My invention relates to electric discharge devices and more particularly to light-sensitive electric discharge devices.

It is an object of my invention to provide a new and improved electric discharge device and electrode structure therefor. It is another object of my invention to provide a new and improved light-sensitive or photoemissive type electric discharge device.

It is a further object of my invention to provide a new and improved light-sensitive electric discharge device comprising a photo-emissive electrostatic control member and an improved shielding structure associated with a thermionic cathode and the associated control member.

Briefly stated, in the illustrated embodiment of my invention, I provide a new and improved light-sensitive electric discharge device of the controlled type in which the electrodes are enclosed within an atmosphere of an ionizable medium, such as an inert gas, and in which a photo-emissive electrostatic control member is thermally shielded and light-shielded from the thermionic cathode, thereby increasing the life of the control member and rendering the control member substantially unaffected by the light and the heat incident to the cathode.

In accordance with a further feature of my invention, I provide in an electric discharge device a new and improved heat-shielding structure of particular configuration which not only serves to shield the control member but also affords a satisfactory communicating path for the establishment of an electric discharge or an arc discharge between the cathode and anode.

In a still further feature of my invention I provide in a light-sensitive electric discharge device an arrangement which permits the use of the discharge device under those conditions where there is a tendency to cause condensation and solidification of moisture on the outside of the tube structure.

For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims. Figs. 1 and 2 represent, respectively, a front and a back view of a light-sensitive electric discharge device employing certain features of my invention, and Fig. 3 is an exploded view of the photo-emissive electrostatic control member and the heat shield structure. Fig. 4 is a top sectional view of the electric discharge device shown in Figs. 1 and 2, and Fig. 5 diagrammatically illustrates a circuit arrangement to which my invention may be applied.
by prongs or conductors 13 and 14 supported by base 3. Cathode 8 is provided with a lower supporting member or wire 15 which is connected to an externally accessible conductor or prong 16 through a conductor 17 which is embedded and sealed in the glass press 2.

A suitable support for a photo-sensitizing material, such as caesium or the equivalent, may be provided, such as a pocketed disk 18, which may be attached to one of the electrodes such as anode 4. A photo-emissive electrostatic control member 19 is positioned in spaced relation between the anode 4 and cathode 8 and has a substantially greater area than either the anode 4 or the cathode 8. Preferably, the electrostatic control member 19 may be of semi-cylindrical configuration as illustrated in Fig. 3, and is arranged so that its principal or longitudinal axis is substantially parallel with the axes of the anode 4 and cathode 8. In addition, the photo-emissive control member 19 is arranged preferably to be concave with respect to anode 4 and convex with respect to cathode 8, and to have the surface facing the anode 4 photo-sensitive in nature, that is coated with a substance such as an alkali metal, or oxide thereof, which emits appreciable quantities of electrons in response to the impingement of light thereon. For example, the surface of the control member 19 facing the anode 4 may be coated with antimony and caesium. This coating may be placed upon the metallic surface of the control member 19 the body of which may be constructed of nickel.

As to the method of making the photo-sensitive electrostatic control member 19, the body or base thereof may be formed of nickel having a film of an oxide thereon, the latter of which may be produced by raising the temperature of the nickel in an atmosphere containing an appreciable content of oxygen. Antimony is then deposited or subcooled on the oxide film. The electric discharge device is then assembled, the caesium being placed in a support, such as 18 shown in Fig. 1, and after the evacuation and gas filling processes the caesium is flashed to effect the desired deposition of the caesium on the antimony, producing thereby a photo-sensitive surface.

As illustrated in Fig. 3, the photo-emissive electrostatic control member 19 is provided with an aperture 20, preferably in the position indicated and having its principal dimension along the longitudinal axes of the anode 4 and cathode 8 to provide, with structure to be described presently, a communicating path between the cathode 8 and the anode 4 along which an electric discharge or an arc discharge may be established.

The photo-emissive electrostatic control member 19 is maintained in spaced relation between anode 4 and cathode 8 by means of a pair of vertical upright wires 21 and 22 which may be welded, formed or soldered to the body of the electrode 19. The control member structure is supported by members or wires 23 and 24 which are embedded in glass press. The latter wire 24 may serve as part of the circuit for connection to the control member 19 and may be connected to an external prong or conductor 25 through an intermediate conductor 26 which is sealed in the glass press 2.

By the proper proportioning of the ingredients of the photo-sensitive surface of control member 19 by employing antimony and caesium, I provide a photo-electric discharge device which is particularly sensitive to “blue” light. Interposed between the cathode 8 and the control member 18, I provide a light and heat shield structure to render the control member 18 substantially unaffected by the temperature of the cathode 8 and the light emitted therefrom. In this way, I provide an arrangement which renders the control member 19 substantially independent of the thermal characteristics of the cathode and increases the effective surface area of control member 19. Furthermore, the particular configuration to be described immediately hereinafter does not interfere with the desired and intended establishment of the arc discharge between the anode and the cathode under desired conditions. The particular form of the shield structure may be more fully appreciated by referring to Figs. 3 and 4 where the heat shield is shown as comprising a metallic structure including a wall 27 having its principal dimension parallel with the longitudinal axis of the cathode 8 and provided with an off-set 28 which may be semi-cylindrical to surround partially the cathode. The shield structure is also provided with a tube-like member 29 which is physically and electrically connected to the wall member 27 and which surrounds the opening 30 in the wall 27. The dimensions of the tube-like structure 29 are less than the corresponding dimensions of aperture 20 in control member 19 so that the tube-like structure may be inserted through the aperture 20 and spaced from the control member 19. It will be noted that the vertical projected area of wall 27 upon the control member is substantially equal to the vertical projected area of control member 19. The assembled position of the control member 19 and the shield structure may be more fully appreciated by referring to Fig. 4 which is a top view for the position of the electric discharge device shown in Fig. 1.

I also provide new and improved structure for supporting the cathode 8 and for supporting the shield structure. This aspect of my invention may be more fully appreciated by referring to Fig. 4 taken in conjunction with Figs. 1 and 2. I provide an insulator, such as a vitreous or glass bead 31, which is supported in the position indicated by means of wire supports 32 and 33 which, in turn, may be welded to the vertical upright wires 21 and 22 which support the control member 19. The ends of these conductors are embedded in insulator 31. A further wire support 34 is anchored in the insulating bead 31 and is also attached to the upper end of the cathode cylinder 8, thereby maintaining the cathode rigidly in position. Furthermore, I provide a plurality, such as four, wire supports for maintaining the shielding structure in position. Two of these supports, 35 and 36, may be located near the top, or at the top, of the electrode control member structure and may be welded to the vertical wires 21 and 22 and welded to the top of the wall 27 of the shield structure. Two additional supporting wires, 37 and 38, may be similarly located at the bottom to maintain the wall 27 rigidly in the desired spaced relation. The wire supports 35-38 inclusive, are preferably constructed of a material having a low thermal conductivity or, in other words, having an impedance to the flow of heat so that no appreciable heat is transmitted from the heat shield to control member 19. For example, these supporting wires may be constructed of a material or alloy, such as a composition of iron, nickel and carbon.

In order to render the electric discharge device shown in Figs. 1 and 2 suitable for use under those atmospheric conditions where there is a
tendency to effect a condensation and solidification of moisture, I place within the base 3 of the discharge device an impedance element such as a resistance 39 thereby completely enclosing the resistance. For example, in the assembly and manufacture of the discharge device shown in Figs. 1 and 2, the base 3 may be fastened to the envelope 14 by the plating in the base 3 an insulating compound or filling compound in a fluid state and placing the resistance 39 in the approximate position illustrated through this step in the assembly of the device. After solidification, the filling compound firmly maintains the resistance 39 in position. The filling compound may be a mixture of marble flour or a calcium carbonate held together by a suitable binder which may include a resin and a shellac. If desired, the resistance or impedance element 39 may be covered with a moisture resistant coating.

In Fig. 5 I have diagrammatically illustrated one application of my improved electric discharge device, wherein the discharge device shown in Figs. 1 and 2 is diagrammatically illustrated as element 40 comprising an anode, thermionic cathode and photo-emissive electrostatic control member of the types and configurations illustrated above and which have been assigned like reference numerals. The resistance 39 is represented as being exterior to the discharge device 40, but it will be appreciated that this impedance may be located within the base as illustrated in Fig. 2. A suitable source of negative unidirectional biasing potential, such as a battery 41 and a voltage divider 42, may be employed to control or adjust the magnitude of the voltage impressed on control member 19, thereby establishing or controlling that value of light intensity impinging on control member 19 at which the electric discharge or arc discharge is established between anode 4 and cathode 5. A suitable source of current, such as battery 43, may be employed for energizing the anode-cathode circuit of electric discharge device 40, and a load utilization device such as electromagnetic relay 44 may be connected in the anode-cathode circuit to control the energization of a circuit 45. A suitable circuit controlling means, such as switch 46, may be connected into the anode-cathode circuit to interrupt this circuit and to reestablish a condition of non-conductivity of discharge device 40 when desired.

By adjustment of voltage divider 42, it will be appreciated that I may control that value of light intensity at which the electromagnetic relay 44 is energized. Furthermore, a joint action of the light intensity and the magnitude of the unidirectional biasing potential may be employed to initiate the arc discharge within the electric discharge device. If it be assumed that no light is impinging on control member 19, or if the light intensity is relatively low for the particular value of biasing potential, the relay 44 will not be energized. Upon increase of the light intensity or upon decrease of the biasing potential, or if both of these factors are changed in the proper direction, the control member 19 will emit sufficient electrons to effect ionization of the medium within the envelope, establishing an arc discharge between the anode and cathode and thereby energizing the relay 44 to effect a desired circuit controlling operation.

The shield structure comprising the wall 21 and member 29 serves a dual purpose, namely it prevents the transmission of appreciable heat from the thermionic cathode 8 to the photo-emissive electrostatic control member 19 and also shields the control member 19 from any light which is emitted by the cathode 8. Both of these functions are of considerable importance. The heat shielding feature increases the life of the photo-sensitive control member 19 and also increases the sensitivity of the electric discharge device as a whole by rendering the control member substantially unaffected by the thermal characteristics of the cathode which otherwise would, to some extent, cause a variation in the emissive characteristics of the control member. The second shielding function of the shield structure also increases the sensitivity of the discharge device as a whole by absorbing, or by the prevention of the transmission of, any light emitted by the thermionic cathode. It will be appreciated that where a high degree of sensitivity is required, the light incident to the cathode 8 causes the emission of some electrons by the photo-sensitive surface, and consequently the output condition of the discharge device, used as an indicant of the light intensity under investigation, will in the absence of a light shielding arrangement vary somewhat in response to the light produced by the cathode.

While I have shown and described my invention as applied to a particular device embodying various elements diagrammatically shown, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention, and I, therefore, claim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:
1. An electric discharge device including a plurality of electrodes comprising an anode, a cathode and a control member, and a heat shield structure positioned between said anode and said cathode and said control member to intercept heat radiated from said cathode comprising a metal surface the projected area of which is substantially equal to the projected area of said control member and comprising a hollow member extending through said control member providing a region for the establishment of an electric discharge between said cathode and said anode.
2. An electric discharge device including a plurality of electrodes including an anode, a cathode and a control member, and a heat shield structure interspersed between said anode and said cathode for reducing the thermal effects of said cathode on said control member and comprising a metallic wall and a tube-like member defining a region between said anode and said cathode for the establishment of an electric discharge.
3. An electric discharge device including a plurality of electrodes comprising an anode, a thermionic cathode and an electrostatic control member, and a heat shield structure spaced between the cathode and the control member for reducing the thermal effects of said cathode on said control member and comprising a wall member at least partially surrounding said cathode and a tube-like member perpendicular to said wall defining an electric discharge path between said cathode and said anode.
4. An electric discharge device comprising a plurality of electrodes including an elongated cylindrical anode, an elongated cylindrical thermionic cathode and an electrostatic control member of substantially greater area than either said anode or said cathode and positioned be-
between said anode and said cathode, and a heat shield structure for reducing the thermal effects of said cathode upon said control member positioned between said cathode and said control member and comprising a wall member having its principal axis substantially parallel with the axes of said anode and said cathode and having a tube-like member substantially perpendicular to said wall member and defining a communicating path for an electric discharge between said anode and said cathode.

5. An electric discharge device including a plurality of electrodes comprising an elongated cylinder-type anode, an elongated cylinder-type thermionic cathode and an electrostatic control member in spaced relation between said anode and said cathode, and a heat shield structure having a metallic wall spaced between said control member and said cathode and provided with a hollow metallic-walled chamber providing a path for the establishment of an electric discharge between said cathode and said anode.

6. An electric discharge device including a plurality of electrodes comprising an elongated anode, an elongated thermionic cathode, a control member of substantially semi-cylindrical configuration having its longitudinal axis substantially parallel to the principal axis of said anode, and having an aperture therein, and a heat shield structure having a metallic wall spaced between said cathode and said control member and provided with a hollow tube-like structure supported by said wall and extending through said aperture providing an electric discharge path between said cathode and said anode.

7. An electric discharge device including a plurality of electrodes comprising an elongated anode, an elongated thermionic cathode, a control member of substantially semi-cylindrical configuration concave towards said anode and having its longitudinal axis substantially parallel to the principal axis of said anode and being provided with an aperture therein, a heat shield structure having a metallic wall spaced between said cathode and said control member and being provided with a semi-cylindrical off-set within which said cathode is positioned and having a hollow tube-like member substantially perpendicular to said wall providing a communicating path between said cathode and said anode.

8. An electric discharge device comprising a plurality of electrodes including an elongated anode, an elongated thermionic cathode, a control member of substantially semi-cylindrical configuration having its longitudinal axis substantially parallel to the principal axis of said anode and being supported by a pair of wire uprights, a vitreous insulator supported by said uprights, and means anchored in said insulator supporting one end of said cathode.

9. An electric discharge device comprising a plurality of electrodes including an elongated anode, an elongated thermionic cathode, a control member in spaced relation between said anode and said cathode and having a surface substantially greater than the surface of said anode, a pair of vertical uprights supporting said control member in said spaced relation, an insulator supported by said upright conductor anchored in said insulator and attached to one end of said cathode maintaining it in position.

10. An electric discharge device comprising a plurality of electrodes enclosed within an evacu-ated envelope, said envelope comprising a glass press near the base thereof and said electrodes including an elongated anode, an elongated thermionic cathode and an electrostatic control member having an area substantially greater than the area of said anode, a pair of wires sealed in said press supporting said control member in spaced relation between said cathode and said anode, an insulator supported by said wires, and means extending between said insulator and one end of said cathode maintaining said cathode in position.

11. An electric discharge device comprising a plurality of electrodes including an elongated anode, an elongated thermionic cathode substantially parallel to the principal axis of said anode, an electrostatic control member in spaced relation between said anode and said cathode and having an area substantially greater than the area of said anode, a heat shield structure comprising a metallic wall between said cathode and said control member, and conductors of low thermal conduction connected between said control member and said wall maintaining said wall in said spaced relation and for limiting the heat flow from said wall to said control member.

12. An electric discharge device of the light sensitive type including a plurality of electrodes comprising an anode, a thermionic cathode and a photo-emissive electrostatic control member in spaced relation between said anode and said cathode and having a photo-emissive surface facing said anode, and a heat shield structure comprising a wall member in spaced relation between said anode and said cathode and having a photo-emissive surface facing said anode, and a heat shield structure comprising a wall member in spaced relation between said anode and said cathode and having an aperture therein, and having a tube-like metallic member substantially parallel to said wall member establishing a communicating path between said cathode and said anode.

13. A light sensitive electric discharge device including a plurality of electrodes comprising an anode, a thermionic cathode and a photo-emissive electrostatic control member having a photo-emissive surface facing said anode, and a heat shield structure comprising a wall member substantially co-extensive with the principal dimension of said cathode and provided with an aperture, and a tube-like metallic member metallically connected to said wall about said aperture and extending through said control member providing a communicating path between said cathode and said anode.

14. A light sensitive electric discharge device including a plurality of electrodes comprising an elongated anode, an elongated thermionic cathode and a photo-emissive electrostatic control member of substantially semi-cylindrical configuration having a photo-emissive surface facing said anode and having an aperture therein, and a heat shield structure comprising a wall member of substantially the same height as the principal dimension of said cathode and provided with an aperture and a tube-like metallic member metallically connected to said wall member about the aperture therein and extending through the aperture of said control member but not in physical contact with said control member.

15. An electric discharge device of the light sensitive type comprising a plurality of electrodes enclosed within an atmosphere of argon having a pressure within the region of 100 to 150 microns, said electrodes comprising an elongated anode and an elongated thermionic cathode and a photo-emissive electrostatic control member in spaced relation between said anode and said cathode and having a substantially semi-cylindrical configura-
tion concave toward said anode, the concave surface being coated with a composition of antimony and caesium rendering said surface selectively responsive to blue light.

16. A light sensitive electric discharge device including a plurality of electrodes enclosed within an atmosphere of an ionizable medium and comprising an electrode having a nickel base, an oxide film thereon, a layer of antimony on said film and a layer of caesium on said antimony.

17. A light sensitive electric discharge device comprising a plurality of electrodes enclosed within an atmosphere of argon and including a photo-sensitive electrode having a nickel base, an oxide film thereon, a layer of antimony and a layer of caesium.

18. A light sensitive electric discharge device comprising a plurality of electrodes within an atmosphere of argon and including a photo-emissive electrostatic control member comprising a nickel base, an oxide film thereon, a layer of antimony and a layer of caesium.

19. A light sensitive electric discharge device comprising a plurality of electrodes within an atmosphere of an ionizable medium comprising a photo-emissive control member having a nickel base, an oxide film thereon, a layer of antimony and a layer of caesium.

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