GAS CUSHION KEEP-ALIVE ELECTRODE

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This invention relates to gaseous discharge devices, and more particularly to the rapid ignition, and maintenance of the main discharge of a cold cathode gaseous device by an auxiliary electrode.

Gas or vapor-filled electron tubes may generally be classified as to the type of cathode employed, namely hot or cold. Each type may vary as to the number of electrodes and further, the cathodes themselves may be either solid or gaseous. These latter find their principal use as rectifiers, voltage regulators, control devices, switches, sweep circuit oscillators and in recent times as modulator and T-R tubes within radar systems. Cold cathode tubes such as those employing a mercury pool afford certain advantages over hot cathode tubes. Certain vapor filled tubes have been used with "keep-alive" electrodes which continuously maintain an arc to the cathode. Such keep-alive electrodes are necessary in single anode mercury-cathode units where the tube would otherwise extinguish during the negative half cycle of an applied A.C. voltage, or where the anode voltage was momentarily interrupted, or where the anode current is pulsed. Ignition methods such as the production of a high field by an auxiliary electrode closely spaced above a mercury cathode pool has proved impractical because of the waves and fluctuations in the mercury pool level of liquid cathode tubes, and the erosion of cathode materials in solid cathode tubes.

The desirable electrical characteristics of cold liquid cathode gas or vapor tubes can be put to many useful purposes as for example, in pulse modulator tubes and T-R tubes where a single anode is employed since high current pulse application is possible and the cold cathode tube is not subject to the current density limitations of thermionic cathodes in application. However, before the type of cold liquid cathode tube may be used successfully, a method for igniting and maintaining a cathode spot is essential.

It is therefore an object of this invention to provide a device for igniting and maintaining a cathode spot on liquid cathodes of gas or vapor-filled electronic tubes.

Another object is to provide a device for creating a continuous supply of electrons from a liquid cathode sufficient to ignite the main arc of a tube.

A further object is to provide a relatively low current drain device for the ignition of a liquid cold cathode gas tube.

Other objects are to provide an electrically and mechanically simple, efficient, inexpensive and reliable device for the ignition of liquid cold cathode gas tubes.

Other objects and advantages will be apparent from the following description of embodiments of the invention and the novel features thereof will be particularly pointed out hereinafter in connection with the appended claims.

In the accompanying drawings:

FIG. 1 is a cross-sectional diagram of a liquid cathode tube illustrating an embodiment of the invention; and FIG. 2 is a perspective, illustrating another embodiment of the invention.

In the embodiment of the invention illustrated in FIG. 1, a closed glass envelope, or an envelope of any suitable material, contains a vapor or gas filling, an anode 2 supported therein by conducting rod 3, and a liquid mercury pool cathode 4 or a gallium pool disposed at the base of the envelope or tube opposite the anode. Electrical connection from outside the envelope is made to the anode through the electrical conducting rod 3 which extends from, and is secured to, the anode and passes through that portion of the envelope opposite and remote from the cathode for external wiring thereto. Conducting rods 5 and 6 extend through a portion of the base of the envelope into the liquid cathode 4, and electrical connection from the exterior of the envelope is made to the cathode by means of these rods. The ends of the rods disposed within the cathode project into the cathode from the base of the envelope and extend upwardly to an area well below the surface of the cathode. Electrical lead-in rods 7 and 8 extend and project through opposite vesicular ends of the envelope in a direction normal to the sides at points intermediate between the surface of the cathode and the anode, and their inner end portions are threaded. Since the tube is vapor or gas filled, the rods 3, 5, 6, 7 and 8 are peripherally bonded to the envelope wall through which they pass so as to hermetically seal the envelope which is evacuated and filled with a noble gas or vapor, such as mercury. Retaining nuts 10 and 11 are threaded on the end portions 9 of each of the lead-in rods 7 and 8 and a splayed shaped tab 12 is supported between the lightly abutting faces of each pair of these nuts. The concave portions of these tabs face each other and are of any spring-like, electrically conductive, heat resistant material, such as for example, molybdenum. Each tab 12 may be affixed to its lead-in rod in any suitable manner providing the end of the tab so affixed is permanently tightly confined against movement. A wire 13 of a material which will withstand high temperatures, having intermediate of its ends a horizontally undulatory portion 13a, such as of S shape is welded or otherwise firmly fixed to the free ends of the tabs to connect them. The tabs 12 support the wire 13, which may be, for example, of tungsten or molybdenum just above and slightly to the side of the cathode, with the plane of the S portion of the wire parallel to the cathode surface, and by reason of the arcuate form and resiliency of the tabs, is movable a short distance toward and away from the cathode surface when subjected to opposing forces. The S shape of the wire 13, by giving extra concentration of weight in the middle portion of the wire and at the ends so as to keep the conductor zone of the wire, gives the wire freedom of motion and causes the S portion of the wire to sag in the direction of the cathode surface.

When a D.C. potential is applied, as by battery 14, between the keep-alive wire 13 and the mercury cathode, the keep-alive wire being positive with respect to the cathode, the keep-alive wire automatically adjusts itself in spaced relation to the cathode surface under the action of two oppositely directed forces. The electrostatic force created by the applied D.C. potential tends to pull the wire in the direction of the mercury cathode, but as the wire approaches the cathode surface arcing occurs between the wire and the cathode, and a cathode spot forms on the cathode surface directly opposite the wire. With the formation of the arc, a vapor blast or a Tanberg effect occurs which applies a repulsive or upwardly directed force that portion of the wire directly opposite the cathode spot. The electrostatic and the vapor blast forces act on the wire in opposing directions and the wire therefore automatically assumes a spaced relation above the cathode surface where these forces are equal and opposite so that the keep-alive wire is in mechanical and physical equilibrium. Under these conditions, an arc is continually maintained between the keep-alive wire elec-
trode and the liquid cathode. The spacing between the keep-alive wire electrode is thus automatically adjusted to maintain the arc. If the D.C. potential should decrease to a low current or extinguish, the keep-alive wire would then move toward the cathode until either the spacing between the wire and the cathode was sufficient to reignite the arc or until its movement toward the cathode was mechanically limited by the tabs 12 and 13. When the D.C. potential were to reignite and the wire 13 would again be repelled by the cathode surface by the vapor blast until it again assumed its equilibrium or firing position.

It has been found that successful operation under the above conditions can be maintained using a 0.0008 inch tungsten wire 13 tabbed with a 0.001 inch thick tab 12, 0.005 inch wide and about one millimeter long. The keep-alive arc provides the necessary vapor ionization, though localized, in the tube so that when a voltage is applied between the main anode 2 and cathode 4, a main discharge or conduction will be accurate, reliable and immediate.

A third electrode, as for example a control grid (not shown), may be added to the above described tube embodiment. This arrangement is the equivalent of a thyatron tube with a cold liquid cathode and is extremely useful as a modulator of electron current. A D.C. potential also exists between the vane 26 and the cathode. The keep-alive devices described herein when used with liquid cold cathodes are means to supply a virtually unlimited electron source for tubes such as pulse modulators, voltage amplifiers, and various other electron devices requiring electron accumulation and storage. High current, high voltage and high rate of storage is required.

It will be seen that the design of the invention has the advantages of high peak anode currents, with low control power of a grid as compared to the tens of amperes at hundreds of volts required by the ignitor. Comparison with the excitor or multi-anode rectifier shows immediately the advantage of substantially lower excitation power and moreover, the keep-alive restrains the motion of the cathode spot to a small area directly below the keep-alive electrode, so that the major problem of excitor and multi-anode tube design, that of keeping the cathode spot off the tube walls, is avoided.

It will be obvious to those skilled in the art that various other changes in the details, materials and the arrangements of parts which have been herein described and illustrated in order to explain the nature of this invention, may be made by those skilled in the art within the principles and scope of the invention as expressed in the appended claims.

We claim:

1. A gaseous electric discharge device comprising a closed envelope containing a gas filling and having therein spaced relation to one another, one anode and a liquid cathode with a surface exposed toward said anode, an auxiliary electrode device disposed in said envelope between the cathode and said exposed cathodic surface, said auxiliary electrode device being curved and so disposed as to move said cathode surface in electrical equilibrium with said auxiliary electrode device against said gaseous environment containing said anode and cathode, the cathode containing a liquid metal cathode,

2. The device according to claim 1, wherein said closed envelope contains mercury vapor and said liquid cathode is mercury.

3. The device according to claim 1, wherein said closed envelope contains another electrode disposed between said auxiliary electrode and said anode for control of said main discharge.

4. The device according to claim 1, wherein said auxiliary electrode is a bar physically supported and balanced for pivotal movement whereby its ends are movable toward and away from said exposed cathode surface.

5. The device according to claim 4, wherein an end of said bar has a large surface area directed substantially toward said cathode.

6. A gaseous electric discharge device comprising a closed envelope containing a gas filling and having therein in spaced relation to one another, an anode and a liquid cathode, said cathode having a surface exposed toward said anode, an auxiliary electrode device disposed in said envelope between the anode and said liquid cathode surface, and said auxiliary electrode device being curved and so disposed as to move said cathode surface in electrical equilibrium with said auxiliary electrode device against said gaseous environment containing said anode and cathode, the cathode containing a liquid metal cathode,
tively small forces but limited against contact with said cathode surface whereby when a potential is created between said electrode part and said cathode surface, said electrode part will be in mechanical physical equilibrium in spaced relation to the cathode surface due to the opposing forces created by the electrostatic attractive force pulling said electrode part toward the cathode and the opposing vapor blast repulsing force from the cathode facilitating thereby the establishment and maintenance of the main discharge between said anode and said cathode.

7. The device according to claim 6, wherein said fine wire has an undulatory portion plane which is substantially parallel to said cathode surface.

8. The device according to claim 7, wherein said undulatory portion of said wire is S shaped.

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