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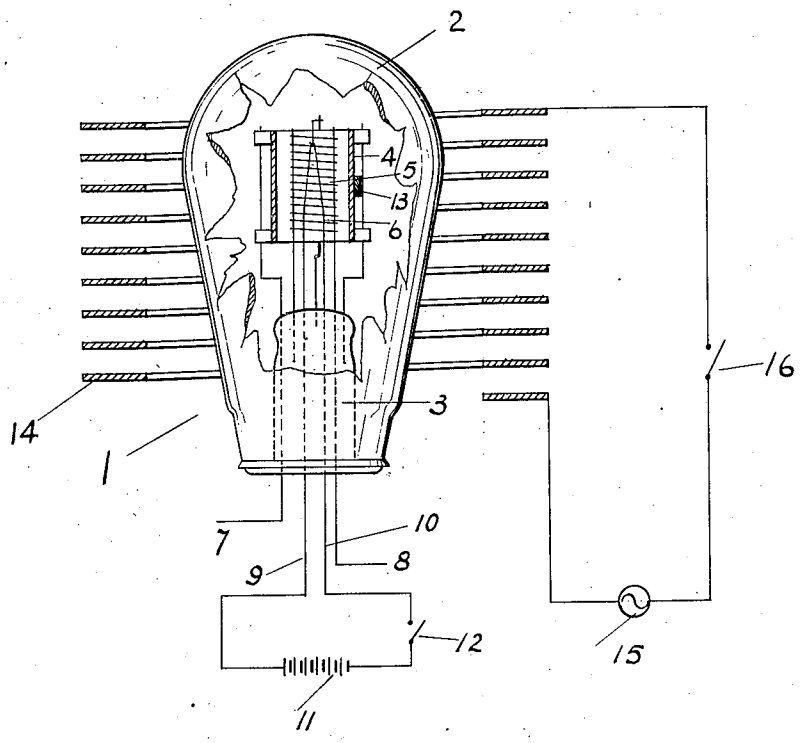

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ELECTRON-DISCHARGE DEVICE WITH OXIDE-COATED FILAMENT.

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This invention relates to an electron discharge device and more particularly to a discharge device, such as a radio tube, using a filament coated with the oxides of the alkaline earth metals.

One of the objects of the invention is to produce an oxide coated filament tube having a long commercial life, high electron emission and substantial freedom from erratic behavior.

Another object is to produce an oxide coated filament tube which is hard when first produced and which will increase in hardness throughout its life.

Another object is to provide a method of producing oxide coated filament tubes which are uniform in their operating characteristics.

A further object is to provide an improved method of treating the filament of an oxide coated filament tube and cleaning-up the gases contained therein.

Other objects and advantages will hereinafter appear.

The invention is especially concerned with the cleaning-up of gases in electron discharge devices, by means of certain metallic clean-up agents, such as misch metal, and to the activation of the filament by conversion of a coating of the carbonates of the alkaline earth metals, to the oxides thereof.

In a prior application, Serial No. 679,489, of John W. Marden and Harvey C. Rentschler, entitled Clean-up and activation by misch metal and the rare earth metals, filed December 8, 1923 and assigned to the Westinghouse Lamp Company, there is set forth the use of misch metal or other metal of the cerium group of rare earth metals, as a clean-up agent for evacuated devices, such as radio tubes and there is pointed out, in said application, the advantages of metals of this nature over other clean-up agents. There is also described in applicant's copending application, Serial No. 740,409, entitled Vacuum device and method of manufacture, filed September 27, 1924 and assigned to the Westinghouse Lamp Company, a simple manner of using misch metal in radio tubes consisting briefly in constructing the plate of iron and attaching the misch metal directly thereto. The misch metal is vaporized by heating the plate by high frequency induction currents.

The present invention is based on the discovery that certain residual gases left in tubes which apparently have been quite thoroughly exhausted, or gases which may have been liberated by the plate or other part of the device, may cause very erratic emission from cathodes coated with the oxides of the alkaline earth metals. These gases, moreover, may cause a decided decrease in the emission obtained from the filament.

For convenience in handling, it is common practice, in producing oxide coated filaments, to coat them with the carbonates of barium or strontium or a mixture thereof. These carbonates are stable in air and after the filaments have been mounted in the tube, they can readily be converted to the oxides by simply heating the filament. The conversion of the carbonates to the oxides is preferably accomplished after the tube has been exhausted and sealed off from the pump, for reasons which will more fully appear hereinafter.

I have found that the residual gases should be eliminated from the device prior to the decomposition of the carbonates, and that means must also be provided for cleaning-up the gases evolved from the filament on decomposition thereof. This is rendered possible in a simple manner by the use of misch metal in a manner to be described, and tubes having a remarkable degree of uniformity and consistency are obtained. These tubes require very little seasoning, are hard at the beginning of their life and become harder throughout their life.

Filaments treated in accordance with this invention have an emission much higher than that normally obtained with oxide coated filaments produced by the general methods in use. For instance, with oxide coated filaments designed to operate in commercial tubes now on the market, at .25 amperes, I am able to obtain by my treatment, easily detectable emission at as low as .10 amperes and quite satisfactory emission for operation of the tube at .16 amperes. Furthermore, the emission for a definite filament temperature and plate voltage is quite as definite as for a metal filament and not variable as is often the case with the present commercial oxide coated filament tubes.

The emission from oxide coated filaments, as heretofore produced, with a fixed filament current and plate voltage, will often take a certain value and then slowly increase or

decrease or fluctuate first one way and then the other. I have found that this erratic behavior and low emission, as compared with results which are obtained by the present invention, are due very largely, if not entirely, to certain gas reactions in the tube which effect the filament.

In accordance with this invention, which will be described hereinafter as applied to the production of radio tubes, the filaments may be coated with the carbonates of the alkaline earth metals, such as barium and/or strontium carbonate, as is well known in the art, and the filaments mounted in the tubes in the usual manner with a grid or other form of control electrode and a plate or anode to which a piece of misch metal or other metal of the cerium group of rare earth metals has been attached. The tube may be exhausted and the glass parts baked out on the pumps in the usual manner and preferably the plate is given a partial heat treatment by high frequency induction currents while on the pump, to drive off some of the occluded gases and vapors. This heat treatment of plate on the pump is not absolutely essential, however, and in no case should it be continued for a sufficient length of time to vaporize an appreciable amount of the misch metal carried by the plate. The tube may then be sealed off from the pump and based after which the plate may again be heated by high frequency induction to vaporize a small quantity of the misch metal to clean-up the residual gas in the tube and any additional gas liberated from the plate and other parts of the device. This thorough cleaning-up of all gas in the tube prior to the decomposition of the carbonates on the filament, is essential in order to obtain the best emission from the filament. The coating of the alkaline earth carbonates may then be converted to the oxides by passing a current through the filament to heat it somewhat above its normal operating temperature. For instance, with a .25 ampere filament, I prefer to use about .3 to .33 amperes heating current for this purpose.

It should be noted that the decomposition of the carbonates to the oxides is accomplished in practically the complete absence of residual gases since these gases were first cleaned up by the preliminary flashing.

With the filament still hot, the plate may again be heated by high frequency induction and an additional portion of the misch metal vaporized to clean-up the gases liberated from the filament or driven off from the heated portions of the tube. The excess misch metal deposits in a thin film on the bulb and serves throughout the life of the tube to maintain it in a hard condition. The tube so produced is hard to start with, and throughout its life gradually increases in hardness. However, the bulb is only partially coated with the misch metal when it is vaporized and by properly placing the misch metal on the plate, any desired portion of the bulb may be left clear.

The seasoning required in using misch metal in the manner described above, is extremely simple, it being sufficient to burn the filament at its normal operating temperature with normal plate voltage for about five minutes or even less, after flashing the getter.

The advantage of cleaning-up the residual gases prior to decomposing the carbonates of the filament is illustrated by the following observations. When the carbonate was converted, without first cleaning-up the residual gas, even though the tubes were exhausted on a diffusion pump, the emission at the lower filament currents, say .16 to .20 amperes were usually quite unsatisfactory and the tubes generally required from .20 to .25 amperes filament current for satisfactory operation in a receiving circuit. Again, when a slight amount of gas, such as hydrogen or oxygen at a pressure of a fraction of a millimeter was introduced into the bulb, after exhausting the tube and flashing a portion of the getter, and the carbonates converted without first cleaning-up the introduced gas, similarly poor results were obtained. Tubes so obtained were as hard as those properly flashed but were practically useless at .20 amperes and had relatively poor emission at .25 amperes. In still other tubes, the bulb was tubulated at both ends and a stream of oxygen blown through the tube during conversion of the carbonates and such tubes proved to be erratic and much inferior to those in which the carbonates were decomposed in the complete absence of active gases. These tests and others clearly indicate the deleterious effect of residual gases in the tube during the conversion of the carbonate coating on the filament.

It was found that certain tubes not properly treated in accordance with this invention had an appreciable quantity of barium or strontium oxide on the grid. It could not be definitely determined whether the oxide was deposited on the grid as a result of the improper treatment or due to mechanical scraping of the filament against the grid during mounting but such tubes were always found to be erratic in behavior. The presence of such oxides on the grid is easily shown by heating the grid by bombardment from the filament then suddenly discontinuing such bombardment, and impressing a voltage between the grid and plate, with the grid negative, and noting the electron current flowing from the grid to the plate.

Among other advantages which may be pointed out in connection with the present invention, are the production of uniform tubes having high electron emission at low filament temperature, long life, and constant operating characteristics as distinguished from er-

ratic behavior. Also the tubes require very little seasoning, i. e., are hard at the beginning of their life and moreover, while having a substantially clear bulb they contain a getter material which serves throughout the life of the tube to maintain it in a hard condition or to actually increase its hardness.

In order that the invention may be more fully understood, reference will be had to the accompanying drawing, the single figure of which illustrates a radio tube and means associated therewith for carrying out the process herein described.

The electron device comprises a bulb 2 with a stem 3 sealed therein, supporting a plate 4, grid 5 and an electron-emitting filament 6. Leading-in wires 7 and 8 are connected to the plate 4 and grid 5 respectively. The filament 6 is joined to leading-in wires 9 and 10 and may be heated by any suitable source of current, as a battery 11 connected in circuit therewith through a control switch 12. The filament 6 may comprise a platinum-iridium core coated with the carbonate of barium and/or strontium.

Prior to its introduction into the bulb, the plate 4 and grid 5 may be baked in hydrogen to remove traces of oxides and other impurities therefrom and the plate has applied thereto a small piece of misch metal 13, as by welding.

After sealing of the mount into the bulb, the bulb may be exhausted by any suitable means.

A coil 14 connected to a high-frequency generator 15 or other source of high-frequency current, through a switch 16 may be applied around the bulb so that when the switch is closed, high frequency current in the coil 14 will induce high-frequency current in the plate and other metal parts of the device and heat the same to a high temperature to drive off occluded gas therefrom and vaporize some of the misch metal 13.

As before stated, I prefer to energize the high frequency coil 14 during the exhausting of the tube, in order to heat the plate and drive therefrom the major portion of the occluded and adsorbed gases and vapors. After the bulb has been sealed from the pump and based, the plate is again heated to remove any additional occluded gases and to vaporize a portion of the misch metal to clean-up such gases and any residual gas contained in the tube.

The carbonates on the filament may then be converted to the oxides by closing the switch 12 to energize the filament and heat the same above the decomposition temperature of the coating.

While the filament is still hot the switch 16 may again be closed to heat the metal parts of the tube and vaporize a further portion of the misch metal to clean-up the gas evolved on decomposition of the filament and the gas liberated from the other metal parts.

The bulb and its contained parts are maintained in a heated condition until the glow in the interior of the bulb entirely disappears, thus indicating that the gas has been entirely eliminated from the bulb. Thereafter the tube should be seasoned for about five minutes, as set forth above.

It will be noted that the decomposition of the carbonates takes place in a completely inert environment so that no contamination of the filament coating may take place and that at the time this misch metal is vaporized, the filament and other contained parts of the tube are in a highly heated condition, whereby the gas evolved on decomposition of the filament or occluded in the various parts of the device will be driven therefrom and entirely cleaned up by the misch metal. The advantage of having all of the parts of the device heated simultaneously with the vaporizing of the getter is obvious, since if certain parts were to remain cool, the gas liberated by the heated portions would be partially reabsorbed by the cool portions and therefore would not be cleaned up by the getter.

Misch metal is particularly adapted to the present invention due to the very effective clean-up obtained thereby and to the relatively slow volatility thereof whereby, unlike magnesium and various other clean-up agents, it does not all volatilize at once but may be vaporized in successive portions and clean-up action obtained before and after decomposition of the carbonates on the filament. While misch metal or other metals of the cerium group of rare earth metals have been specifically mentioned, it is to be understood that any other metallic clean-up agent which can be vaporized in steps and which has similar clean-up action to misch metal, may be employed.

While the invention has been described as applied particularly to radio tubes, it is to be understood that it is not so limited but may be applied to electron discharge devices of whatever type, employing an oxide coated filament and that many changes and modifications may be made in the process described without departing from the invention.

What is claimed is:

1. The method of producing electron devices having a plate and an electron-emitting cathode which comprises coating the cathode with a carbonate of an alkaline earth metal, sealing the plate and cathode in an envelope, evacuating the envelope, and thereafter heating the filament to decompose the coating thereon to the oxide and while the filament is in a heated condition vaporizing a metallic clean-up agent within the envelope.

2. The method of producing electron devices having an electron-emitting cathode which consists in coating the cathode with a compound of the alkaline earth metals, sealing the cathode into an envelope, introducing

a clean-up agent into the envelope, exhausting the envelope, vaporizing a portion of the clean-up agent to eliminate the residual gases in the envelope, heating the filament to decompose the compound and while the filament is in a heated condition vaporizing another portion of the clean-up agent to eliminate the gases evolved from the filament.

3. The method of producing electron devices including a plate and a filament, comprising coating the filament with carbonates of the alkaline earth metals, attaching a piece of misch metal to the plate, sealing the filament and plate into the envelope, evacuating the envelope, then heating the filament to decompose the carbonates and while the filament is in a heated condition, heating the plate to vaporize the misch metal to clean-up the gases evolved from the filament.

4. The method of treating an electron device having a plate and a filament consisting in heating said plate and filament to liberate gases therefrom and while in said heated condition vaporizing a rare earth metal of the cerium group to clean-up said liberated gases.

5. The method of producing electron devices having an oxide coated filament and a plate which comprises coating the filament with the carbonate of an alkaline earth metal, sealing said filament and plate into an envelope, introducing a quantity of a rare earth metal of the cerium group into said envelope, vaporizing a portion of said metal to produce a high vacuum in the device, passing a current through said filament to decompose the carbonate, heating the plate and while said parts are in a heated condition, vaporizing another portion of the misch metal in said envelope and maintaining it in a vaporous condition for a sufficient time to completely clean-up the gases evolved from said parts.

6. The method of activating filaments coated with the carbonates of the alkaline earth metals which comprises heating the filament in a high vacuum at a temperature above the decomposition temperature of the carbonates and cleaning-up the gases evolved in the filament by a metallic clean-up agent.

7. The method of activating filaments coated with the carbonates of the alkaline earth metals which comprises passing a current through the filament to heat the same to a temperature sufficiently high to decompose the carbonates and while the filament is heated, vaporizing a metal of the cerium group of rare earth metals in the presence of the filament to eliminate the gases evolved from the filament.

8. The method of activating filaments coated with the carbonates of barium and strontium which comprises removing all deleterious gases from the presence of the filament, heating the filament to decompose the carbonate coating and while the filament is in a heated condition, vaporizing misch metal in the presence of the filament to eliminate the gases evolved therefrom.

In testimony whereof, I have hereunto subscribed my name this 27th day of March, 1925.

HARVEY CLAYTON RENTSCHLER.