Aug. 26, 1941. F. J. G. VAN DEN BOSCH 2,254,128

ELECTRON MULTIPLIER

Filed June 1, 1939

Fig.1.

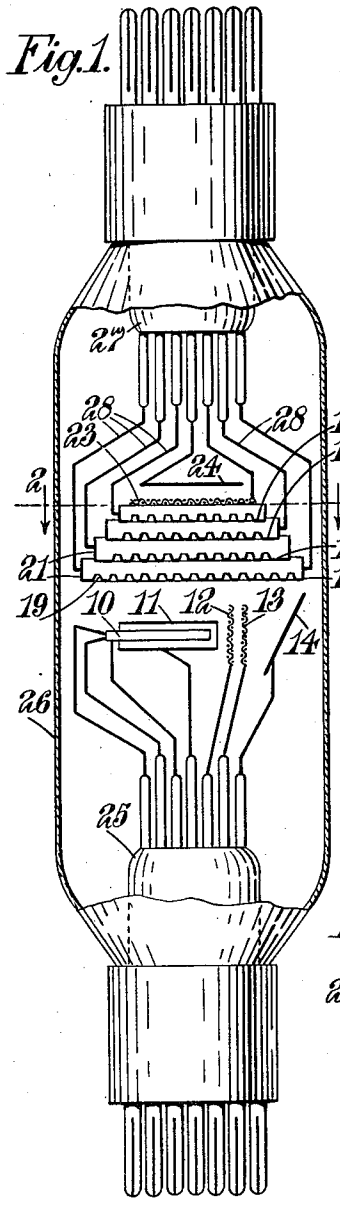


Fig.3.

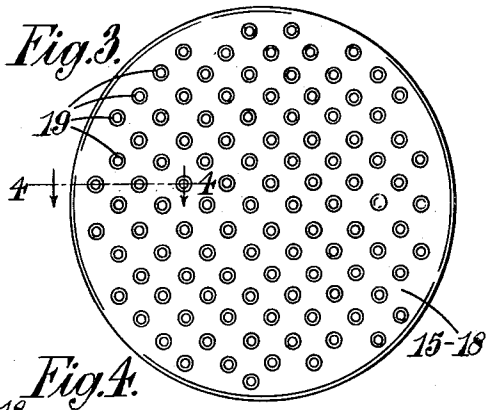


Fig.4.

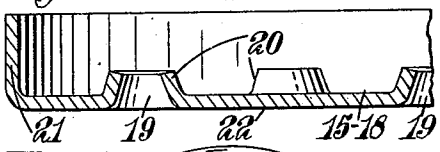


Fig.5

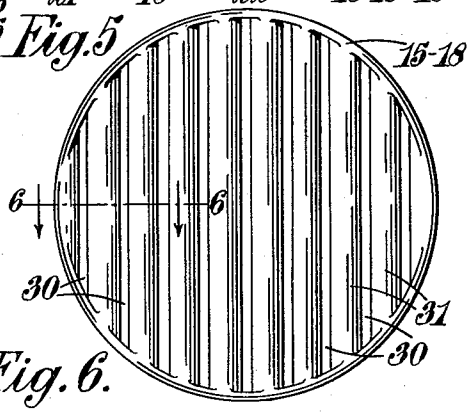


Fig.6.

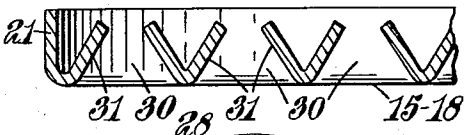
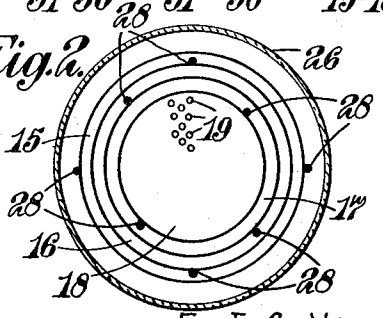


Fig.2.



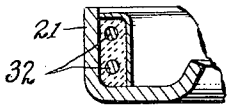


Fig.7.

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ELECTRON MULTIPLIER

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9 Claims. (Cl. 250—175)

This invention relates to electron-multipliers comprising an electron-emitting cathode, one or more secondary electron-emitting electrodes arranged in an envelope in such manner that electrons emitted by the cathode are caused to impinge on a secondary electron-emitting electrode and liberate other electrons which impinge upon the next secondary electron-emitting electrode, when more than one, and so on, to a final collector.

According to a feature of this invention there is provided an electron-multiplier having one or more secondary electron-emitting electrodes each of which is formed of a perforated metal plate.

According to another feature of the invention there is provided an electron-multiplier comprising one or more secondary electron-emitting electrodes each of which has holes for the passage of electrons, which holes are bounded by a wall, of which at least a part on which approaching electrons impinge is inclined to the path of these approaching electrons. Preferably, the holes are of diminishing cross-section in the direction of travel of the electrons.

Another feature of the invention consists in the provision of a plurality of secondary electron-emitting electrodes arranged one behind the other in spaced relationship and preferably the holes are staggered in successive secondary electron-emitting electrodes.

One specific embodiment of electron-multiplier according to the invention is shown by way of example in the accompanying drawing, in which:

Figure 1 is a diagrammatic elevation of the multiplier;

Figure 2 is a section on line 2—2 of Figure 1;

Figure 3 is a front view of a secondary electron-emitting electrode on an enlarged scale;

Figure 4 is a section on line 4—4 of Figure 3;

Figure 5 is a front view of a modified form of secondary electron-emitting electrode;

Figure 6 is a section on line 6—6 of Figure 5, and,

Figure 7 is a detail view showing the provision of a heater for the secondary electron emitting electrode.

Referring to the drawing, there is shown a source of primary electrons consisting of a cathode 10. For the control of the primary electrons there is provided a cylindrical electrode 11 around the cathode and a control grid 12 extending across but spaced from an open end of the cylindrical electrode 11. An accelerator grid 13 is arranged at that side of the control grid 12 remote from the cathode and a reflector 14 is provided for changing the direction of the primary electrons towards the secondary electron-emitting electrodes. In the example shown there are four such electrodes indicated at 15, 16, 17 and 18. The secondary electron-emitting electrodes each consist of a disc formed of sheet metal, preferably nickel, coated at the front surface 22 with silver and having a silver oxide outer layer coated with oxide of cesium or other alkali metal. These electrodes are provided with a plurality of holes 19. The holes are conveniently formed by a punching operation such that the metal bounding each hole is deformed to form a conical wall 20 for the hole. The construction is such that the area of the hole at the front of the electrode is greater than the area of the hole at the rear of the electrode, for example, in the proportion of approximately 5:3. The holes, considered according to their largest dimension, may occupy about 15 percent of the area of the electrode.

The secondary electron-emitting electrodes are mounted in parallel relationship one behind another so that the holes in them are of decreasing area in the direction of travel of electrons. The electrodes are also arranged with the holes in them staggered with respect to those of an adjacent electrode. Each of the secondary electron-emitting electrodes has a peripheral flange 21 extending rearwardly of the electrode and the electrodes 15, 16, 17 and 18 are progressively smaller in diameter so that they nest one within the other with the flange of one electrode surrounding the space between that electrode and the next.

Close to the secondary electron-emitting electrode 18, for example, about ½ mm. from it, there is a collecting electrode 23 constructed as a wire grid or mesh and at the remote side of this collector electrode there is a final secondary electron-emitting electrode 24. The cathode 10, associated electrodes 11, 12 and 13 and reflector 14 are carried in a pinch 25 mounted in one end of an envelope 26 and the collector electrode 23 and secondary electron-emitting electrodes are carried in another pinch 27 mounted in the opposite end of the envelope 26. The connections 28 to the electrodes 15, 16, 17 and 18 indicated in Figure 2 are distributed around the periphery of these electrodes and are spaced apart in the pinch 27 in order to minimise the inter-electrode capacity. In use of the electron-multiplier

progressively increasing positive potentials with respect to the cathode 10 are applied to the secondary electron-emitting electrodes 15, 16, 17, 18 and 24 and the collector 23. Primary electrons from the cathode 10 are directed on to the first secondary electron-emitting electrode 15 under the control of the electrodes 11, 12 and 13 and liberate secondary electrons which pass through the holes in this electrode to the next secondary electron-emitting electrode 16, and so on, to the final secondary electron-emitting electrode 24. The secondary emission from this electrode 24 is received on the collector 23, from which the output is taken. The flanges 21, because they have the same operating potential as the electrodes of which they form part, and extend rearwardly of these electrodes towards the next electrode of higher potential, constitute electrostatic focussing means serving to concentrate the electrons in a beam through the secondary electron-emitting electrodes towards the collector 23.

Electrons travelling towards a secondary electron-emitting electrode impinge upon the inclined or conical surfaces 20 constituted by the walls forming the holes of the secondary electron-emitting electrodes and thus strike the electrode at an angle well suited for the production of secondary electrons and for the liberation of these electrons in a direction through the holes towards the next electrode. Instead of employing as the secondary electron-emitting electrodes, discs formed with a plurality of holes as described with reference to Figures 3 and 4, they may be constituted by discs of the form shown in Figures 5 and 6. In this alternative construction the electrode consists of a metal disc formed with a plurality of narrow slots 30. These slots are conveniently produced by a punching operation, displacing the metal to provide the slots in such a manner as to produce inclined walls 31 for the same purpose as the conical surfaces 20 of the construction described with reference to Figures 2 and 3.

In order to assist the liberation of secondary electrons from the electrodes 15 to 18 indirect heating means may be provided for these electrodes to raise them in temperature but not sufficiently high to produce appreciable primary emission. For this purpose the electrodes may be indirectly heated by means of a heater coil 32 as shown in Figure 7 carried on the flange 21.

It will be understood that the invention is not restricted to the specific embodiments hereinbefore described and in particular, a transparent or apaque photo-electric cathode may be used instead of a thermionic cathode. Moreover, electrodes for performing other electronic functions may be incorporated in the envelope in addition to the electrodes for obtaining electron multiplication.

I claim:

1. An electron multiplier comprising a primary cathode, a secondary electron-emitting electrode for emitting secondary electrons under bombardment by other electrons and having holes for the passage of electrons, and a collector electrode for the secondary electrons, which holes are each bounded by a wall of which a part on which approaching electrons impinge is inclined to the path of the approaching electrons.

2. An electron multiplier comprising a primary cathode, a secondary electron-emitting electrode for emitting secondary electrons under bombardment by other electrons, which secondary electron-emitting electrode is formed with holes for the passage of electrons and diminishing in cross-section in the direction of travel of the secondary electrons and a collector electrode for the secondary electrons.

3. An electron multiplier comprising a primary electron-emitting electrode, a plurality of secondary electron-emitting electrodes mounted one behind another and spaced progressively from said primary electron-emitting electrode, which secondary electron-emitting electrodes are formed with holes for the passage of electrons, a final collector electrode for the secondary electrons, which secondary electron-emitting electrodes are progressively smaller in size in the direction of travel of electrons, and are each provided with a peripheral flange extending therefrom to surround the space between the electrode and the next following smaller electrode.

4. An electron multiplier comprising a primary electron-emitting electrode, a plurality of secondary electron-emitting electrodes mounted one behind another and spaced progressively from said primary electron-emitting electrode, which secondary electron-emitting electrodes are formed with holes for the passage of electrons, a final collector electrode for the secondary electrons, which secondary electron-emitting electrodes are each provided with a peripheral flange extending therefrom to surround the space between the electrode and the next following electrode, and means provided on the flange of each secondary electron-emitting electrode to indirectly heat the electrode to assist the secondary emission.

5. An electron multiplier comprising a primary electron-emitting electrode, a plurality of secondary electron-emitting electrodes mounted one behind another and spaced progressively from said primary electron-emitting electrode, which secondary electron-emitting electrodes are formed with holes for the passage of electrons, a final collector electrode for the secondary electrons, which secondary electron-emitting electrodes are progressively smaller in size in the direction of travel of electrons and are each provided with a peripheral flange extending therefrom to surround the space between the electrode and the next following smaller electrode, and means carried on the flange of each secondary electron-emitting electrode for indirectly heating the electrode to assist the secondary emission.

6. An electron multiplier comprising a primary cathode, a secondary electron-emitting electrode for emitting electrons under bombardment by other electrons, which secondary electron-emitting electrode is formed with holes for the passage of electrons and diminishing in cross-section in the direction of travel of the secondary electrons, which holes according to their largest dimension occupy approximately 15 per cent of the area of the electrode in which they are situated, and a collector electrode for the secondary electrons.

7. An electron multiplier comprising a primary cathode, a secondary electron-emitting electrode for emitting electrons under bombardment by other electrons, which secondary electron-emitting electrode is formed with holes for the passage of electrons and diminishing in cross-section in the direction of travel of the secondary electrons, which holes are approximately 1 mm. deep and the proportion of the area of the top of the hole to the area at the bottom of the hole

is approximately 5:3, and a collector electrode for the secondary electrons.

8. An electron multiplier comprising a primary cathode, a secondary electron-emitting electrode for emitting electrons under bombardment by other electrons, which secondary electron-emitting electrode is formed with holes for the passage of electrons, which holes are in the form of narrow slots extending across the electrode and diminishing in cross-section in the direction of travel of the secondary electrons and a collector for the secondary electrons.

9. An electron multiplier comprising a primary electron-emitting electrode, a plurality of secondary electron-emitting electrodes spaced progressively from said cathode, a collecting electrode positioned close to the final one of said secondary electron-emitting electrodes on that side thereof remote from said primary cathode, which secondary electron-emitting electrodes consist of perforated metal discs of progressively decreasing diameter towards said collecting electrode, said discs being each provided with a rearwardly extending focussing flange surrounding the space between the electrode and the next following electrode.

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