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METHOD OF MANUFACTURE FOR ELECTRIC DISCHARGE DEVICES

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This invention relates to the manufacture of electric discharge devices and is particularly concerned with a method of neutralizing undesirable electron-emissive deposits in such devices. The invention is especially valuable in the production of ionic discharge devices, such as grid-controlled gas-filled rectifiers otherwise known as thyratrons, and will be specifically described in that connection.

The cathodes of many types of electric discharge devices, such as vacuum tubes, ionic discharge tubes, cathode-ray tubes, etc., are commonly formed by coating a surface of the cathode structure with a compound or mixture of compounds which may be broken down or decomposed by heat treatment to form an electron-emissive coating. Typical examples of such compounds are barium nitrate or barium carbonate, used alone or in mixtures with strontium and/or calcium carbonate, which may be decomposed by heat treatment to form a matrix of barium oxide and barium. The decomposition is normally carried out after the cathode structure has been mounted within the tube envelope and may cause evaporation and deposition of barium or other electron-emissive materials upon the envelope or other parts of the device other than the cathode. Furthermore, it is common practice to "break-in" ionic discharge devices during processing by establishing an arc between the cathode and the anode, which occasionally results in some sputtering when the arc is initially established; this also may undesirably deposit some electron-emissive material on electrodes of the device other than the cathode. In some high-vacuum discharge devices, the operative effects of these extraneous electron-emissive deposits are too minute to be of any great concern. However, in high-current vacuum devices and in most ionic rectifiers, such deposits present a considerable problem by causing the flow of appreciable currents between the control electrode and the anode, especially where the devices are operated at relatively high ambient temperatures. These deposits emit electrons whenever the control electrode is negative so that an opposite-polarity voltage is developed in the grid resistor, changing the control characteristics of the device.

It is an object of this invention to provide a novel method of neutralizing undesirable electron-emissive deposits in electric discharge devices.

It is a particular object of this invention to provide a novel method of neutralizing undesirable electron-emissive deposits formed on the control electrodes of ionic rectifiers during the final stages of manufacture.

It is a corollary object of this invention to provide a method of neutralizing undesirable electron-emissive deposits in electric discharge devices which is simple and expedient to perform and which does not require unduly complicated or expensive machinery.

Accordingly, the invention is directed to a method of neutralizing undesirable electron-emissive deposits incurred in the manufacture of an electric discharge device

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including an envelope and an anode, a cathode having a surface formed from a heat-decomposable compound, and a control electrode, all mounted within the envelope. The inventive method comprises the step of heating the cathode to decompose the compound and form on the above-mentioned surface an electron-emissive substance. The envelope of the device is then filled with an oxidizing atmosphere in order to oxidize any undesirable electron-emissive deposits present therewithin. Following this, the envelope is exhausted and is subsequently sealed.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The organization and sequence of performance of the steps of the inventive method, together with further objects and advantages thereof, may best be understood by reference to the following detailed description.

In its preliminary stages, the processing schedule of the invention is identical with that normally employed in the manufacture of ionic discharge devices such as thyratrons. The electrode system of the device is assembled and mounted within the envelope after which the tube is sealed to a vacuum pump and exhausted to a relatively low pressure to avoid any undesirable and uncontrolled oxidation of the tube components during subsequent processing steps. The device is then baked in an oven to drive off any volatilizable contaminants which might be present, and, while still in the oven, the cathode is heated to decompose its surface coating and form an electron-emissive substance. The device is then removed from the oven and subjected to a high-frequency magnetic field; cooling prior to the induction heating is normally required with indirectly heated cathodes to prevent oxidation of the filaments. The high-frequency field inductively heats the electrodes of the device and effectively degases these elements. Following this, the envelope of the device is filled with a selected ionizable gas, usually the same as that to be employed as an atmosphere when the device is completed, at a preselected pressure corresponding generally to the normal operating pressure of the tube. An arc discharge is then established between the anode and the cathode of the device and is maintained for a considerable interval, after which the arc is extinguished and the envelope is again evacuated. This step is included in the processing to ascertain whether or not the device will later be operable; it should be noted that some cathode sputtering often occurs during initiation of the discharge, which may result in deposition of undesirable electron-emissive deposits on the anode, control electrode, or envelope. In the normal course of processing, the device is then refilled with an atmosphere corresponding to its operating atmosphere and is operated at normal average current for a short period as a check on its performance under rated conditions. The envelope is then again evacuated and cooled to room temperature to permit filling with a desired operating atmosphere under standardized conditions; it is then sealed and is removed from the pump ready for operation.

During the above manufacturing procedure, undesirable electron-emissive deposits may be formed on various portions of the device other than its cathode; these deposits are particularly objectionable when formed on the control electrode. It has been determined that most such deposits occur during the heat treatment or activation of the cathode or during that stage of the processing in which an arc discharge is first established between the anode and cathode. In order to neutralize these deposits, in accordance with the invention, the above-outlined procedure is modified following the evacuation of the envelope subsequent to initiation of the original arc dis-

charge. At this point in the process, an oxidizing atmosphere is introduced into the envelope and remains therein for a short period of time; this step is taken to oxidize and thus neutralize any undesirable electron emissive deposits remaining in the tube after the original cleaning and degassing steps as well as to neutralize those deposits which may be formed during the cathode breakdown and original arc discharge stages of processing. The oxidizing atmosphere is then pumped out, after which the usual steps in the processing are again resumed.

In order to provide a complete and concrete illustration of the operation of the invention, the detailed steps followed in processing a type C5F14 xenon thyratron are set forth below. The thyratron comprises an anode, a control electrode, and a cathode all mounted in a glass envelope; the decomposable compound applied to the cathode prior to mounting in the envelope is barium carbonate. The cathode is of the indirectly heated type. The general operating characteristics of the tube are shown in Table A.

Table A

Filament voltage.....	14 volts.
Atmosphere.....	Xenon.
Pressure.....	62 microns Hg.
Normal average current.....	5 amperes.
Normal anode-cathode arc drop.....	8 volts.

Prior to final processing, as above, the electrodes of the device are mounted in the envelope which is then sealed to a vacuum pump and exhausted to a relatively low vacuum of the order of 20-500 milli-microns of mercury. The device is then baked in an oven for approximately one hour at approximately 470° C. to volatilize and drive off any contaminants which might be present on the internal surface of the envelope or on any of the electrodes. While still baking at 470° C., the cathode is decomposed and activated by an individual heat treatment; this heat treatment is effected by raising the filament voltage progressively up to 30 volts, approximately twice the normal filament operating voltage. This process step usually requires about two minutes. The device is then cooled to room temperature with the filament at normal operating voltage and the tube is subjected to a high-frequency magnetic field for approximately five to ten minutes to heat and degas its metallic parts. At this point, the envelope of the device is filled with a xenon atmosphere at approximately 100 microns pressure and an arc discharge is established between the anode and the cathode with the grid connected to the anode through a 10,000 ohm resistor. The arc current is progressively increased to approximately 150% of the design maximum average current until the tube arc drop is of the order of approximately 8 volts.

Following the initial activation of the cathode, the xenon atmosphere is evacuated, the entire tube is allowed to cool, and pure oxygen at several millimeters pressure is admitted into the envelope. The oxygen remains in the envelope for approximately two minutes, after which it is exhausted and the filament voltage is raised progressively to 30 volts and maintained until there is no indication of the presence of gas. This exhaustion usually requires approximately 30 seconds. The device is again filled with an atmosphere of xenon at approximately 100 microns and the initial arc discharge procedure outlined above is repeated. Following this, the xenon is exhausted, the tubulations leading to the pump are flamed out, the device is refilled with xenon and is operated at the normal average current of five amperes for approximately 15 minutes. The device is then exhausted, cooled to room temperature, and filled with xenon at the operating pressure of 62 microns, after which the envelope is sealed and the thyratron is removed from the pump ready for operation.

It will be apparent to those skilled in the art that con-

siderable variation in the above-outlined processing schedule may be made without departing from the basic teaching of the invention. For example, it has been determined that it is not necessary to use pure oxygen for neutralizing the unwanted electron-emissive deposits and that this may be carried out by the use of ordinary air or any other mixture of gases containing an oxidizing gas. Furthermore, for some devices, certain of the steps may be eliminated entirely, as, for example, the prescribed cooling prior to introduction of the oxidizing atmosphere or the "break-in" period of operation at normal tube current. However, it is essential that the oxidation of the undesirable emissive deposits be done after the cathode is activated and preferably after the original arc discharge stage. It should be noted that the time interval during which the oxidizing atmosphere remains within the envelope must be restricted so that only a superficial layer of the cathode coating is oxidized and the remainder of the emissive matrix is not affected. This time varies with the type of decomposable coating used and its thickness as well as the cathode temperature and the pressure of the oxidizing atmosphere; however, it may be readily determined for each individual cathode type. Although the paramount effect of the oxidation treatment is the neutralization of emissive deposits, the superficial oxidation of the cathode coating may also have a beneficial effect upon the operation of the device since it tends to reduce the rate of evaporation of emissive material from the cathode.

While a particular embodiment of the present invention has been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects. Accordingly, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

We claim:

1. In the manufacture of an electric discharge device having an envelope enclosing an anode, a cathode having a surface of a heat-decomposable compound, and a control electrode, the method of neutralizing undesirable electron-emissive deposits in said device comprising the following steps: evacuating said envelope; heating said cathode to decompose said compound and form on said surface an electron-emissive substance, which may concurrently cause formation of undesirable electron-emissive deposits on said envelope, said anode, or said control electrode; filling said envelope with an oxidizing atmosphere and maintaining said atmosphere for a time sufficient to oxidize any undesirable electron-emissive deposits present within said device; exhausting said envelope before oxidation of more than a superficial portion of said electron-emissive substance occurs; and sealing said envelope.

2. In the manufacture of an ionic discharge device including an envelope and an anode, a cathode having a surface formed from a heat-decomposable compound, and a control electrode all mounted within said envelope, the method of neutralizing undesirable electron-emissive deposits in said device comprising the following steps: evacuating said envelope; heating said cathode to decompose said compound and form on said surface an electron-emissive substance, which may concurrently cause formation of undesirable electron-emissive deposits on said envelope, said anode, or said control electrode; filling said envelope with an oxidizing atmosphere and maintaining said atmosphere for a time sufficient to oxidize any undesirable electron-emissive deposits present within said device; exhausting said envelope before oxidation of more than a superficial portion of said electron-emissive substance occurs; filling said envelope with a selected ionizable gas at a preselected operating pressure; and sealing said envelope.

3. In the manufacture of an ionic discharge device including an envelope and an anode, a cathode having

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a surface formed from a heat-decomposable compound, and a control electrode all mounted within said envelope, the method of neutralizing undesirable electron-emissive deposits in said device comprising the following steps: evacuating said envelope; heating said cathode to decompose said compound and form on said surface an electron-emissive substance, which may concurrently cause formation of undesirable electron-emissive deposits on said envelope, said anode, or said control electrode; cooling said cathode to a temperature below the normal operating temperature of said device; filling said envelope with an oxidizing atmosphere and maintaining said atmosphere for a time sufficient to oxidize any undesirable electron-emissive deposits present within said device; exhausting said envelope before oxidation of more than a superficial portion of said electron-emissive substance occurs; filling said envelope with a selected ionizable gas at a preselected operating pressure; and sealing said envelope.

4. In the manufacture of an ionic discharge device including an envelope and an anode, a cathode having a surface formed from a heat-decomposable compound, and a control electrode all mounted within said envelope, the method of neutralizing undesirable electron-emissive deposits in said device comprising the following steps: evacuating said envelope; heating said cathode to decompose said compound and form on said surface an electron-emissive substance, which may concurrently cause formation of undesirable electron-emissive deposits on said envelope, said anode, or said control electrode; filling said envelope with a selected ionizable gas at a preselected pressure; establishing an arc discharge between said anode and said cathode and maintaining said discharge for a predetermined interval, which may concurrently cause formation of undesirable electron-emissive deposits on said envelope, said anode, or said control electrode; extinguishing said arc discharge and evacuating said envelope; filling said envelope with an oxidizing atmosphere and maintaining said atmosphere for a time sufficient to oxidize any undesirable electron-emissive deposits present within said device; exhausting said envelope before oxidation of more than a superficial portion of said electron-emissive substance occurs; filling said envelope with a selected ionizable gas at a preselected operating pressure; and sealing said envelope.

5. In the manufacture of an ionic discharge device including an envelope and an anode, a cathode having a surface formed from a heat-decomposable compound, and a control electrode all mounted within said envelope, the method of neutralizing undesirable electron-emissive deposits in said device comprising the following steps: evacuating said envelope; heating said cathode to decompose said compound and form on said surface an electron-emissive substance, which may concurrently cause formation of undesirable electron-emissive deposits

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on said envelope, said anode, or said control electrode; subjecting said device to a high-frequency magnetic field to heat and degas all of said electrodes; filling said envelope with a selected ionizable gas at a preselected pressure; generating an arc discharge between said anode and said cathode and maintaining said discharge for a predetermined interval, which may concurrently cause formation of undesirable electron-emissive deposits on said envelope, said anode, or said control electrode; extinguishing said arc discharge and evacuating said envelope; filling said envelope with an oxidizing atmosphere and maintaining that atmosphere for a time sufficient to oxidize any undesirable electron-emissive deposits present within said device; exhausting said envelope before oxidation of more than a superficial portion of said electron-emissive substance occurs; filling said envelope with a selected ionizable gas at a preselected operating pressure; and sealing said envelope.

6. In the manufacture of an ionic discharge device including an envelope and an anode, a cathode having a surface formed from a heat-decomposable compound, and a control electrode all mounted within said envelope, the method of neutralizing undesirable electron-emissive deposits in said device comprising the following steps: evacuating said envelope; heating said cathode to decompose said compound and form on said surface an electron-emissive substance, which may concurrently cause formation of undesirable electron-emissive deposits on said envelope, said anode, or said control electrode; filling said envelope with a selected ionizable gas at a preselected pressure; generating an arc discharge between said anode and said cathode and maintaining said discharge for a predetermined interval, which may concurrently cause formation of undesirable electron-emissive deposits on said envelope, said anode, or said control electrode; extinguishing said arc discharge and evacuating said envelope; filling said envelope with an oxidizing atmosphere and maintaining said atmosphere for a time sufficient to oxidize any undesirable electron-emissive deposits present within said device; exhausting said envelope before oxidation of more than a superficial portion of said electron-emissive substance occurs; filling said envelope with a selected ionizable gas at a preselected pressure; again establishing an arc discharge between said anode and said cathode and operating said device at normal average current for a predetermined interval; extinguishing said arc discharge and evacuating said envelope; filling said envelope with a selected ionizable gas at a preselected operating pressure; and sealing said envelope.

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