary, a collector electrode, and a plurality of auxiliary electrodes mounted in helical formation in a cylindrical boundary coaxial with said first boundary.

3. An electron discharge device comprising a primary cathode, a collector electrode, a plurality of secondary electron emitting cathodes in cooperative relation with said primary cathode and said collector electrode, each secondary cathode being a segment of a cylinder and said secondary cathodes being mounted end-to-end in spaced relation in helical formation in a cylindrical boundary, and means for focussing the electrons emanating from said primary and secondary cathodes.

4. An electron discharge device comprising a primary cathode, a collector electrode, a plurality of secondary cathodes between said primary cathode and said collector electrode, said secondary cathodes being mounted in helical formation and in a substantially cylindrical boundary, and a plurality of auxiliary electrodes each in juxtaposition to one of said secondary cathodes.

5. An electron discharge device comprising a primary cathode, a collector electrode, a plurality of arcuate secondary cathodes between said primary cathode and said collector electrode, said secondary cathodes being mounted edge to edge in helical formation and in a substantially cylindrical boundary, and a plurality of arcuate auxiliary electrodes, one opposite each of said secondary cathodes and in radial alignment therewith, said auxiliary electrodes lying in a boundary substantially coaxial with said cylindrical boundary.

6. An electron discharge device comprising a primary cathode, a collector electrode, a plurality of electrically separate secondary cathodes between said primary cathode and said collector electrode, mounted in helical formation in a substantially cylindrical boundary, means for producing a magnetic field adjacent said primary and secondary cathodes, and means for producing electrostatic fields adjacent said primary and secondary cathodes.

7. An electron discharge device comprising a primary cathode, a collector electrode, a plurality of arcuate electrodes between said primary cathode and said collector electrode, mounted in helical formation and in a substantially cylindrical boundary, corresponding surfaces of said arcuate electrodes being adapted to emit secondary electrons, means for producing a magnetic field adjacent and parallel to said surfaces, and means including a plurality of electrodes opposite said surfaces for producing electrostatic fields in the vicinity of said surfaces.

8. An electron discharge device comprising a primary cathode, a collector electrode, a plurality of aligned secondary cathodes between said primary cathode and said collector electrode, and a plurality of plate electrodes adjacent opposite sides of said secondary cathodes, at substantially right angles to the surfaces of said secondary cathodes and electrically separate therefrom.

9. An electron discharge device comprising a primary cathode, a collector electrode, a series of arcuate, substantially rectangular secondary cathodes mounted in helical formation and in a substantially cylindrical boundary, and a plurality of pairs of conductive plates, the plates of each pair being mounted adjacent opposite sides of a corresponding one of said secondary cathodes.

10. An electron discharge device comprising two opposed series of electrodes mounted in helical formation in substantially coaxial cylindrical boundaries, the electrodes in one of said series having corresponding surfaces coated with an

electron emitting material, a collector electrode, and means for confining electrons emanating from said surfaces to paths between said two series of electrodes.

11. An electron discharge device comprising a plurality of successively arranged cathodes, a collector electrode, and metallic means adjacent said cathodes, electrically separate therefrom and defining therewith a series of electrically separate aligned enclosures arranged end to end.

12. An electron discharge device comprising a plurality of substantially rectangular cathodes mounted successively and edge to edge, a collector electrode, and metallic means adjacent and electrically separate from said cathodes and defining therewith a series of longitudinally aligned substantially tubular enclosures.

13. An electron discharge device comprising a primary cathode, a collector electrode, a plurality of secondary cathodes mounted in helical formation between said primary cathode and said collector electrode, and a plurality of metallic members adjacent said secondary cathodes and defining therewith a sectionalized substantially helical enclosure.

14. An electron discharge device comprising two equal series of arcuate electrodes mounted in helical formation and in substantially coaxial boundaries, corresponding electrodes in said series being in radial alignment and the electrodes in one of said series of electrodes having the surfaces thereof toward the electrodes of the other series sensitized to be electron emissive, a collector electrode, and a plurality of pairs of plate members, the plate members of each of said pairs being adjacent opposite sides of corresponding arcuate electrodes and defining aligned canals therewith.

15. An electron discharge device comprising a primary cathode, a collector electrode, a plurality of arcuate substantially rectangular secondary cathodes mounted in helical formation between said primary cathode and said collector electrode, said secondary cathodes having corresponding surfaces thereof adapted to emit secondary electrons, a plurality of auxiliary electrodes each opposite the emitting surface of a corresponding one of said secondary cathodes, and field plates adjacent opposite sides of said surfaces.

16. An electron discharge device comprising a pair of cylindrical insulating members, disposed one within the other, a primary cathode, a collector electrode, a series of secondary cathodes mounted upon one of said insulating members, and a series of auxiliary electrodes mounted upon the other of said members and disposed opposite said secondary cathodes.

17. An electron discharge device comprising a pair of coaxial, substantially cylindrical insulating members disposed one within the other, a primary cathode, a series of electrodes mounted upon the outer wall of the inner of said members, and a series of electrodes mounted upon the inner wall of the outer of said members and opposite said first electrodes, the electrodes of one of said series including a metallic deposit upon the wall mounting said one series.

18. An electron discharge device comprising a pair of coaxial, substantially cylindrical insulating members disposed one within the other, a primary cathode, a collector electrode, a plurality of electrodes mounted in helical formation upon a wall of one of said insulating members, each of said electrodes including a metallic film on said wall adapted to emit secondary electrons, and a

plurality of film electrodes upon the wall of the other of said members opposite said plurality of electrodes.

19. An electron discharge device comprising a pair of coaxial, cylindrical insulating members disposed one within the other, a primary cathode, a collector electrode, two series of metallic film electrodes upon opposed walls of said insulating members, mounted in helical formation, the electrodes of one series being adapted to emit secondary electrons, and plate members adjacent corresponding electrodes of said series and extending between said opposed walls.

20. An electron discharge device comprising an enclosing vessel having inner and outer cylindrical walls, a primary cathode and a collector electrode within said vessel, a series of arcuate secondary cathodes mounted in helical formation upon the inner surface of one of said walls, a series of auxiliary electrodes mounted upon the inner surface of the other of said walls and opposite said secondary cathodes, and a magnet within said inner wall.

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