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ELECTRODE STRUCTURE FOR GASEOUS DISCHARGE DEVICES

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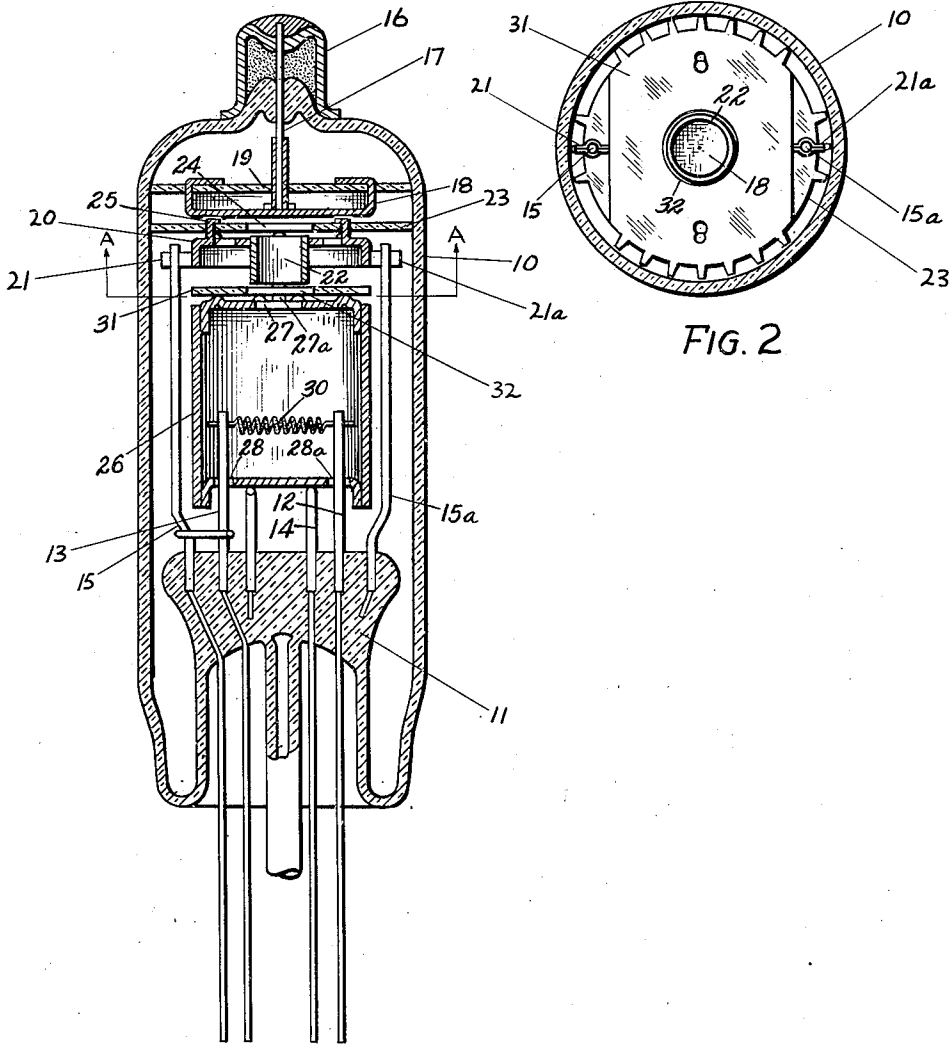


FIG. 1

FIG. 2

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ELECTRODE STRUCTURE FOR GASEOUS DISCHARGE DEVICES

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This invention relates to gaseous discharge devices, and more particularly to such devices employing a control and auxiliary electrodes.

Gaseous conduction devices employing electron-emissive cathodes, thermally energized, have been favored considerably in a wide range of commercial applications. The operation of such devices, utilizing alternating current, has much to do with its favorable acceptance by those employing the same. However, a predominant failing of devices of the type described is the inherent undesirable effect that starting and stopping of space current has on the operating life and efficiency of the heated cathode, and particularly the coating thereon. The generation of high-velocity positive ions causes bombardment of the cathode coating and disintegrates or sputters the active material from the cathode surface with a subsequent lowering of the electron-emissive efficiency. Furthermore, ionic bombardment of the anode sometimes takes place and particles sputtered from said anode are deposited on the cathode and result in again lowering the efficiency of this electrode by contamination.

An object of this invention is to provide a device of the type described in which deleterious effects of high-velocity positive ions on the cathode structure are obviated.

Another object is the provision of means to shield the coating of the cathode from ionic bombardment without reducing the output of said cathode.

A further object is the provision of a gas and electron-emissive coating combination which allows simultaneous application of anode and cathode potentials.

A still further object resides in the provision of means for preventing ionic bombardment of the anode surface of said device.

These and other objects are attained, generally, in accordance with this invention, by the arrangement of the elements within the device, the type of ionizable gas employed, the pressure used and the composition of the electron-emissive coating applied to the cathode.

A feature of the construction of the present device is the particular configuration of an auxiliary electrode and its space relation with respect to the anode, wherein, by reason of this particular configuration and space relation, the positive ion population present in the plasma, during ionization of the atmosphere within the envelope, is mainly concentrated within the confines of said particular configuration. When the anode of the present device is subjected to a potential

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of negative polarity, a positive ion space charge is formed adjacent to the surface of said anode, said space charge acting as a buffer against the higher velocity positive ions and, therefore, inhibiting excessive bombardment of the anode and consequent sputtering of the same.

Another feature resides in the use of xenon or xenon and a small percentage of krypton, as the ionizable gas, at a pressure from about 1.5 mm. to about 2.5 mm. of Hg, combined with an electron-emissive coating of barium monoxide on the cathode. It has been found that this combination permits simultaneous application of anode and cathode potentials, without the customary wait for the cathode to be brought to actual working temperature and without excessive deterioration of the cathode coating.

These and other features and advantages of the invention are more clearly set forth in the following detailed description which, together with the drawing, represents one embodiment of the device:

Fig. 1 is a sectionalized view of a device made in accordance with the present invention; and

Fig. 2 is a transverse view of that portion of the device indicated at A—A.

Referring to the drawing, particularly to Fig. 1, the device of this invention embodies an envelope 10 provided at one end with an inwardly projecting stem or press 11 for supporting the various electrodes within said envelope and for conveying energy to said electrodes through the conductors 12, 13, 14 and 15, imbedded in said press 11. The other end of said envelope is provided with a cap 16 which is attached, by soldering or other means, to a lead-in conductor 17 sealed in the top of said envelope 10 and connected to an output electrode or anode 18.

The anode 18 is a dish-like metallic member, the dish-like cavity being covered by a circular spacing member 19 which may be made of mica or other equivalent material. The peripheral edge of spacer 19, herein illustrated, contacts the wall of the envelope and thus maintains the anode 18 centrally positioned in a plane perpendicular to the axis of said envelope. The anode 18 may be covered with carbon or other heat radiating material to dissipate the heat generated during the operation of the device.

Positioned in a plane, parallel with respect to the anode 18, is an electrode 20 which shall be termed an auxiliary electrode. Its function will be described hereinafter. The form of said auxiliary electrode 20 is substantially dish-shaped and has a pair of tabs 21, 21a extending from

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the vertical sides of said electrode 20, said tabs 21, 21a being attached to the supporting-conducting member 15, 15a. A tubular member 22 extends from the center of said electrode 20 in a direction away from the anode 18.

Disposed between the electrodes 18 and 20, in a plane parallel to said last-mentioned electrodes, is another circular spacer 23 which may be formed of mica or any equivalent material. Said spacer 23 has an aperture 24, slightly larger in diameter than the diameter of the tubular member 22, and in register with the open end of said tubular member. Spacer 23 is firmly attached to electrode 20 by tabs 25 extending from the last-named electrode. Said spacer 23 serves to maintain electrode 20 in a plane parallel with respect to anode 18 and its edges are in contact with an appreciable part of the envelope surface. Furthermore, it also serves to confine the positive ion population in a manner and for a purpose which will be disclosed hereinafter.

An electrode 26, which will be referred to in this description as a control electrode, is in the form of a practically closed cylindrical chamber except for an aperture 27 therein, said aperture being in register with the orifice in the tubular member 22 to allow the passage of electrons to the anode 18 from the cathode 30 positioned within said electrode 26. There is also a pair of apertures 28, 28a in the lower plane surface of said electrode 26, said apertures 28, 28a being provided for admission of the cathode-supporting conductor members 12 and 13. The reason for the particular configuration of the control electrode 26 will be explained in detail as this specification progresses.

Positioned in a plane, parallel to the upper plane surface of the electrode 26, is a substantially rectangular spacer 31 whose shorter sides are arcuate, the distance between said arcuate sides being substantially the inside diameter of the envelope 10 as more particularly illustrated in Fig. 2. Said spacer 31 may be formed of mica or equivalent material and is attached to said electrode 26 by extruded tabs 27a extending from said electrode 26. Centrally located in said spacer 31 is an aperture 32 whose diameter is slightly larger than the aperture 27 but is in register with the same.

In devices of the gaseous conduction type and particularly where such devices employ alternating current potentials, the anode during the non-conducting cycle becomes negative and causes positive ions present in the plasma or discharge path to be accelerated toward the anode. Said ions being of large mass are capable of accumulating sufficient energy to attack the anode and cause sputtering or detachment of particles from the anode. These particles are vaporized and, if permitted to fall on the cathode coating, tend to lower the efficiency of emission.

Let us assume a particular set of conditions under which the device is to be operated. This device contains a gas at a pressure of about 1.5 mm. to 2.5 mm. of Hg. In this example an alternating potential will be applied to the anode 18 of the device. The auxiliary electrode 20 will be connected to the cathode 30 and will therefore be at that potential. The control electrode 26 will have impressed thereon a potential sufficiently negative with respect to the cathode 30 to prevent a discharge from taking place between said cathode 30 and anode 18. Now, if a signal voltage be impressed on the control electrode 26 which will cause said electrode to become suf-

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ficiently less negative, ionization of the atmosphere, within the device, between the cathode 30 and the anode 18 will take place. During the conduction period just established, a large number of the positive ion population will be concentrated in the restricted space of the tubular member 22. This is due to the fact that said member is at the same potential as the cathode 30 and therefore attracts the positive ions to the surface thereof. It is believed this congested positive ion condition in the space 22 tends to reduce the intensity of the anode field to an extent that a slow-down of velocity of the positive ions occurs and a positive ion space charge forms adjacent that surface of the anode 18 facing the auxiliary electrode 20. Additional concentration of the positive ions is aided by the position of spacers 19 and 23.

Upon reversal of the anode 18 potential, that is, when said anode becomes negative, the positive ions in the region immediately adjacent said anode are attracted thereto, but not with sufficient velocity to bombard the aforesaid anode, and therefore form a positive ion sheath around said electrode. This sheath of positive ions repels the faster moving ions approaching the anode and consequently slows them down to harmless velocities and prevents deleterious bombardment of the anode 18.

Another feature of this invention resides in the control electrode 26. As illustrated in the drawing, said electrode represents a practically closed chamber. An aperture 27 in the top of said electrode is centrally located and allows the passage of ions and electrons along the path of conduction between the cathode 30, which is positioned within said electrode 26, and the anode 18. It has been found that in this type of electrode structure, emission from internal points within said electrode is relatively ineffective (at the potentials normally used in such a device) to change the control characteristic thereof and therefore permits the use of a high impedance grid input signal network. This can be of the order of ten megohms if so desired. There are several features incorporated in said electrode 26 which have a bearing on the control characteristic mentioned hereinbefore. Its size with respect to the energy losses at the cathode 30 is such that the temperature of said electrode 26 is kept extremely low. This condition inhibits to a large extent the possibility of significant electron emission from the surface thereof. Furthermore, the configuration of electrode 26 and the associated structure is such that the electrode 26 is shielded from the effect of the anode field and a glow discharge between it and said anode is inhibited. Maintaining the electrode 20 at the same potential as cathode 30 reduces the intensity of the field of electrode 18 with respect to the electrode 26 without interfering with the control exercised by said electrode 26 and inhibits the occurrence of a glow discharge between said last-mentioned electrode and the anode 18. The initiation of a glow discharge between the anode 18 and control grid 26 would cause loss of control over the main discharge and this condition is highly undesirable.

As pointed out above, the present device is filled with a gas which may be xenon or a mixture of xenon and a small percentage of krypton at a pressure of about 1.5 mm. to about 2.5 mm. of Hg. Heretofore simultaneous application of anode and cathode potentials was considered impracticable as such operation always resulted in

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premature destruction of the cathode coating. This was caused by ion bombardment of the cathode before the electron emission from the cathode was available. To guard against this effect it was necessary to have a plentiful supply of thermionically emitted electrons available before conduction began. This meant that it was necessary to wait until the cathode was brought up to proper emitting temperature before the anode potential was applied. It was found that, by combining the gas above described at the pressures mentioned with a cathode having a coating of barium monoxide, even at a temperature lower than the working temperature, enough electrons would be emitted to provide conduction or ionization to take place without excessive ion bombardment of the cathode, and therefore no waiting period for operation of the device was necessary.

While but one embodiment of this invention has been described and illustrated, it is of course understood that many modifications and alterations may be made wherein the relation of the electrodes may be altered to achieve the primary concepts of this invention; for example, the control electrode may be used as a shield electrode and the auxiliary electrode as the control electrode, which arrangement would provide a low impedance control grid, or by moving the cathode closer to the aperture in the control electrode, the critical control electrode voltage could be changed.

What is claimed is:

1. A gaseous discharge device comprising: an envelope containing an ionizable gas; a plurality of electrodes supported, in spaced relation with respect to each other, within said envelope; a first of said electrodes being electron-emissive; a second of said electrodes substantially enclosing said first-named electrode, said second-named electrode having an aperture therein for the passage of electrons therethrough; a third of said electrodes being disposed intermediate said second and a fourth of said electrodes, said third-named electrode being electrically connected to said first-named electrode and having an elongated tubular member extending from the center thereof and facing the aperture in said second-named electrode, for concentrating large numbers of positive ions therein during the period of ionization of the atmosphere between said first and fourth-named electrodes, whereby a positive space charge is created adjacent said fourth-named electrode for a period of time of the order of several milliseconds, after the discharge ceases.

2. A gaseous discharge device comprising: an envelope containing an ionizable gas; a plurality of electrodes supported, in spaced relation with respect to each other, within said envelope; a first of said electrodes being electron-emissive; a second of said electrodes substantially enclosing said first-named electrode, said second-named electrode having an aperture therein for the pas-

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sage of electrons therethrough; a third of said electrodes being disposed intermediate said second-named and a fourth of said electrodes, said third-named electrode being electrically connected to said first-named electrode and having an elongated tubular member extending from the center thereof and facing the aperture in said second-named electrode, the opening of said tubular member being slightly smaller than the aperture in said second-named electrode, for concentrating large numbers of positive ions therein during the period of ionization of the atmosphere between said first and fourth-named electrodes, whereby a positive space charge is created adjacent said fourth-named electrode for a period of time of the order of several milliseconds, after the discharge ceases.

3. A gaseous discharge device comprising: an envelope containing an ionizable gas; a plurality of electrodes supported, in spaced relation with respect to each other, within said envelope; a first of said electrodes being electron-emissive; a second of said electrodes substantially enclosing said first-named electrode, said second-named electrode having an aperture therein for the passage of electrons therethrough; spacing means, having an aperture in the center thereof, and being affixed to said second-named electrode and disposed intermediate said second-named electrode and a third of said electrodes; said third electrode having integral therewith a tubular member in the center thereof and facing the aperture in said second-named electrode; a second spacing means, having an aperture in the center thereof, and being affixed to said third-named electrode and disposed intermediate said third-named electrode and a fourth of said electrodes; and a third spacing means affixed to said fourth-named electrode and being disposed intermediate said fourth-named electrode and the top of said envelope, whereby, upon the occurrence of any ionization of the atmosphere between said first and fourth-named electrodes, the apertures in said spacing means and electrodes form a restricted conduction path along the axis of said device intermediate said first and fourth-named electrodes.

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