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SECONDARY ELECTRON DISCHARGE TUBE

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Fig. 1

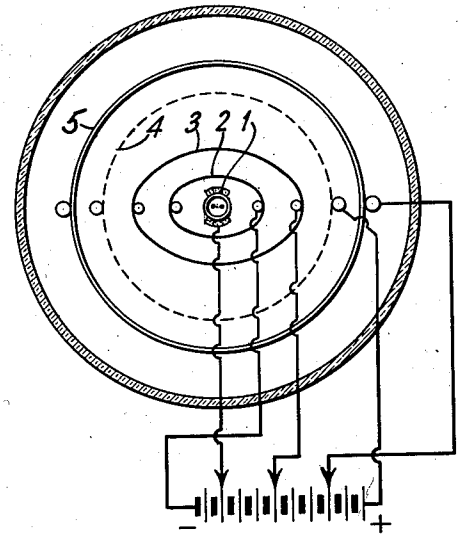
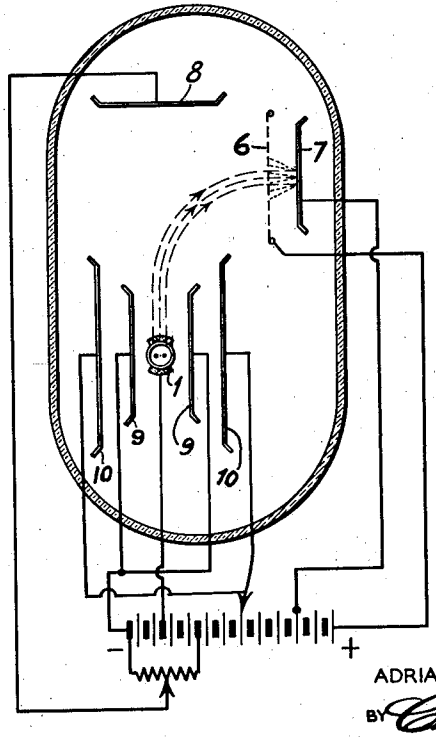


Fig. 2



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SECONDARY ELECTRON DISCHARGE TUBE

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4 Claims. (Cl. 250—174)

The invention relates to electron discharge tubes, and more particularly to discharge tubes in which the electrons emanating from the cathode may strike an electrode, hereinafter referred to as a secondary emission electrode, having a surface of such properties that it can readily emit secondary electrons.

The principal object of this invention is to provide an improved tube of this type having long life and other advantages.

In accordance with our invention, a tube having at least a cathode, one or more control elements, an anode and a secondary emission electrode is constructed in such a way that the latter electrode is not affected by active material which may vaporize from the primary cathode, or so that such vaporization is reduced to a minimum. A great deal of work on this subject indicates that the disadvantages which appeared in the use of the previously known tubes having a secondary electron emission electrode may be due to active material, such as barium, caporizing from the primary cathode, reaching the secondary emission electrode, and causing reduction of the secondary electron emission from the secondary emission electrode, which is activated by any of the materials used for this purpose, such as caesium oxide where the electrode operates at low temperature.

In one embodiment of the invention the cathode of a discharge tube which contains, in addition, one or more grids, an anode, and a secondary emission electrode, is so dimensioned that at the normal operating voltage the cathode is substantially nonvaporizing, as the maximum temperature of the hottest points of the cathode does not exceed 700° C., with the result that vaporization of the active material from the cathode is either absent or present to only a very slight extent so that the secondary emission electrode may have a long life. It has proved to be advantageous to utilize, in combination with such an arrangement, an indirectly heated cathode wherein the surface of the cathode has a very uniform temperature, which may be obtained by utilizing a thick cathode, or by making the cathode of less diameter at the ends than in the middle, or by winding the heater coil with a varying pitch. Vaporization of the active material of the primary cathode may also be made negligible by making the indirectly heated cathode elongated, with no emitting material on those parts of the surface which participate only slightly or not at all in the primary emission; for example, those parts which are located immediately opposite the grid supports.

In one particular embodiment of the present invention the cathode consists at least partly of copper or a copper alloy, materials which have, as is well-known, a satisfactory thermal conductivity, and in another embodiment, the primary cathode utilizes an emitting material which vaporizes only at a comparatively high temperature; for example, a mixture of barium oxide and strontium oxide containing at least 80% by weight of strontium oxide.

In order to achieve the object of the invention, it is not always necessary to treat the primary cathode and, according to one embodiment of the invention, the conditions may be so chosen that during operation the temperature of the secondary emission electrode becomes higher than normal, if the secondary emission electrode is kept as hot as feasible without causing primary electron emission from it; for example, 500° C. It has been found that the life of such a tube may be lengthened, probably because barium which vaporizes from the primary cathode and which strikes the hot secondary emission electrode becomes oxidized and does not lower the secondary electron emissivity of the secondary emission electrode. The activating material for the hot secondary emission electrode may be a material known for this purpose, such as barium oxide, magnesium oxide, and the like.

A discharge tube according to the invention may also be made with the secondary emission electrode mounted in the tube in such manner that it cannot be struck by particles which are vaporized or sputtered from the cathode and which move in a straight line from the cathode to said electrode, so that any barium which may vaporize from the primary cathode cannot by following a straight line path reach directly the secondary electrode. This object may be achieved by utilizing a tube construction in which, for example, the secondary emission electrode is shielded from the cathode by being mounted behind a solid shield or electrode so that particles from the cathode cannot follow straight paths to the secondary emission electrode, and the electron stream must be caused, by the aid of either electrostatic or magnetic fields, to flow along a curved path from the primary cathode in order to reach the secondary emission electrode.

The invention will be explained more fully with reference to the accompanying drawing wherein—

Figure 1 shows diagrammatically and in cross

section a discharge tube in which the electrodes are arranged according to the present invention wherein electrons from a non-vaporizing primary cathode move in a straight line to the secondary emission electrode; and

Figure 2 shows diagrammatically a form of construction wherein the electrons are directed to the secondary emission electrode along curved paths.

The tube shown in Figure 1 of the drawing has an indirectly heated oxide coated cathode 1, comprising a tubular cathode inside of which is an insulated heater, coaxial with the cathode is a control grid 2, screen grid 3, and a grid-like tubular anode 4, which is surrounded by a coaxial tubular electrode or emitter 5 having a surface of such properties that when bombarded by primary electrons it easily liberates secondary electrons in a ratio to the primary electrons which is greater than unity. As indicated in the drawing, those portions of the cathode in register with the grid rods or with corresponding portions of other electrodes are uncoated and therefore non-emissive.

In a discharge tube as shown in Figure 1 the secondary emission electrode may be prevented from being affected by active material which may vaporize from the primary cathode by ensuring that at the operating temperature of the cathode this material does not vaporize at all or only to a very slight extent. This result may be achieved, for example, with an indirectly heated cathode in which the surface of the cathode amounts to about 1.36 cm^2, while the heating energy of this cathode, calculated from the values indicated for the heating current and the heating voltage, is 1.64 watts. It has been found that the temperature of such a cathode made of nickel coated with a mixture of barium oxide and strontium oxide, and having a heater surrounded by insulation, amounts during operation to about 700° C. If the coating mixture consists of about 20% barium oxide and about 80% strontium oxide, the vaporization from the cathode is negligible at this temperature.

In the modified tube structure shown in Figure 2 the electron stream originating at the cathode flows in opposite directions along curved paths, indicated by arrows, to reach the grid-like anode 6 with a secondary emitter 7 mounted behind it and out of alignment with the direction of flow of the electron stream from the cathode, so that the emitter cannot be reached by particles which are driven off from the cathode and move in straight lines from the cathode toward the emitter. In this particular construction an auxiliary electrode 8 in alignment with the initial direction of flow of the electron stream acts in conjunction with the other electrodes to produce an electrostatic field which causes the electron stream to follow the curved paths to the anode 6 and emitter 7. It is obvious that the electron stream could also be directed along curved paths by the conjoint action of electrostatic and magnetic fields, as well known in the art. The electron discharge from the cathode is concentrated into a modulated stream directed toward the anode by a duplex control element 9 and a duplex accelerating electrode 10, each of which consists of two plane parallel solid metal sheets mounted on opposite sides of the cathode and spaced to permit an unobstructed flow of electrons toward the auxiliary electrode 8. The control element 9 and accelerating electrode 10 form a kind of electron gun for producing an electron stream which is directed toward the auxiliary electrode 8, but is constrained to follow a path which curves past the end of the accelerating electrode to the anode and to the emitter 7. The solid sheet accelerating electrode 10 shields the emitter 7 from particles driven off from the cathode, and thus the life of the tube is prolonged and its properties preserved.

We claim:

1. An electron discharge tube comprising a thermionic cathode, an apertured anode, a secondary electron emission electrode behind said anode, an imperforate sheet element between said cathode and said electrode positioned to intercept all particles moving in straight lines from any point on said cathode toward said electrode, and an auxiliary electrode positioned to cooperate with said cathode and anode to direct an electron stream from said cathode past the end of said element and through said anode to said electrode.

2. An electron discharge tube comprising an accelerating electrode comprising a pair of parallel flat metal sheets spaced to leave a straight channel between them, a cathode between said metal sheets and in said channel, an auxiliary electrode positioned in alignment with the channel between said metal sheets to leave an unobstructed gap between said auxiliary electrode and the ends of said metal sheets, an apertured anode out of alignment with said channel and opposite said gap, and a secondary emission electrode behind said anode and shielded from said cathode by said accelerating electrode.

3. An electron discharge device comprising a thermionic cathode, means for concentrating the electron discharge from said cathode into an electron beam directed along a straight path near said cathode, an apertured anode mounted out of alignment with the straight portion of said beam near said cathode, a secondary electron emission electrode having high secondary electron emissivity mounted behind said anode, and an auxiliary electrode extending from a point in alignment with the straight portion of the beam to a point adjacent said anode for bending said electron beam to direct the portion remote from said cathode through said anode to said secondary electron emission electrode.

4. An electron discharge device comprising a thermionic cathode, an emitter anode having a high coefficient of secondary electron emission, means for directing a primary electron stream from said cathode to said emitter, a grid-like output anode adjacent and in front of said emitter anode and extending across the path of said electron stream to said emitter anode, and a shield interposed between said cathode and said emitter anode in position to prevent impingement upon said emitter anode of particles ejected from said cathode.

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