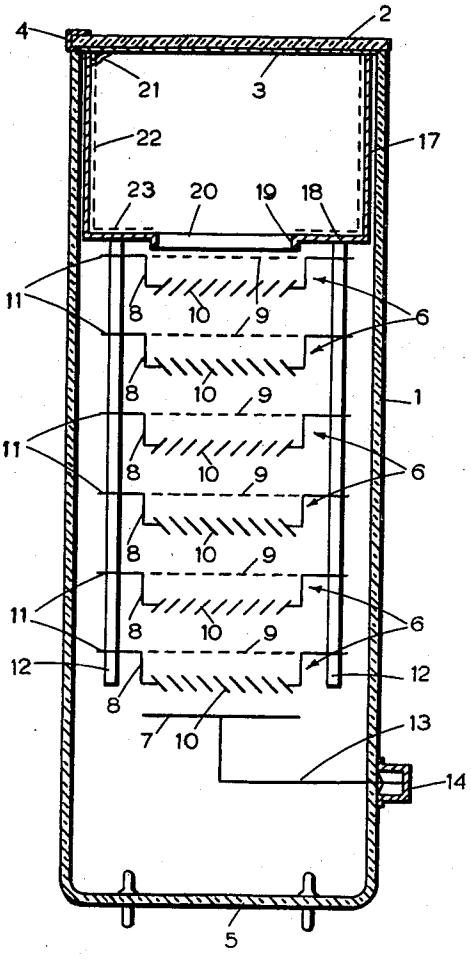
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PHOTO-EMISSIVE DEVICES

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PHOTO-EMISSIVE DEVICES

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This invention relates to photo-emissive devices such as photo-electric multipliers.

In photo-electric multipliers so-called dark current that is current which is not directly dependent upon incident light, is a well known disadvantage and is produced in various ways. One source of dark current is by thermionic emission in the device. In an ideal photo-electric multiplier the only dark current would be thermionic emission from the photo-emissive cathode. However, in photo-electric multipliers as at present constructed dark current due to thermionic emission arises not only from the photo-emissive cathode but also from surfaces near the photo-emissive cathode which become photo-emissive during the manufacture of the photo-emissive cathode.

The object of the present invention is to provide an improved photo-emissive device with a view to reducing the flow of dark current from such a surface and according to the invention there is provided a photo-emissive device having a photo-emissive cathode, a receiving electrode and a surface capable of giving rise to dark current due to electron emission therefrom, in which a foraminated electrode is provided in said device, so disposed relatively to said surface that the flow of said dark current from said surface to said receiving electrode is reduced without substantially impeding the flow of electrons from said cathode to said receiving electrode.

The receiving electrode may be any suitable surface which is intended to receive electrons from the photo-emissive cathode and may for example be the first dynode of an electron multiplier, and said surface may be a surface of a shield electrode for said first dynode. Said foraminated electrode may be similar in shape to the shape of the surface which is capable of giving rise to dark current and may be spaced therefrom by a small distance and may normally be at the same potential as said surface or preferably at a negative potential with respect thereto as a result of contact potential differences.

In order that the invention may be clearly understood and readily carried into effect it will now be more fully described with reference to the accompanying drawing which illustrates in section a photo-electric multiplier in accordance with the invention.

The photo-electric multiplier shown in the drawing comprises an evacuated substantially cylindrical glass envelope 1, having at one end a substantially flat transparent glass end wall 2 on the inner surface of which is provided a photo-electron emissive cathode 3. Electrical connection to the cathode 3 is provided by means of a contact member 4 which is hermetically sealed between the end wall 2 and the cylindrical envelope 1. The other end of the envelope 1 is closed by a contact carrying base 5.

Within the evacuated envelope 1 between the cathode 3 and base 5 are arranged a plurality of secondary electron emitting dynodes 6, six such dynodes being shown, and an electron collecting electrode 7, disposed on the side of said dynodes 6 remote from the cathode 3. Each dynode 6 comprises a box-like structure 8 the side of said dynode 6 facing the cathode 3 being covered by a wire mesh 9, and the other side of said dynode 6 having a plurality of obliquely disposed louvres 10. Each dynode 6 is provided with flanges 11 whereby a plurality

of dynodes can be assembled as a unitary structure by means of insulating supporting rods 12 as shown, the louvres 10 of adjacent dynodes 6 being arranged to be oppositely inclined. Although in the drawing six dynodes 6 are shown it will be appreciated that the number provided may be varied for different tubes depending, for example, upon the degree of amplification required. The collecting electrode is, in the device shown, supported by an arm 13 sealed through the wall of the envelope 1 and electrically connected to a contact cap 14. Arranged between the cathode 3 and the first dynode 6 is a cylindrical shield electrode 17 supported by the rods 12. The shield electrode 17 is of cylindrical form having a diameter slightly less than the internal diameter of the envelope 1 and extending substantially from the cathode 3 to said first dynode 6. The end of the electrode 17 adjacent the dynodes has an inwardly projecting flange 18 having a lip 19 which defines a substantially central circular aperture 20 to allow electrons from the cathode 3 to pass to the first dynode 6. The electrode 17 is maintained at the potential of the cathode 3 by means of an internal strap 21.

In operation of the device the dynodes 6 and collecting electrode 7 are maintained at increasing potentials positive with respect to the cathode 3 so that when light is incident on said cathode 3, photo electrons emitted thereby impinge on the first dynode 6 to cause secondary electrons to be emitted which in turn impinge on the second dynode 6, and so on, the secondary electrons emitted by the last dynode 6 being collected by the collecting electrode 7. During operation the electrostatic field conditions set up by virtue of the electrode 17 between the cathode 3 and the first dynode 6 are such that a substantially uniform withdrawal of electrons from the whole of the surface area of the cathode 3 is obtained.

In manufacturing the photo electron emissive cathode 3 electron-emissive material is deposited on the end wall 2 and the shield electrode 17 frequently also has some electron-emissive material deposited thereon and hence is rendered electron-emissive. The shield electrode 17 thus consitutes a source of dark current. In order to reduce the flow of dark current from the shield electrode 17 a cylindrical foraminated electrode 22 is provided spaced slightly from the interior surface of the shield electrode 17. This foraminated electrode 22 is provided inside the shield electrode 17 prior to the formation of the cathode 3. Said foraminated electrode may be a mesh of close weave but high transparency such as one having over 90 percent transparency, for example about 93 percent transparency, such a mesh being made for example from wire 0.002" in diameter with 30 bars per inch, and may be attached to the interior surface of the shield electrode 17 by the provision of stand-off wires which are welded to the interior of the shield electrode 17 so that the mesh is in proximity to said surface, the gap therebetween being for example, ⅛ inch. The foraminated electrode 22 may be provided with an inwardly projecting lip 23 as shown which lies over the inwardly projecting flange 18 of the shield electrode 17. Without the provision of the foraminated electrode 22 electrons constituting dark current from the shield electrode 17 would be collected by the positive field of the first dynode 6 but the provision of the foraminated electrode 22 which may be at the same potential as the shield 17 i.e. at cathode potential removes the positive field from the shield electrode 17 leaving the field only on the foraminated electrode 22 which is a much smaller area. During manufacture both the foraminated electrode 22 and the shield electrode 17 probably become thermionic emitters and since the field from the first dynode 6 is cut off from the shield electrode 17 by the foraminated electrode 22, thermionic electrons from the

shield electrode 17 are not collected by the first dynode 6. Some emission may still, however, occur from the foraminated electrode 22 and a few high energy electrons may leave the shield electrode 17 also.

It is preferred so to choose the metals of the shield electrode 17 and the foraminated electrode 22 so that due to contact potential differences the foraminated electrode 22 is at a negative potential with respect to the shield electrode 17. With the use of the invention it is found that some photo-electric multipliers have had dark currents of 0.0025 μamp. compared with similar multipliers in which no foraminated electrode has been provided which have a typical dark current of 0.01 μamp.

In one practical embodiment of the invention the foraminated electrode 22 comprises stainless steel wire woven as a mesh and the shield 17 is formed of nickel. The electrode 22 is mounted on a frame comprising four wire struts to which is secured three spaced almost complete wire loops and this frame is spaced from the shield electrode 17 by three rectangular metal strips which are secured to both the mesh supporting frame and the electrode 17. Both the electrode 17 and the foraminated electrode 22 are provided with a longitudinal slot so as to prevent undue heating of these members by induced currents when other parts of the device are eddy current heated during processing.

With a device just described a count of thermionic electrons from a 2 inch diameter of cathode was less than 3 per square centimetre second at 20° centigrade whereas in a similar device not provided with the electrode 22 the count was 10 per square centimetre-second.

Although the invention has been described with particular reference to its application to the photo-electric multiplier shown in the drawing it is applicable to other photo-emissive devices in which dark current due to thermionic emission from surfaces other than the required photo-emissive surface may occur.

What I claim is:

1. A photo-emissive device, a photo-emissive cathode in said device, a receiving electrode for electrons, a surface around the path of electrons from said cathode to said receiving electrode and capable of emitting electrons which give rise to dark current, and a foraminated electrode disposed in a path from said surface to said receiving electrode but not substantially in the path of electrons from said cathode to said receiving electrode so that the flow of dark current from said surface is reduced.

2. A photo-emissive device, a photo-emissive cathode in said device, a receiving electrode for electrons, a surface around the path of electrons from said cathode to said receiving electrode and capable of emitting electrons which give rise to dark current, a foraminated electrode disposed in a path from said surface to said receiving electrode but not substantially in the path of electrons from said cathode to said receiving electrode, connections to said foraminated electrode and said surface for maintaining said foraminated electrode and surface at the same potential, so that the flow of dark current from said surface is reduced.

3. A photo-emissive device, a photo-emissive cathode in said device, a dynode electrode of an electron multiplying arrangement for receiving electrons, a surface around the path of electrons from said cathode to said dynode electrode and capable of emitting electrons which give rise to dark current, and a foraminated electrode disposed in a path from said surface to said dynode electrode but not substantially in the path of electrons from said cathode to said dynode electrode so that the flow of dark current from said surface is reduced.

4. A photo-emissive device, a photo-emissive cathode in said device, a dynode electrode of an electron multiplying arrangement for receiving electrons, a shield electrode around the path of electrons from said cathode to said dynode electrode and having a surface capable of emitting electrons which give rise to dark current, and a foraminated electrode disposed in a path from said surface to said dynode electrode but not substantially in the path of electrons from said cathode to said dynode electrode so that the flow of dark current from said surface is reduced.

5. A photo-emissive device, a photo-emissive cathode in said device, a dynode electrode of an electron multiplying arrangement for receiving electrons, a cylindrical shield electrode extending between said cathode and dynode electrode around the path of electrons from said cathode to said dynode electrode, the internal surface of said shield electrode being capable of emitting electrons which give rise to dark current, an inwardly projecting flange of said shield electrode at the end of said shield electrode adjacent said dynode electrode, and a foraminated electrode disposed close to and within said shield electrode in a path from said surface to said dynode electrode but not substantially in the path of electrons from said cathode to said dynode electrode so that the flow of dark current from said surface is reduced.

6. A photo-emissive device, a photo-emissive cathode in said device, a receiving electrode for electrons, a surface around the path of electrons from said cathode to said receiving electrode and capable of emitting electrons which give rise to dark current and a foraminated electrode which conforms in shape to the shape of said surface and is disposed in a path from said surface to said receiving electrode but not substantially in the path of electrons from said cathode to said receiving electrode so that the flow of dark current from said surface is reduced.

7. A photo-emissive device, a photo-emissive cathode in said device, a receiving electrode for electrons, a surface around the path of electrons from said cathode to said receiving electrode and capable of emitting electrons which give rise to dark current and a mesh electrode disposed in a path from said surface to said receiving electrode but not substantially in the path of electrons from said cathode to said receiving electrode so that the flow of dark current from said surface is reduced.

8. A device according to claim 7, said mesh having a transparency of at least 90 percent.

9. A device according to claim 7, said mesh being made from wire of 0.002 inch diameter and having thirty bars per inch.

10. A photo-emissive device, a photo-emissive cathode in said device, a receiving electrode for electrons, a surface around the path of electrons from said cathode to said receiving electrode and capable of emitting electrons which give rise to dark current, a foraminated electrode disposed in a path from said surface to said receiving electrode but not substantially in the path of electrons from said cathode to said receiving electrode, and stand off wires secured to said foraminated electrode and said surface, so that the flow of dark current from said surface is reduced.

11. A photo-emissive device, a photo-emissive cathode in said device, a receiving electrode for electrons, a surface around the path of electrons from said cathode to said receiving electrode and capable of emitting electrons which give rise to dark current, and a foraminated electrode disposed in proximity to said surface in a path from said surface to said receiving electrode but not substantially in the path of electrons from said cathode to said receiving electrode so that the flow of dark current from said surface is reduced.

12. A device according to claim 11 in which said foraminated electrode is spaced from said surface by ⅛ inch.

13. A photo-emissive device, a photo-emissive cathode in said device, a receiving electrode for electrons, a surface around the path of electrons from said cathode to said receiving electrode and capable of emitting electrons

which give rise to dark current, a foraminated electrode disposed in proximity to said surface in a path from said surface to said receiving electrode but not substantially in the path of electrons from said cathode to said receiving electrode, and said surface and foraminated electrode being made of such materials that the foraminated electrode is at a negative potential with respect to said surface due to contact potential differences.

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