

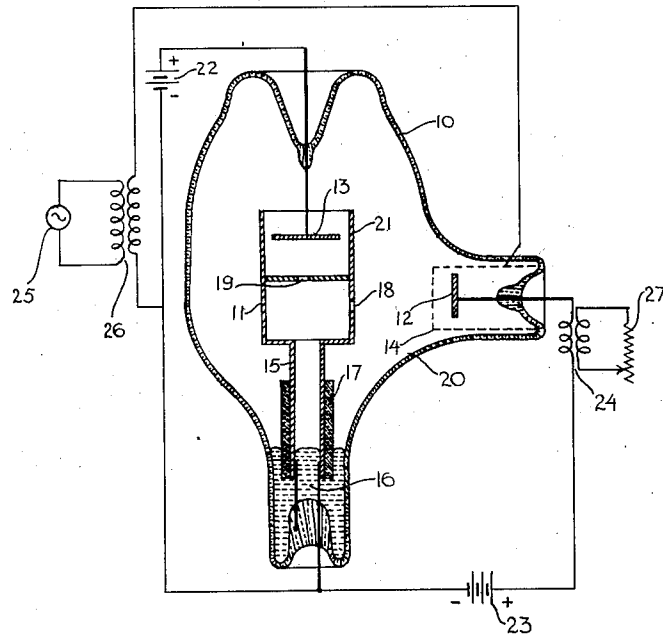
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SPACE CURRENT DEVICE

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SPACE CURRENT DEVICE

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5 Claims. (Cl. 250—27.5)

This invention is a division of my co-pending application Serial No. 696,337, filed March 1, 1924. The invention relates to gaseous space current devices of the kind utilizing a gaseous body as a source of space current carriers.

Mercury vapor rectifiers heretofore used in the art for rectifying large currents are operated with a liquid mercury cathode. As a result, there is a large evolution of mercury vapor at the incandescent hot cathode spot that forms on the mercury causing a large amount of energy dissipation, complicating the construction and operation and making necessary bulky and expensive structures.

Objects of the present invention are to overcome the above difficulties; to provide methods of controlling tubes utilizing ionized gas or vapor; and generally to improve the construction and operation of space current apparatus.

In the arc-discharge devices according to the invention, the cathode is not made of a vaporizable material, but of a solid, refractory body with an extended electrode surface that remains intact while serving as a cathode terminal for the arc discharge. Adjacent the solid cathode surface is formed an enclosure, preferably by making the cathode in the form of a hollow, solid body with an extended interior cathode surface. A gaseous conducting body, such as vapor of mercury, potassium, sodium, gallium, but preferably cesium, is held in the enclosure adjacent the solid cathode surface, there being no vaporizable conducting body in the enclosure upon which a cathode terminal could form. The enclosed gas with the associated cathode surface are heated by means of the discharge current or by independent means, or both, to a high temperature and maintained in a state of intense excitation, at which the gas is highly ionized, the cathode enclosure preserving and intensifying the ionization. Under such conditions there is no loss of energy due to excessive vaporization, and the device will operate with an arc or arc-like discharge by which is meant a discharge at a voltage of the order of the ionization voltage of the gas or less. A relatively high pressure is maintained in the cathode enclosure, and the pressure is preferably made substantially independent of the load by supplying the vapor into the cathode enclosure from a vaporizable body that is vaporized by an auxiliary heater.

The invention is described more fully hereinafter in connection with the accompanying diagrammatic drawing of exemplification thereof, in which—

The figure is a vertical section of an electrostatically-controlled discharge device.

In the device shown in the figure, envelope 10 of impervious material, such as glass, contains the cylindrical cathode chamber 11 having the opening 19 through which space current is transmitted to "keep alive" anode 13 from the space current source 22. The cathode 11 consists of a cylindrical chamber having a conduit 15 of smaller diameter depending therefrom and dipping into a pool 16 of mercury, gallium, cesium or other suitable vaporizable substance, the conduit 15 being surrounded by a jacket or sleeve 17 of heat insulating material, such as porcelain, for preventing rapid loss of heat through the walls of the conduit. The cathode chamber may be made of any suitable conducting material which is refractory at the temperature utilized, such as tungsten. The cylindrical shell 21 extending upward from the cathode and surrounding the anode 13 tends to restrict the influence of the space current on the surrounding space and to retain the vapor within a small zone. Opening 18 in the cathode allows space current to flow from the cathode to the portion 20 of the tube where the vapor pressure is very low, the current passing to the anode 12 in this region. The source of space current 23 is connected in series with the primary winding of transformer 24 between cathode 11 and anode 12.

A source of current 25 to be detected or to be repeated, with or without amplification, transmits current through transformer 26 to the grid or electrostatic control element 14 to produce variations in the space current being transmitted to anode 12, these variations being transmitted to load 27. The circuit including the secondary winding of transformer 26, the grid 14 and cathode 11 constitutes the input circuit, while the circuit connected between anode 12 and the cathode 11 constitutes the output circuit.

The tube permits flow of current only in the direction from the anodes to the cathode. The rectifier is started by producing an initial amount of vapor in the cathode chamber 11, as by an auxiliary discharge or heating the vaporizable material, and a flow of space current is produced between the cathode 11 and the anodes. The heat evolved within the cathode 11 is conducted down the conduit 15 to the vaporizable substance 16 which is vaporized by the heat and passes upward into the chamber 11 wherein the heat evolved by the drop of potential in the vapor rapidly increases the temperature of the vapor and the cathode until the in-

crease of temperature reduces the impedance of the vapor by ionizing the vapor or by exciting the vapor to a prepared state in which it is readily ionized by low voltage collisions of electrons and molecules. The reduced impedance within the cathode caused by the increase of temperature and the increased ionization of the vapor automatically sets a limit to the heating of the cathode, so that a relatively fixed temperature is quickly established, the heat evolved within the cathode being dissipated by the external cathode surface which is free to radiate the heat in substantially all directions from the cathode to surrounding heat-absorbing media.

The intense heating of the chamber 11 and of the gas or vapor within the chamber 11 produces a strong emission of electrons, the heat and intense radiation within the chamber photoelectrically or otherwise ionizing the vapor or exciting it to a prepared state, as mentioned before. When mercury vapor is employed, the cathode is preferably raised to a white heat and at this temperature adequate ionization of the mercury vapor is readily produced.

In order to produce ionization resulting from exciting the atoms to a prepared state in which slight further excitation produces ionization, the vapor to be ionized is fed into a conducting chamber having a restricted opening through which electrons are transmitted to the anode under the influence of the potential gradient between the cathode and anode. The conducting chamber functions as a shield around the ionized gas within the chamber, the openings through which the electrons are transmitted being large enough to permit withdrawal of the electrons by the electric field but being of such restricted size that the relatively heavy ions are afforded little or no opportunity of escaping through the openings.

The slight drop of potential within the cathode chamber caused by space current flowing through the openings causes the chamber and the vapor in the chamber to rise to a much higher temperature thereby maintaining a copious supply of electrons, so that at all times more electrons are available than are required for transmission of space current. The heating of the gas in the chamber maintains the vapor thermally excited.

By the arrangement of the invention, vapor or other ionizable substance is heated to such an extent that thermal ionization, (as distinguished from ionization by an electric field) takes place within the vapor to produce a copious emission of electrons for conveying current between the cathode and the anode of the space current apparatus. An explanation of the phenomena in the operation of the tube which I believe at present to be correct is given in my application Serial No. 696,337, filed March 1, 1924.

The chamber form of cathode is particularly adapted for use of sodium potassium alloy, cesium or other alkali metal as well as for mercury, gallium or other vaporizable substance. The advantage in employing the alkali materials being in part due to the very low voltage drop at the cathode when thermal ionization or ionization employing the prepared state of the atom is used. Another advantage in using alkali vapor results from the fact that such vapor is readily excited by radiation of relatively long wave length. In general, when the gas or vapor has to be excited by radiation, it is preferred to employ

a gas or vapor capable of excitation by a longer wave length than that required to excite mercury vapor.

The cathode chamber may be made of any suitable conducting material which is refractory at the temperature utilized. By employing high refractory material in the cathode and providing a relatively large external surface, the outer cathode wall presents an efficient radiating surface for radiating the heat losses within the chamber. It is advantageous to utilize a cathode chamber, the inside walls of which are capable of efficient reflection. When mercury vapor is employed, the cathode is preferably raised to a white heat and at this temperature produces adequate ionization of the mercury vapor, at the same time directly radiating the heat to the walls of the tube or through the walls of the tube to the surrounding space at such a distance from the cathode that the intensity of heat is reduced to the desired extent in accordance approximately with the inverse square law, so that objects receiving radiation from the cathode are not greatly heated even though large quantities of energy are being dissipated by the cathode.

By utilizing high temperatures in the cathode, the ionization of vapor is not only facilitated, but the temperature of the cathode tends to remain more constant when the space current fluctuates between wide limits for the reason that heat is radiated from the cathode at a rate which is enormously greater than the proportional increase in temperature above that utilized in ordinary tubes, owing to the tendency of the radiation to increase according to the fourth power of absolute temperature. When the space current increases, a very slight increase in the temperature of the cathode results in a greatly increased radiation of heat, so that the temperature tends to remain relatively constant. As a result of the high temperature used, efficient ionization is produced and the voltage drop in the tube is very small, thereby involving very small loss of energy and a relatively small amount of heat to be dissipated as compared to prior tubes, this heat being concentrated by the cathode chamber so that a suitably high temperature is produced. The tube may accordingly be made of smaller size for a given power than prior tubes, and the construction and operation of the tube is greatly simplified owing to the method of cooling.

In the chamber form of cathode, gas or vapor is raised to a relatively high pressure, the pressure outside the cathode being low, whereby a steep pressure gradient of the vapor is produced between the cathode and anode, giving the space current path a low impedance in one direction and a substantially infinite impedance in the opposite direction.

The device of Fig. 1 is particularly adapted for detecting or repeating electric waves with or without amplification for signal communication by wire or radio. The waves to be repeated or detected are impressed upon the input circuit and produce the desired response in the output circuit.

I claim:

1. A space discharge device comprising a gas tight evacuated vessel, an anode in one portion of said vessel, a cathode having an extended electrode surface arranged to be heated to thermionic emission in another portion of said vessel, means for supplying during operation to the discharge space in front of the cathode electrode surface an ionized gaseous body at high pressure sufficient to sustain an arc discharge between said cathode and said anode, means including barrier elements

for confining the gaseous body to the region adjacent to said cathode surface and for holding a region between said cathode and said anode at a low pressure to permit control of the electron discharge from the cathode to the anode by the potential of a grid, and means acting in said low pressure region for controlling said discharge.

2. A space current device comprising a gas tight evacuated vessel, an anode located in one portion of said vessel, a cathode having an extended electrode surface arranged to be heated to thermionic emission during operation in another portion of said vessel, means for supplying during operation ionized vapor to the discharge space in front of said cathode electrode surface at a pressure sufficient to sustain an arc discharge between said cathode and said anode, means including barrier elements for confining the vapor to the region adjacent to said cathode surface and for holding a region between said cathode and said anode at low pressure to permit control of the discharge therebetween, and means acting in said low pressure region for controlling said discharge.

3. A space current device comprising a gas tight evacuated vessel, an anode located in one portion of said vessel, a cathode structure having an extended electrode surface arranged to be heated to thermionic emission located in another portion of said vessel, said cathode structure constituting an enclosure confining the space of said electrode surface, a source of ionizable vapor in said vessel outside said enclosure, means for supplying vapor from said source to the space inside of said enclosure to maintain the vapor confined near said cathode surface at a pressure sufficient to sustain an arc discharge between said cathode and said anode and for holding a region between said cathode and said anode outside said enclosure at low pressure sufficient to permit control of the flow of

the electrons to the anode throughout the discharge, and means for controlling the discharge in said low pressure region.

4. A gaseous arc-discharge tube comprising a gas tight vessel containing an anode and a cathode structure having an extended solid electron-emitting electrode surface arranged to be heated to thermionic emission during operation, said cathode structure constituting an enclosure bounding a part of the space in front of the electrode surface of said cathode structure but permitting space current flow between said electrode surface and said anode, means for maintaining during operation of the device an ionizable gas inside said enclosure at a high temperature and substantial pressure at which the confined gas is in a state of excitation and secures an arc-like discharge between said anode and said cathode surface, and a control grid between said cathode structure and anode.

5. A gaseous arc-discharge tube comprising a gas tight vessel containing an anode and a partially open hollow cathode constituting an enclosure around a part of the space in said vessel and having an extended interior, solid, electrode surface, a vaporizable conducting substance arranged in said vessel to prevent formation of a cathode spot thereon during normal operation of the device, means for heating the interior of said cathode to high temperature during operation of the device and simultaneously maintaining vapor from said vaporizable substance excited at a high temperature and sufficient pressure within said enclosure to secure an arc-like discharge between said interior electrode surface and said anode, and a control grid between said cathode structure and anode.

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