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CATHODE AND METHOD OF PREPARING THE SAME

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Fig. 1.

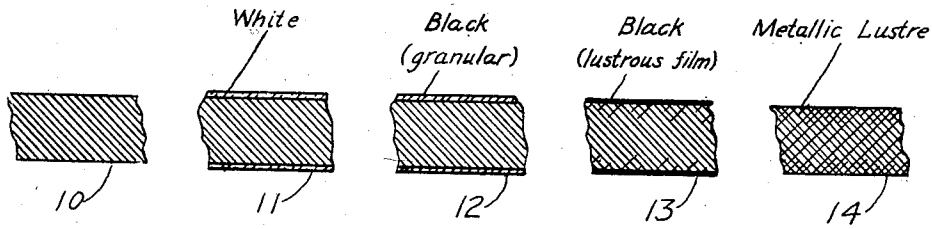
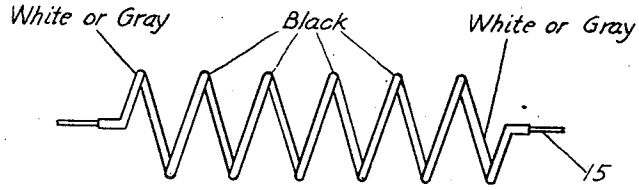


Fig. 2.



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CATHODE AND METHOD OF PREPARING THE SAME

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Application July 30, 1932, Serial No. 626,618

15 Claims. (Cl. 250—27.5)

This invention relates to electron emissive cathodes and method of preparing same, and has special utility for cathodes in gaseous discharge tubes having control electrodes.

In the operation of discharge tubes of the type known as control tubes in which the starting of an arc discharge between the cathode and anode is controlled by a third element, it is important that the various operating characteristics of the tube shall remain constant throughout its life. In some applications there are periods of no-load with the cathode heated; in such case it often happens that the point of control will shift more and more from that which is normal for the tube, until control is completely lost.

One of the causes of such difficulty is the vaporization of highly electro-positive metals and the deposit thereof upon the normally non-emissive electrodes. Such vaporization occurs, in coatings containing barium, at temperatures as low as 600° C.

The object of the present invention is to devise a cathode and method of making the same, such that the cathode will have a high degree of stability with minimum vaporization of the electro-positive metal, at temperatures above the melting point of the electro-positive metal.

In carrying out our invention we form a core of suitable base metal, such as nickel, and dissolve therein an emissive compound of a highly electro-positive metal which is soluble in the core metal. The chemical changes which take place have not been exactly determined but they are evidenced to the unaided eye by changes in appearance and color of the treated core.

One embodiment of the invention has been selected for the following description which should be read in connection with the accompanying drawing, in which

Fig. 1 represents a portion of a cathode or filament, embodying the invention, in several stages of its treatment; and

Fig. 2 illustrates a similar filament formed into a coil.

A core, preferably of nickel, is formed to the shape and size which it will have in the cathode structure of which it is to be part, and is heated in air to oxidize its surface. Such a core is illustrated at 10 in Fig. 1. A coating 11, which preferably consists of an alkaline earth carbonate or a mixture of such carbonates in the form of a water paste is applied to the core. A preferred substance is carbonate of barium, and a suitable amount is approximately 6% by weight of the core material. The coating is dried in air at a temperature of about 300° to 400° C. to remove the water before subjecting the core to higher temperatures. The coating then has a white color.

The white coated core is then further heated in air or in the presence of oxygen to a temperature of approximately 800° C., to convert the major portion of the coating to barium oxide. A simple method for heating the core consists in passing a suitable current through it. After the coating has been oxidized, the temperature of the core is then increased to approximately 900° C. which changes the coating to a compound having a black color and a granular structure, as illustrated at 12. A further increase in temperature to approximately 1000° C. causes the black, granular coating to melt and dissolve in the core, as indicated at 13. During the several heating steps it is preferable to have a draft of air passing over the core.

Upon cooling, the core has a lustrous black surface having the appearance of a vitreous film thereon. The barium compound thus formed is not confined to the core surface however, but penetrates the surface and includes a portion of the core metal in its composition.

At this stage of the treatment the cathode may be assembled in a tube. The treatment is then continued by heating the cathode to approximately 1100° C. in the presence of some uncombined barium oxide, which is usually left on the ends of the cores, while maintaining a vacuum with a suitable pump. The heating in vacuum completes the conversion of the coating compound and causes a further change in the black compound 13 to the ultimate form, in which the cathode surface takes on the appearance of a metallic lustre similar to metallic nickel, as indicated at 14.

The excess of oxygen in the cathode compound is removed by the pump, together with any other gases which are liberated from the electrodes by the usual process of degassing.

Each step of the aforementioned heating in air may be performed in a few seconds or continued for several minutes, the core being allowed to cool between steps, or the temperature of the coated core may be continuously increased until the condition illustrated at 13 is obtained. The heating in vacuum and degassing is continued until the cathode is in proper emissive condition.

In the condition shown at 14, the cathode comprises a nickel core having a soluble compound, which we believe to be barium nickelate, dissolved therein. To the best of our knowledge

the soluble compound has the chemical composition BaO.NiO and is not the commonly known di-nickelate $BaO.2(NiO_2)$, sometimes referred to as barium nickelite.

We have reason to believe that any compound of one of the alkaline-earth metals with oxygen and one of the metals of the iron group, which is soluble in the latter metal and which is not volatile at the temperature at which the emission of the alkaline-earth metal would be sufficient, may be substituted for the compound of nickel, barium and oxygen above mentioned.

A form of filament for retaining some uncombined barium oxide after the coated filament has passed through the aforementioned steps of heating in air, is shown in Fig. 2 in which a core 15 is formed into a coiled filament. When heating current is passed through the coil an excess of barium oxide is automatically left on the end turns due to the center portion of the wire being hotter than the end portions. Therefore, the black compound is formed and melted more quickly on the center portion of the coil, the end portions still being in the uncombined condition. When such a coiled filament is heated in vacuum the excess barium oxide on the ends combines with the excess oxygen in the middle and the compound disappears into the core as the dissolved nickel-barium-oxygen compound.

It should be understood that the core may be composed in whole or part of nickel or another metal of the iron group, in which the alkaline earth metal is soluble, so long as its surface is composed of such a metal to a depth sufficient to constitute a reservoir of emissive compound to meet the required life of the cathode. The central or inner portion of the core may contain a more refractory metal.

Instead of leaving some uncombined oxide on the filament after it has passed through the aforementioned steps of heating in air, it is sometimes desirable to continue the heating until all of the coating compound is converted to the black compound 13, in which case the desired compound is formed and the excess oxygen removed by heating the core in a reducing atmosphere, such as hydrogen. After the hydrogen treatment the cathode is assembled in the tube and degassed in the usual manner.

Filling the tube with inert gas and bombarding the cathode while it is heated to about 1000° C. or 1100° C. speeds up the final stage of the cathode treatment.

Instead of forming the black compound 13 on the core as above described, an alternative process is to make, separately, a similar compound comprising barium, nickel and oxygen, which is soluble in the core metal and then to dip the core into the molten compound under conditions permitting the solution of the emissive compound in the core metal.

Cathodes as above described have a high degree of stability, and are free from the effects of electrolysis and from consequent wide variation in initial velocity of electrons leaving the cathode surface. With such cathodes the arc drop quickly reaches equilibrium when load is suddenly applied, and loss of grid control in control tubes, after idleness with filament lighted and no load, is avoided.

A modification of the ideas and general principles disclosed herein, employing similar compounds and a similar hydrogen treatment, is disclosed and claimed in our application, Serial Number 754,590, filed November 24, 1934, said application being a continuation in part of the present application.

We claim:—

1. The method of preparing an electron emissive cathode which comprises forming a soluble non-volatile compound of a highly electro-positive metal and dissolving substantially all of the said compound in a core having, for its surface, a metal of the iron group.

2. The method of preparing an electron emissive cathode which comprises coating a nickel core with barium carbonate, causing the carbonate to be changed to a compound soluble in the core, and dissolving the said compound in the core.

3. The method of preparing a cathode for an electron discharge tube which comprises coating a nickel core with a compound of barium, heating the core in the presence of oxygen to convert said compound into barium oxide, continuing the heating at higher temperatures until in the presence of oxygen the coating melts and is dissolved in the core, and then heating in vacuum to a still higher temperature.

4. The method of preparing a cathode for an electron discharge tube which comprises coating a nickel core with barium carbonate, heating in air to approximately 800° centigrade whereby the white carbonate changes to the oxide, and heating in air at temperatures from 900° to 1000° centigrade until substantially all of the coating becomes black in color and is absorbed by the nickel core, and further heating in vacuum to approximately 1100° centigrade.

5. The method of making an emissive cathode which comprises forming on the surface of a core a compound containing an alkaline earth metal, a metal of the iron group and oxygen, the said core consisting of a metal of the iron group, and dissolving said compound in the core.

6. The method of making an emissive cathode which comprises forming on the surface of a nickel core a compound consisting of barium, nickel and oxygen, dissolving said compound in the core, and heating the same in vacuum.

7. The method of making an emissive cathode which comprises applying a compound of barium on the surface of a nickel core, heating the core in the presence of oxygen and forming thereon a black compound of nickel, barium and oxygen, heating to a higher temperature until the black compound dissolves in the core, and subsequently heating the core in vacuum at approximately 1100° centigrade until substantially all gas is removed therefrom and the core has a metallic lustre similar to nickel.

8. The method of making an emissive cathode which comprises applying a compound of barium on the surface of a nickel core, heating the core in the presence of oxygen and forming thereon a black compound of nickel, barium and oxygen, heating to a higher temperature until the black compound dissolves in the core, and subsequently heating in a reducing atmosphere.

9. An electron emissive cathode comprising a nickel core having dissolved therein barium nickelate.

10. An electron emissive cathode comprising a nickel core containing in solution therein a compound of nickel, barium and oxygen in which the barium is securely bound at temperatures up to 900° centigrade, whereby the barium is not evaporated from said core below said temperature.

11. An emissive cathode comprising a com-

pound of one of the alkaline earth metals with a metal of the iron group and oxygen, the melting point of said compound being above 875° centigrade, and a core of metal of the iron group containing the said compound in solution therein.

12. An electron emissive cathode comprising a core of a metal of the iron group containing in solution therein a barium compound which is non-volatile up to 900° centigrade, said compound consisting of barium, a metal of the iron group and oxygen.

13. An electron emissive cathode comprising a metallic core and a compound of one of the metals of the iron group with an alkaline earth metal and oxygen, the said core containing the said compound in solution therein.

14. The method of making an emissive cathode which comprises applying a compound containing an alkaline earth metal, a metal of the iron group and oxygen, on a core surface consisting of a metal of the iron group, and dissolving said compound in the core.

15. The steps in the preparation of an electron emissive cathode which comprise coating a metal core with a compound of highly electro-positive metal and heating the same in the presence of oxygen until the coating melts and runs into the solid core metal.

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