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UNITED STATES PATENT OFFICE

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THERMIONIC CATHODE

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My invention relates to thermionic tubes or space discharge devices and more particularly to an improved thermionic cathode for such devices that is capable of emitting electrons.

An object of my invention is to provide an inexpensive cathode for space discharge devices, such as thermionic tubes, that has uniform physical properties and which is capable of emitting electrons at temperatures lower than cathodes composed of oxide-coated platinum or platinum alloys.

Another object of my invention is to provide an improved alloy or aggregate for the cathodes of space discharge devices that has a comparatively high specific resistance, that may be made from cheap and readily obtainable materials and that has physical properties which are superior to oxide-coated filaments.

Another object of my invention is to provide improved vacuum tubes or space discharge devices, and especially those of the three or four electrode type having output and control electrodes, and a cathode comprising an alloy or aggregate that is capable of emitting electrons when heated to a moderately high temperature.

A further object of my invention is to provide a method of producing an alloy or aggregate in which one or more of the alkaline earth metal oxides are incorporated that may be forged and drawn into wires or filaments capable of being utilized as the cathode in space discharge devices.

It has heretofore been the practice to employ tungsten, thoriated tungsten and oxide-coated filaments of platinum or platinum alloys as the cathode in space discharge devices, such as X-ray tubes, hot cathode rectifiers and vacuum tubes of the three and four electrode type that are utilized for radio purposes.

Vacuum tubes having cathodes made of tungsten or thoriated tungsten have a comparatively short life and the electron emission is somewhat irregular. Oxide coated filaments having a foundation metal of platinum or nickel, or alloys of these metals, have been in extensive use. Oxide coated filaments, however, are not altogether satisfactory because of the difficulty of producing filaments of this type having uniform physical properties.

In producing oxide coated cathodes in accordance with the present practice, it is difficult to obtain a filament having an adherent layer of the oxide or one which has a uniform thickness of the oxide coating on the wire. There is also considerable difficulty in obtaining true temperature measurements of oxide-coated filaments to determine the temperature at which the tube is to be operated because they are formed of two layers; namely, the foundation metal and the superimposed oxide coating. Oxide-coated filaments also have a rough soft surface and care must, therefore, be exercised in handling the material to prevent the oxide coating from being removed or contaminated with oil or grease while it is being mounted in the tube.

The mechanism of thermionic emission from oxide coated surfaces is not clearly understood, but according to the latest theory, part of the oxide is reduced to the metallic state in minute quantities which forms a superficial filament of high thermionic activity. Only a layer of metal one molecule thick is presumed to give satisfactory emission.

In making experiments in accordance with the above specified theory, I have made the discovery that when an alkaline-earth-metal oxide is disseminated through or alloyed with a metal which is suitable as a base for electron emitting bodies, such as nickel, to which is added a metal which is highly active toward oxygen, such as titanium, a filament material is provided that not only gives good emission, but is free from the disadvantages resulting from the use of oxide-coated material.

In practicing my invention, I may form intimately powdered mixtures of a foundation metal, such as nickel with a metal which is highly active toward oxygen, such as titanium, and the oxides of one or more of the alkaline earth metals, such as calcium, barium or strontium, or I may mix pow-

dered nickel or nickel oxide with a salt of one or more of the alkaline earth metals, such as the nitrites, nitrates or oxalates. When the salt or a mixture of the salts of alkaline earth metals are employed they are added to the powdered nickel or nickel oxide forming a suspension of nickel or nickel oxide in an aqueous solution of the alkaline-earth-metal salt. The water is removed by evaporation and the resulting dry mass is heated to a roasting temperature in an oxidizing atmosphere to convert the alkaline-earth-metal salts to their oxides. The nickel oxide, if present in the mixture obtained from either of the methods above described, is then reduced to nickel, the mixture being ground to a fine powder so that reduction may be facilitated. When hydrogen is utilized as the reducing agent it will be understood that the mixture should be heated to a sufficient temperature before the reducing agent will be effective.

mass consisting of a homogeneous of powdered nickel and the alkaline nd oxides of the alkaline earth ich were utilized is then thoroughly mixed der; thoroughly mixed with a deoxidizer, such as a deoxidizer, which is highly al which is highly then pressed into ents. bars by the ap- steel die. A square inch is bars. ted to a se sin- m, in or

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An alloy or aggregate of powdered nickel with 3% of barium oxide, and a similar alloy containing 2.5% titanium and 3% of a mixture of barium and strontium oxides, when prepared in the manner specified, were capable of being drawn into a fine wire suitable for filaments in radio tubes.

When a mixture of two or more of the alkaline earth oxides are incorporated with the metal or alloys, it is sometimes desirable to mix them in certain well defined proportions, for example, when barium and strontium oxides are employed, it has been found that a mixture of from 40 to 60% barium oxide and from 60 to 40% strontium oxide gives good results. I do not desire, however, to be limited in this respect as it will be understood that any one or a suitable mixture of any of the alkaline-earth-metal oxides may be employed.

While I have mentioned mixtures of nickel or nickel oxide and titanium in the specific example given above, it will be understood that my invention is not limited to the particular ingredients. The composition or aggregate of one or more of these parts with nickel or nickel oxide may be employed as an alloy or aggregate of nickel or nickel oxide with the alkaline earth metals or alloy with these parts. The composition will depend upon the particular incorporate the alkaline-earth metals or alloy with nickel or nickel oxide which it is the cathode is to be operated under. The however, during the operation of the cathode is to be operated under. The a high strength at high temperature sired, and especially at temperature at high temperature, however, the mixture should be operated under the all

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such a composition have good physical properties and also have the advantage of giving electron emission at about 100° C. lower temperature than platinum. A small percentage of other metals which are highly active toward oxygen, such as thorium, vanadium, tantalium, silicon, manganese, aluminum, or metals of the rare earth group such as cerium or zirconium, or mixtures thereof, may be substituted in whole or in part for the titanium.

Other modifications of my invention will become apparent to those skilled in the art, and I desire, therefore, that only such limitations shall be placed on my invention as are imposed by the prior art and the appended claims.

I claim as my invention:

1. Electron emitting material of substantially homogeneous character capable of being forged into wire consisting of a base metal selected from a group consisting of nickel and cobalt, said base metal containing about 0.5 per cent titanium and about 10 per cent metal selected from a group consisting of titanium and iron, with about 2 to 10 per cent alkali-earth metal oxide uniformly distributed therethrough.

2. Electron emitting material of substantially homogeneous character capable of being forged into wire consisting of a base metal of about 70 per cent nickel, 20 per cent cobalt, 0.5 per cent titanium and the balance selected from a group consisting of iron and titanium, with about 2 to 10 per cent alkali-earth metal oxide uniformly disseminated therethrough.

3. Electron emitting material of substantially homogeneous character capable of being forged into wire consisting of a base metal of about 70 per cent nickel, 20 per cent cobalt, 8 per cent iron and 2 per cent titanium with about 4 per cent alkali-earth metal oxide uniformly distributed therethrough.

In testimony whereof, I have hereunto subscribed my name this 12th day of December 1928.

GEORGE P. HALLIWELL.