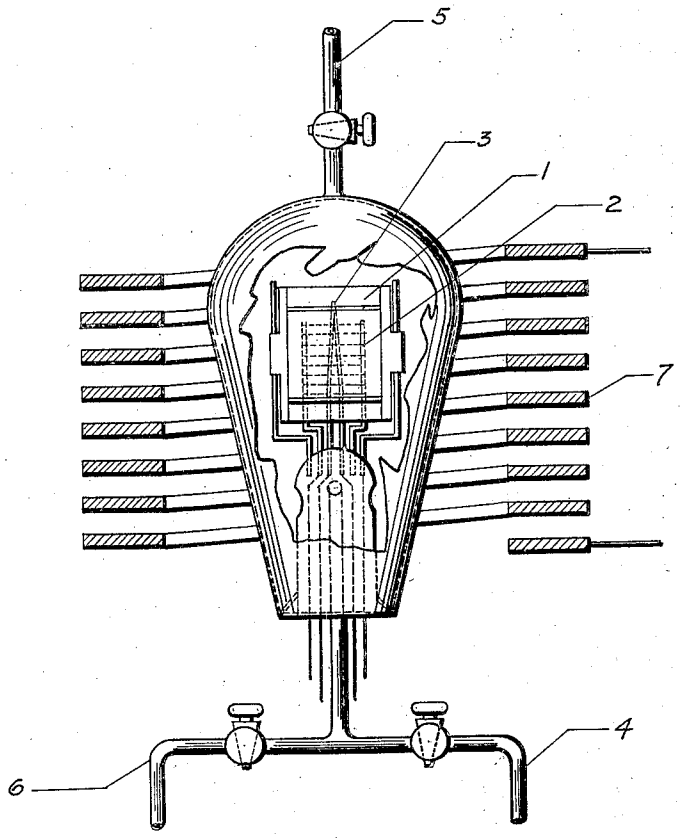
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ELECTRON DISCHARGE DEVICE

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ELECTRON-DISCHARGE DEVICE

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This invention relates to an electron discharge device and more particularly to a discharge device such as a radio tube employing an anode or plate electrode and a cathode of the thoriated type adapted to operate at incandenscence.

Thoriated cathodes are well known in the art and consist briefly of a tungsten filament having a very minute quantity of thorium or of a thorium compound distributed throughout. In view of the very limited qantity of the active electron-emitting substance, namely the thorium contained in the filament, it is essential that every precaution be taken to eliminate from the device any material which can react with the thorium to decrease the emission thereof. For instance, in commercial practice the bulb is now carefully baked during exhaust and the plate heated to a high temperature by some suitable means, as by high frequency induction currents to drive off the gases and vapors therefrom and a clean-up material such as magnesium or misch metal is vaporized in the bulb to eliminate any residual or occluded gases contained therein and form an active getter for such gases as are liberated during operation.

In spite of these precautions, tubes which are manufactured and treated as nearly alike as is physically possible, show different operating characteristics and have a very different useful life, some tubes failing very early while others may have a relatively long life. This variation in life is particularly noticeable in tubes using filaments having a low power consumption, such as dry cell tubes and clearly indicates that there is a variable condition present in the manufacture of thoriated filament tubes which heretofore has not been under control.

One of the objects of this invention is to provide a method by which electron discharge devices of the thoriated cathode type having a uniform high emission and a long commercial life may be consistently produced.

Another object is to provide a method of producing electron discharge devices of the thoriated cathode type in which the variable conditions which heretofore have materially affected the operation or life of the device are readily controlled and made constant.

Another object is to provide an electron discharge device of the thoriated filament type substantially free from material capable of reacting with the thorium of the filament to decrease the electron emission properties thereof.

Another object is to provide an electron discharge device which will be stable in operation, which will have a long and dependable life and which may be readily reproduced.

Other objects and advantages will hereinafter appear.

We have found that the cause of early loss in emission of thoriated tungsten filaments is due very largely to the presense of occluded oxygen or decomposable oxides on the plate or on the plate and grid and further that such falling emission is not appreciably caused by pure chemical reaction of the filamentary material with the residual gases of the device or by positive ion bombardment due to the presence of residual gas in the tube. This is clearly indicated by the following experiments which will be given briefly in order that the invention may be more fully understood.

For the sake of simplicity, the experiments about to be described were conducted principally with two element tubes, that is, tubes employing only a plate and a thoriated filament, although it is to be understood that the invention is not limited to devices of this nature since the results obtained apply equally well to discharge devices employing a grid or control electrode.

We have found that when using iron, nickel, or molybdenum plates, that the emission of the filament after seasoning dropped noticeably in a minute or less when plate voltages of about 40 volts were used and that with higher voltages the drop in emission was correspondingly greater. The results were not noticeably affected by the kind of clean-up agent or getter used or by the degree of care with which the tubes were baked out and exhausted. The fact that burning of the filament without plate voltage or with plate

voltage under about 40 volts did not destroy the emission, indicates that the drop in emission is not due to direct chemical action of the free residual gases in the tube with the thorium of the filament.

Tubes which were made up with aluminum plates instead of nickel, iron or molybdenum required a plate voltage of from 65 to 70 volts instead of about 40 volts to produce the similar falling emission. In using aluminum plates it was necessary to flash the getter from an auxiliary plate since aluminum has a melting point below that of magnesium or misch metal which were used as getters. Also, care was taken to have the aluminum as free from grease etc., as possible, but no more care was exercised than when using iron, nickel or molybdenum plates.

Apparently a two-fold effect takes place in the cathode during operation. First, the thorium on the surface of the cathode is either removed or reacts with some material in the tube to form compounds which are poor emitters, and secondly, the thorium diffuses to the surface of the filament from the interior to replace the thorium removed from the surface. When the thorium is removed or destroyed faster than it is diffused to the surface, the emission falls. The fact that the falling emission requires a different plate voltage when using one kind of a plate than when using another, clearly shows that it cannot be due to the positive ion bombardment caused by minute traces of residual gases, but rather to some condition of the plate. We have found this falling emission to be due almost entirely to the electron bombardment of the plate and the consequent liberation of harmful gases therefrom which react with the thorium to reduce the emissivity thereof.

Tubes employing iron, nickel, or molybdenum plates through which a stream of hydrogen was passed during baking out of the bulb on the pump were uniform in operation and did not exhibit this falling emission. This indicates, in all probability, that the oxides on the plate which were formed during the mounting, sealing and exhaust of the bulb or were left unreduced before introducing in the bulb, were reduced by the hydrogen stream and the plate, therefore, during electron bombardment was not capable of liberating oxygen for reaction with the thorium of the filament.

This theory that falling emission is due to oxygen liberated from the plate is further verified by the fact that when using aluminum plates the falling emission does not occur at as low a plate voltage as when using iron, nickel or molybdenum plates, aluminum oxide being more stable than iron, nickel or molybdenum oxide.

In accordance with the present invention, the plate or the plate and grid of the electron discharge device are freed from occluded oxygen or residual oxides after these elements have been mounted in the device. The freedom from oxygen or oxides may be obtained in several different ways. For instance, a stream of hydrogen may be passed through the tube during exhaust and while baking the tube, as set forth above, or the plate may be composed of a metal, the oxide of which is readily decomposed by heat or when heated in hydrogen liberated from the plate such as silver, gold or platinum. For economy of manufacture, however, we prefer to make the plate or both the plate and grid, of copper. We have found that if copper is first heated in hydrogen or if made to contain occluded hydrogen in any suitable manner prior to sealing the same into the envelope, that the tubes in which such plates are used do not show falling emission with even as high as 135 volts on the plate. Higher voltages have not been tried. Electrolytic copper is particularly adapted for the construction of plates and/or grids since it as a rule, already contains sufficient occluded hydrogen to effect a reduction of the oxides thereon.

We found, however, that the emission obtained using iron, nickel and molybdenum plates was not materially affected by baking the plates in hydrogen prior to sealing-in.

In manufacturing tubes using copper plates and grids, the tubes are made up in the usual manner and a getter, which may comprise a small piece of magnesium is attached to the plate. The tubes should be baked out during exhaust and the plate heated as by high frequency induction to drive out the occluded hydrogen to effect a reaction between this hydrogen and the oxygen or oxides on the plate and to vaporize the magnesium to clean-up the gases so liberated. The tube should then be seasoned in the usual manner.

When using silver as the material for the plate, the baking in hydrogen may be eliminated, it being only necessary to heat the plate, to drive the occluded gases therefrom and cause a reduction of the oxides. The plate is thus rendered substantially free of materials capable of being liberated by electron bombardment during operation and deleteriously affecting the emission of the cathode.

In the single figure of the drawing there is shown an electron discharge device of the conventional type such as is used for radio receiving apparatus. This tube comprises the usual plate, grid and filament electrodes 1, 2 and 3, respectively. The cathode or filament 3 may be of the thoriated tungsten type or of other type, the emission of which is readily destroyed or impaired by oxygen and the plate 1 may be composed of copper or, if desired, silver, iron, nickel or molybdenum, or other suitable metal, the oxide of which is readily reduced by hydrogen. In case one of the latter metals is employed as the anode it is necessary to provide means for passing a stream

of hydrogen through the device during the baking operation. For this purpose a connection 4 is made to the exhaust tube from a supply of hydrogen not shown and a tubulature 5 is secured to the dome of the bulb to permit the exit of the hydrogen therefrom. A separate connection 6 from the exhaust tube is provided for the vacuum pump. In order to treat out the plate when employing as the plate material, a metal which is not reduced by heat alone in vacuum, the envelope is first exhausted through the connection 6 and a stream of hydrogen permitted to flow therethrough to the connections 4 and 5. Simultaneously with this hydrogen flow the plate is heated in any suitable manner as by a high frequency induction coil 7 to raise the plate to a sufficiently high temperature to effect a reduction of the oxides thereon by the hydrogen. The tube is then re-exhausted and sealed off. When employing copper containing occluded hydrogen or when using silver as a material for the plate, it is unnecessary to maintain a hydrogen stream through the tube during the heat treating of the electrodes and in this case the connections 4 and 5 may be dispensed with.

While copper has been specified as the preferred material for forming the plate, it is to be understood that other suitable materials may be used either alone or coated with copper or silver, and the plate may be treated in various manners to free the same from oxygen or metallic oxides.

It will be noted that an electron discharge device has been produced, the plate or the plate and grid of which is substantially free from oxides, that such tubes are uniform in their operating characteristics, have a long life and a high emission and may be readily reproduced.

What is claimed is:

1. An electron discharge device comprising an envelope, a cathode of the thoriated type and an anode composed of copper containing occluded hydrogen.

2. The method of producing an electron discharge device employing a thoriated cathode and at least one cooperating electrode which consists in forming said cooperating electrode of copper containing occluded hydrogen, sealing said cathode and cooperating electrode into an envelope, exhausting the envelope, reducing the oxides formed on said cooperating electrode to the metal and rendering the reaction products thus formed, inactive with respect to the cathode.

3. The method of producing an electron discharge device employing a thoriated cathode and a cooperating copper electrode comprising baking said electrode in hydrogen, sealing the cathode and cooperating electrode into an envelope, evacuating the envelope, heating said electrode to cause a reduction of the oxides thereon and rendering the reaction products thus formed inactive with respect to the cathode.

4. The method of treating a cooper anode for an electron discharge device consisting in baking said anode in hydrogen, sealing the same into an envelope, exhausting the envelope and heating said anode to cause a reduction of the oxides thereon by the hydrogen occluded therein.

In testimony whereof, we have hereunto subscribed our names this 27th day of March, 1925.

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