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CATHODE FOR THERMIONIC DEVICES

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This invention relates to electron-emitting filaments commonly employed as cathodes, in audions, vacuum tubes, and thermionic devices, and particularly to those in which the emission results from an emissive surface formed by the application of a coating to an electrically conductive base or core.

It has for an object the provision of a filament or cathode emission surface which will render the completed member thermionically active at comparatively low temperatures and with a high degree of durability and uniformity or constancy of activity.

Another object is the provision of a filament or cathode coating which will both readily adhere to a metallic core, as platinum for example, and possess a high activity with longevity.

Generally stated these objects are accomplished by providing the electrode or conducting core with a coating containing material having a comparatively high degree of thermionic activity (that is, at the operating temperature of the filament), and also a composition substantially refractory at the baking temperature of the filament and which will serve essentially as a binder by forming a bond between the conducting core and the active material. These binder materials may thus possess a smaller degree of thermionic activity. In this manner comparatively highly thermionically active materials, which in themselves show a tendency to be easily removed from the core (i. e. adhere only weakly to the core) may be employed in emissive surfaces without including the danger of short life resulting from a probable loss of the emissive material from the coating surface.

More specifically my present invention comprises an emissive surface formed by the joint application of one or more of the oxides of metals of the alkaline earth group and one or more compounds, preferably oxides, of those metals contained in the Fourth Orbit Series of the Periodic Table between groups three and eight inclusive, such metals including scandium, titanium, vanadium, chromium, manganese, iron, cobalt and nickel. Hereafter in the specification and claims this latter group of metals will be termed the associate group. Such a coating may be applied either in the form of a mixture of the desired oxides in suitable proportions and preferably powdered, or as superposed coatings of the individual oxides.

My invention is particularly adapted for use with thermionic devices employing a heated filament, as exemplified by the three electrode vacuum tube containing filament, input and output electrodes, and whose operating characteristics, especially life, 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 the most important and for general uses of thermionic devices, this factor is maintained as small as possible since the power dissipated in the heating of the cathode to obtain a definite thermionic current decreases as the electron affinity is decreased. Thus, a low value of the electron 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 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 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 constant values. Difficulty has been encountered in the use of these Wehnelt coated filaments, however, in that the alkaline earth oxides, though possessing satisfactory emissive characteristics, showed a tendency to adhere only rather weakly to the conducting core, and the life of the tube became thus appreciably reduced. It has been my object to overcome this difficulty while at the same time preserving the desirable low electron affinity characteristics.

In accordance with my invention, I have found that a coating or electron emitting surface which will satisfactorily adhere to the

core surface and at the same time possess the desirable low electron affinity value is produced by incorporating or applying jointly with a highly thermionically active material, as the alkaline earth group oxides, a binder material which may possess a lower degree of activity, that is, be less active thermionically, and which is substantially refractory (that is does not break down by volatilization or otherwise) at the temperature used in the baking operation. This binder material also preferably does not impair or appreciably reduce the emissive characteristics. I have found such a class of materials to comprise the compounds and preferably the oxides, of the metals contained in the Fourth Orbit Series of the Periodic Table between groups three and eight inclusive.

When such a combination of materials is applied to a suitable core, the filament or cathode is provided with a film or surface which is not only closely adherent in itself but also adheres closely to the core and at the same time possesses the desirable emissivity or activity of the alkaline-earth materials. Thus the coated filament or cathode in accordance with my invention possesses suitably high electron emitting activity and also uniformity or constancy of action over a long period of use when employed as the heated element of a vacuum tube or thermionic device.

Of the metals of the alkaline earth group, barium, calcium, and strontium, barium has been found to be particularly well adapted for general use in electron emitting surfaces, though it will be understood that in some instances it may be preferable to use either calcium or strontium in place of barium, or even some mixture of these metals, or more properly of their oxides or salts.

The preferred metal of the associate group for use with alkaline earth metal in accordance with my invention will be dependent upon the particular conditions to be met in any given instance. In some cases, for example, it has been found desirable to employ not only one of these metals but a mixture of several of them. For general use, however, scandium and manganese, preferably as oxides, form especially satisfactory materials for application with compounds of the alkaline earth group in the formation of electron-emitting surfaces.

My new combination of materials may be applied to the desired surface in various ways but a process which I have found satisfactory comprises successively coating the heating element or core, such as platinum or a platinum-iridium alloy, which solutions containing the alkaline-earth metal compound and with others containing the associate metal compound, and baking the product after each coating has been applied. In this manner, there is formed a completed filament comprising a core having a number of superposed layers of electron emissive material the individual layers adhering well to each other and to the core. The two solutions to be applied are preferably formed of the same concentration in the particular emissive material and the operating conditions, such as duration of immersion and baking and the intervals between coating and baking are preferably maintained substantially constant, so that the desired proportion between the alkaline-earth group and the associated group metals may readily be obtained by suitably proportioning the number of coatings of each.

The particular solvent or flux employed to form a coating solution may be one of several substances but several which I have found to give good results are a molten wax and oils. With such a flux, the core is passed through baths of molten wax in which have been incorporated the powdered metals, their oxides, or salts. In this manner, the desired materials are uniformly distributed over the core surface as a thin film and the wax or flux removed in the baking operation, which is preferably done at a temperature between 900° C. and 1200° C.

The proportions of the alkaline earth and associate group metals may be varied within wide limits to meet the requirements of a large range of operating conditions, but I have found that satisfactory results are obtained when the ratio of the actual weight of the oxide equivalent of the alkaline earth content to that of the associate group content is maintained substantially between the ratios of three to one and five to one. In all cases, however, it has been found desirable to maintain the barium oxide content at least two thirds of the total content by weight. When the coating comprises superposed layers of the oxides, the proper proportions may be obtained by employing solutions of concentrations which are equal when expressed in the same terms, and making the ratio between the number of applications or layers of alkaline earth material to that of the associate material correspond to the desired ratio of alkaline-earth oxide to associate group oxide.

As a result of the aforementioned treatment, the desirable high activity characteristics of the alkaline earth group oxides may be obtained in a filament coating and the undesirable characteristic of weak adherence of these oxides overcome by the use of a binder material as above described. Furthermore, the filament thus produced is covered with a dense, closely adherent film possessing high durability and constancy of electron emitting activity when used as the heated cathode of a thermionic device.

What I claim is:—

1. A thermionic coating comprising as essential elements thereof, compounds of bari-

um and manganese, to afford to said coating a degree of thermionic activity comparable to that of the barium compound and a constancy of activity with protracted use of the coating, with strong adhesion within said coating.

2. A filament for thermionic devices comprising a core serving as the heating element, and having an electron emissive surface formed by the application of a compound of barium and a compound of manganese to afford to said surface a degree of thermionic activity comparable to that of the compound of barium and a constancy of activity with protracted use of said filament, with a high degree of adhesion in itself and to said core.

3. An electron emissive surface comprising as essential elements thereof an oxide of an alkaline earth metal and an oxide of a metal belonging to the Fourth Orbit Series of the Periodic Table, between groups three and eight inclusive, the ratio in terms of actual weights of former to that of the latter being substantially between the ratios of three to one, and five to one, to afford strong adhesion within said surface, with an immunity from action such as to impair the emissive characteristics of the oxide of the alkaline earth metal and to afford to said surface a degree of thermionic activity comparable to that of the oxide of the alkaline earth oxide metal and a constancy of activity with protracted use of said surface.

4. A thermionic coating for an electron emissive surface comprising an alkaline earth oxide material and the oxide of manganese, to afford to said surface a degree of thermionic actuation comparable to that of the alkaline earth oxide material and constancy of activity with protracted use of the surface, with strong adhesion within said surface.

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