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CATHODE FOR THERMIONIC DEVICES AND METHOD OF PRODUCING SAME

Filed Feb. 14, 1927

Fig. 1.

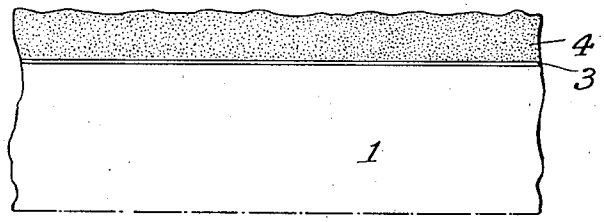
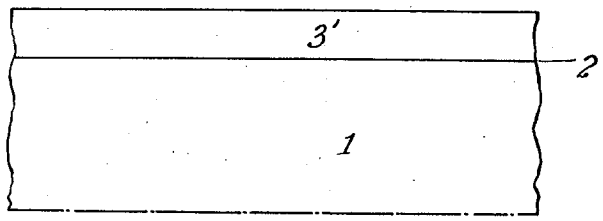


Fig. 2.



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UNITED STATES PATENT OFFICE

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CATHODE FOR THERMIONIC DEVICES AND METHOD OF PRODUCING SAME

Application filed February 14, 1927. Serial No. 168,243.

This invention relates to electron emitting electrodes, employed in audions, vacuum tubes, and thermionic devices, and particularly to those in which the emission of electrons results from an emissive surface formed by the application of a coating to a base or core, and to methods of preparing the same.

It has for an object the provision of an electron emitting electrode having a comparatively thin and regular coating or emissive surface of substantially uniform depth and in which the electronically inactive and physically unstable portions have been reduced to a minimum.

Another object is the provision of an electron emitting electrode surface whose thickness and therefore capacity for emission or activity may be regulated during the process of production and increased as desired while remaining closely adherent in itself and to the core and which coating is substantially entirely active at comparatively low operating temperatures.

Another object is the provision of a method of decreasing and reducing to a minimum the quantity of substantially electronically inactive and mechanically or physically unstable components in the emissive coating of a completed filament or electrode.

Another object is the provision of a method of decreasing and reducing to a minimum the quantity of substantially electronically inactive and mechanically or physically unstable components in the emissive coating of a completed filament or electrode.

Another object is the provision of a method of producing electron emissive coatings on a conductive base or core in which the surface produced is regular, substantially entirely active and conductive, and may be made of any desired thickness without becoming non-adherent.

Generally stated, the accomplishment of the above objects is based upon my discovery that the surface formed by coating a base or core is made up of two components, one of which is essentially the source of the electron-emitting activity of the filament while the other is substantially non-essential as regards the emissive characteristics of the filaments. This essential component, I have found, comprises substantially a thin film formed adjacent the conductor and adhering particularly well to the latter. I believe this film to be essentially a chemical combination, as alloyed or compounded with the composition of the core, but regardless of this phase of the matter it may be said to be closely attached to or associated with the core. Working upon this basis, I have achieved the above objects by treating the coated conductor or core after the application of a coating composition so as to remove the physically unstable and chemically uncombined constituents from the surface.

More particularly this treatment according to my invention comprises, the subjecting of the coated and baked conductor to a dissolving process, such as a leeching in water or in an alkaline solution, whereby the readily soluble and physically unstable components are separated from the emissive surface, leaving the active portion thereon. In this manner any desired depth of completed emissive surface which is closely adherent may be procured by repeating the successive steps of coating, baking and leeching a sufficient number of times. The surface remaining on the conductor after this leeching treatment may be termed substantially the under-coat of the originally applied coating and is remarkably superior to the original coating formed merely by application and baking.

To these and other ends, the invention consists in further features all of which will be more fully described and thoroughly understood with the aid of the description to follow, the novel features being particularly set forth in the appended claims.

In the drawing, Figure 1 shows in greatly magnified form the relative thicknesses of the undercoat or adhering portion 3 and the overcoat or unstable portion 4 of a thermionic coating applied to a flat ribbon filamentary core 1, the latter having been found

suitable for use as an electron emitting cathode.

Figure 2 is a similarly enlarged form of a portion of a filamentary conductor 2 treated in accordance with the process of my invention, the completed coating 3 being formed of several successively applied thermionic coatings from which the overcoat or unstable portions have been repeatedly removed.

My invention is particularly adapted for use in connection with thermionic devices employing a heated filament, as exemplified by the three electrode vacuum tubes containing a filament, and input and output electrodes, and whose operating characteristics are directly dependent upon the composition or substance used as the filament or cathode. Of the factors influencing the choice of a cathode, the electron affinity (ratio of electron evaporation constant to the electron charge) is probably the most important and for general uses of thermionic devices, this factor is maintained as small as possible since the power dissipated in heating the cathode to obtain a definite thermionic current decreases as the electron affinity is decreased. Thus, a low value of the electrode affinity constant implies economy of operation and increased life of both filament and tube, because of the lower temperature at which the filament or cathode can be operated to produce the desired saturation current values. To this end, the cathode is preferably treated to obtain a low value of the electron affinity and one of such treatments is the Wehnelt process which comprises coating a conductive and highly refractory core, as platinum, with the oxide of one of the alkaline earth metals, these latter compositions having been found to possess high emissivity or activity characteristics, or in other words low electron affinity values.

Another filament characteristic which is determinative in the choice of a filament which will operate at low temperatures producing suitable activity values is the heat conductivity characteristic of the emissive surface which should be as high as possible, since the surface derives its heat substantially entirely by radiation and diffusion from the conductive heated core and the heat conductivity of the surface will thus determine the temperature to which the core must be heated to produce a given temperature in the coating.

In accordance with my invention, I have found that the emissive or activity characteristics of coated filaments are due essentially to a thin almost imponderable undercoat film 3 formed immediately adjacent the conducting core while the remainder 4 of the coated surface, which for the purpose of description may be termed the overcoat, does not exert any material beneficial influence upon the operation of the filament. On the other hand, this overcoat portion possesses an undesirable high resistance thereby causing a loss of power from unnecessary heating and further possesses an irregular surface while the undercoat film is comparatively smooth and regular, approximating the desirable regularity of the uncoated metallic conductor or core. Furthermore, my discovery includes the fact that the undercoat film adheres strongly to the conducting core and possesses new physical and chemical properties particularly as regards solubility, whereas the overcoat portion retains its original properties and also does not adhere particularly strongly to the undercoat film. I believe this undercoat film to be substantially a compound formed by an interaction of the composition of the core with the substances applied as the coating.

To obtain the advantages of the above discovery, my improved process includes a treatment of the coated and baked conductor whereby the overcoat portion is removed and the undercoat film unaffected, leaving essentially only the thin undercoat film, and the steps of the coating, baking and overcoat removal treatment are repeated until a finished coating surface of the desired thickness has been built up. By this process, I am able to produce a thermionically active filament having an active surface of uniform depth thus appreciably reducing the likelihood of occurrence of bright spots in the heated filament, and possessing a regular even surface which closely approximates the desired regularity of an uncoated conductor surface. Furthermore, the desirable strong adherence of the coating in itself and to the core is not reduced by increasing the thickness of the surface and successively applied undercoat films adhere strongly to each other, thus making possible the production of any desired thickness of surface or degree of activity. The life of the filament is also materially increased, since the entire coating is highly electrically conductive, thereby implying low temperature of operation.

In the preferred treatment, the conductor after being coated and baked is passed through a dissolving or leeching treatment in a solvent which will dissolve the overcoat portion without materially affecting the undercoat film. Solvents which have been found satisfactory include water and various alkaline solutions, as sodium hydroxide, potassium hydroxide and ammonium hydroxide. The duration of leeching treatment will of course depend upon the amount of coating applied and upon the strength and temperature of the solvent, but as a general rule I have found that the greater number of thermionically active coating materials are appreciably deliquescent and

readily soluble and that a treatment of a few seconds duration will suffice to remove the overcoat portion from a single coating. Of course in those instances where the material employed is of an insoluble nature it may be necessary to vary the solvent or other factors in the process.

The weight of film remaining will depend upon various factors, but in one instance I treated a platinum filament of 2000 mms. length and 0.615 grams weight which had been given a coated and baked surface of 0.035 grams weight and found first that after five minutes leeching there remained an undercoat film weighting 0.005 grams and second that a continuous leeching of the same coated and baked filament for as long as fifty hours resulted in no further removal of the coating.

Various materials may be used as the actual coating composition, but I have found the use of a mixture of a highly active material with a binder material, as disclosed in my copending applications, Serial No. 108,676, filed May 12th, 1926; No. 108,961, filed May 13th, 1926; No. 154,035, filed December 10th, 1926; and in my joint patent with E. C. Hull, No. 1,209,324, dated December 19th, 1916. Briefly these disclosures comprise the use of an emissive surface including both an alkaline earth material, particularly a compound of barium, and a material which may or may not possess any activity characteristics but which serves as a binder between the active alkaline earth material and the material of the core. The binder materials disclosed and claimed, as above listed, comprise compounds of strontium, the rare earth group (titanium, zirconium, cerium, thorium, lanthanum, praseodymium, samarium, yttrium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutecium,) and the group contained in the fourth series of the periodic table between groups three and eight inclusive (scandium, titanium, uranium, chromium, manganese, iron, cobalt, nickel), the oxides of these metals being preferable. When such materials are employed as the coating compositions, I have found that the undercoat film is particularly adherent and believe that this film or layer is composed of the compounds of the coating metals used with the core material employed.

Noble metal cores, and particularly those composed essentially of platinum as platinum and platinum-iridium alloys, are especially satisfactory for use in accordance with my invention.

My improved process is especially advantageous in that the activity or emissivity properties of the coated filament may be increased to any desired value by repeating the successive steps of coating, baking and leeching a sufficient number of times, since the removal of the "inactive" overcoat portions makes it possible to bring "fresh" material into contact with the core and the conductive undercoat film to thereby form a fresh layer of the latter. Without the removal of the overcoat, it would be substantially impossible to increase the thickness of the essential undercoat film, as there could then be no interaction between the core composition and the uncombined portions of the applied coating composition.

What I claim is:—

1. The method of producing an electron emitting electrode which comprises coating a conducting core with an electron emissive material, baking the coated core, and removing the uncombined coating material.

2. The method of forming an electron emissive electrode which comprises repeating the successive operations of coating an electrically conductive core with an electron emissive material, baking the coated core and removing the chemically uncombined coating material to produce a coating surface of the desired thickness.

3. The method of producing a thermionically active filament which includes the step of removing the uncombined portions of the coating.

4. The method of producing a coated electron emissive filament which includes the step of leeching the coated conductor to remove the uncombined constituents.

5. The method of producing a coated electron emissive filament which includes the steps of coating a conductive core with an electron emissive material, baking the material thereon, and leeching the baked conductor to remove the overcoat portion.

6. The method of making an electron emitting cathode, which comprises coating a conductive core with a composition containing an alkaline earth metal compound, baking said coated conductor, to combine a portion of the coating with the core composition, and subjecting the cathode element to a dissolving treatment to remove the uncombined portion of the coating.

This specification signed this 9th day of February, 1926.

ALEXANDER McLEAN NICOLSON.