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ELECTRON DISCHARGE APPARATUS AND METHOD OF OPERATING THE SAME.

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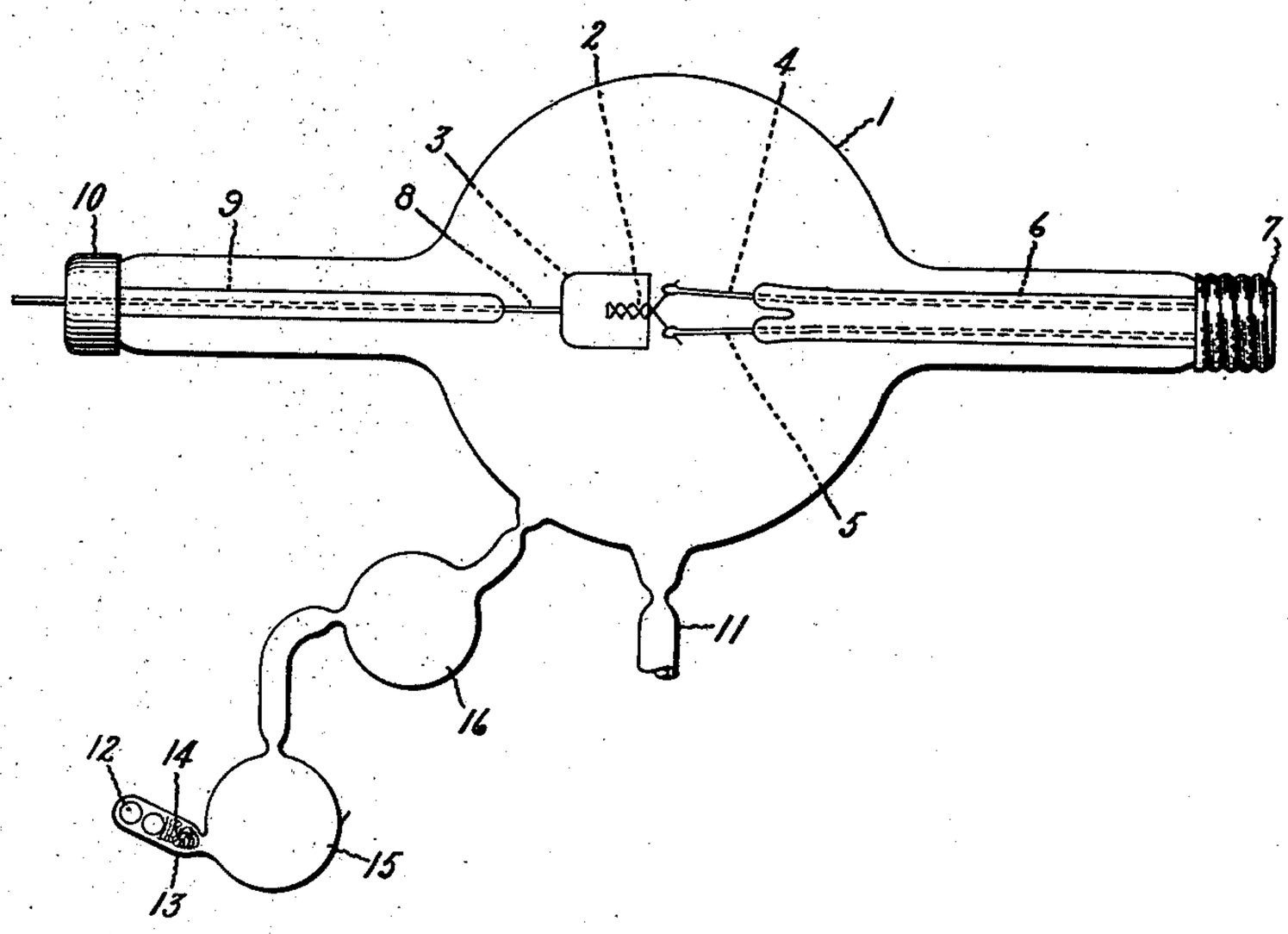
1,244,217. Patented Oct. 23, 1917.



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UNITED STATES PATENT OFFICE.

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ELECTRON-DISCHARGE APPARATUS AND METHOD OF OPERATING THE SAME.

1,244,217. Specification of Letters Patent. Patented Oct. 23, 1917.

Application filed October 28, 1915. Serial No. 58,377.

To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Electron-Discharge Apparatus and Methods of Operating the Same, of which the following is a specification.

The present invention relates to electrical devices having an electrode consisting at least in part of thorium and having at a given temperature an electron emission per unit surface materially greater than the emission of a refractory metal such as tungsten at the same temperature independently of and in the absence of positive ionization. These devices are described and claimed in a copending application, Serial No. 851,095, of July 15, 1914, renewed on June 25, 1917, as application Serial No. 176,926, to which the present application is closely related.

In the preparation of these devices great care must be exercised to remove the last traces of oxygenous gases, particularly water vapor, and precautions must be observed not to evolve water vapor from the bulb walls during the operation of the device.

In accordance with my present invention, I have improved the above described device and also rendered easier the preparation of the same by providing in the envelop a quantity of a vaporizable reagent of low vapor pressure capable of preventing the oxidation of thorium. I prefer to use for this purpose an alkali metal, such for example, as potassium.

The accompanying drawing illustrates one particular form of apparatus to which my invention is applicable, namely, an incandescent cathode discharge device provided with means for introducing the desired reagent.

The device shown in the drawing which may be used for rectifying alternating current, comprises an envelop 1 consisting of a glass not chemically attacked by alkali metal provided with a cathode 2 consisting for example of thoriated tungsten, and a cylindrical or cup-shaped anode 3, also consisting of a highly refractory metal, such for example, as tungsten. A heating current may be conveyed to the cathode by leading-in conductors 4, 5, sealed into a stem 6 in the usual manner and connected to a threaded socket 7 similar to an incandescent lamp socket. The anode stem 8 is also sealed into a glass stem 9 and attached to an external metal cap 10.

The cathode 2 is prepared by adding a thoria compound, such as nitrate of thorium to the oxid of tungsten before reduction of the metal, or by adding either thorium nitrate or thoria to the metal powder after reduction, but before consolidation of the metal powder by sintering and mechanical working to the solid state as described, for example by reference to thoriated tungsten in U. S. Patent #1,082,933. The proportion of thoria in the unsintered metal usually varies from ½ to 10% but in some cases may be even greater. The proportion of thorium compound within the above limits makes little difference in the maximum electron emission that may be obtained under the best conditions but the favorable conditions will be more easily attained with a greater than with a lesser amount.

The preliminary evacuation of the envelop is carried out by the usual methods of producing a non-striking high vacuum, which includes baking out the envelop to remove water vapor. The final stage of the evacuation is preferably but not necessarily carried out by a Gaede molecular pump to the highest possible vacuum obtainable by this means, that is, to about .001 micron. While the apparatus is still on the pump the cathode 2 is heated to a temperature of about 2900° K. (2727° C.) for a short time and the envelop 1 is baked out in an oven at a temperature of about 360 to 450° C.

The substance to be distilled into the envelop, for example, potassium, is indicated at 12 in a small side chamber 13, a small quantity of glass particles, or glass wool, 14 being preferably placed in front of the reducing material. As already indicated all glasses (including the glass wool) used in the apparatus should be unattacked by alkali metal. When the envelop is baked out care should be exercised not to heat the chamber 13 to too high a temperature. The potassium, or other material, is transferred by melting into a communicating chamber 15, after which the chamber 13 may be sealed off. Thereupon, the material is distilled into a second communicating chamber 16 and

finally a very small amount is introduced into the main envelop 1, both the chambers 15, 16 being successively sealed off. The redistillation of the reducing material serves to purify it. Although alkali metals have been indicated as preferable for the purposes of my invention, other reducing materials may be used, for example, hydrocarbon compounds. The bulb is finally sealed from the vacuum system at the contraction 11.

The thoriated cathode 2 is now heated to about 2900° K. for about one minute. The treatment of the filament at this temperature appears to be desirable for purifying the surface of the cathode. The cathode is then incandesced within the range of about 2000° to 2400° K. and by this temperature treatment some change is produced in the cathode which enormously increases its electron-emitting property under the condition described. The greatest activity is obtained between about 2200° to 2500° K. and the treatment at this temperature is usually continued for about one minute. Apparently a concentration of metallic thorium or of some other oxidizable thorium material takes place on the surface of the filament. The filament 2 may now be used as a cathode at or below this forming temperature.

The presence of the reducing agent in the main receptacle maintains the thorium reduced in spite of traces of water vapor which may be liberated from the glass. In any event the high electron emissivity of the thoriated cathode is more easily secured and maintained in the presence of the reducing agent than without it.

With a filament thus prepared I have obtained at a temperature of about 1300° to 1380° K. substantially the same electron emission per sq. cm. as with a pure tungsten filament at about 2000° K., that is, about three milliamperes per sq. cm. A thoriated cathode may be operated around 1700° to 1800° K., at which temperatures its life is long, and thermionic current may be obtained many thousands of times greater than obtainable with pure tungsten at the same temperature.

Subsequently heating the filament to a higher temperature, for example, to 2800° K. causes some change, apparently a distillation of the film of thorium from the surface, as the electron emitting power of the cathode falls to the same order of magnitude as pure tungsten. When the cathode after being thus heated is re-subjected to a temperature of 2200° to 2300° K. the active condition is restored.

The vapor pressure of potassium, sodium or other alkaline metal at room temperature is so low that objectionable positive ionization of its own vapor during the operation of the pure electron device is negligible and the vapor pressure of the oxidation products of the alkaline metal have no perceptible vapor pressure. For this reason, the alkali metals are to be preferred to carbonaceous compounds as reducing agents in the present device.

The vapor of alkaline metals does not produce an increased emission of a pure tungsten filament thereby furnishing proof that the beneficial effect of the alkaline metal is exerted upon thoria content of the filament and is not due to some ionization phenomena.

Under carefully controlled conditions the benefit of the increased electron emission of a thorium-containing cathode may be secured in a device filled with an inert gas, such, for example, as argon or other monatomic gases, at pressures ranging from a few millimeters of mercury pressure upward, in the presence of potassium or equivalent material for preventing the oxidation of thorium. Care must be exercised to have the cathode at a high enough temperature with reference to the current transmitted so that the vicinity of the cathode is surrounded by free electrons. In other words, the electron emission should be greater than necessary to convey the current thereby preventing a removal of the active thorium material on the surface of the cathode by a bombardment of positive ions.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. An electrical discharge device comprising electrodes, one of which contains thorium, an inclosing envelop the space within which is evacuated to a pressure so low that positive ionization is substantially absent, and a quantity of a vaporizable reagent capable of preventing the oxidation of thorium in communication with the space within said envelop.

2. In an electrical discharge device, an inclosing envelop, a quantity of alkali metal within said envelop, and electrodes therein, one of which comprises in part at least, oxidizable thorium material, said electrodes having at a temperature of about 1300 to 1380° absolute an electron emission substantially equal to that of tungsten at about 2000° absolute.

3. In an electrical discharge device, an inclosing envelop, a quantity of potassium within said envelop, and electrodes therein, one of which consists largely of tungsten and containing thorium, said electrode having an electron emissivity at a given temperature materially greater per unit surface than tungsten at the same temperature.

4. An electrical discharge device comprising electrodes, one of which consists of metallic tungsten and a thorium material in an oxidizable state, an inclosing envelop, and a quantity of a vaporizable reagent within said envelop capable of preventing

the oxidation of thorium at an elevated temperature.

5. The process of improving the operation of an electron discharge apparatus containing an electrode operating at incandescence comprising a highly refractory metal and a thorium material which consists in bringing into contact with said electrode the vapor of a reagent preventing the oxidation of thorium at an elevated temperature.

6. The process of improving the operation of an electron discharge apparatus containing an electrode of tungsten and thorium operating at incandescence in a non-striking vacuum, which consists in bringing into contact with said electrode the vapor of an alkali metal at a pressure too low to cause appreciable positive ionization phenomena.

7. An electrical device comprising the combination of a sealed evacuated envelop, a refractory cathode, means for heating said cathode to incandescence, a coöperating anode and a quantity of potassium within said envelop.

8. An electrical device comprising the combination of an evacuated envelop, a cathode, an anode and a quantity of alkali metal inclosed within said envelop, and means for heating said cathode to incandescence.

In witness whereof, I have hereunto set my hand this 27th day of October, 1915.

IRVING LANGMUIR.