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INSULATING COATING FOR FILAMENTS AND METHOD OF APPLYING THE SAME

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INSULATING COATING FOR FILAMENTS AND METHOD OF APPLYING THE SAME

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This invention relates to coatings for filamentary wires and especially insulating coatings used on the filaments of vacuum tubes.

It is generally desirable in vacuum tubes to place the filament as nearly as possible to the other elements of the tube in order to take advantage of all of the heat radiated from the filament or the electron emission where a filamentary cathode is used. Especially in a heater type tube is it necessary to have the heating element as close to the cathode as possible so as to conserve the heat energy of the filament and reduce to a minimum the time required to bring the cathode up to electron emitting temperature when the current is turned on. Where a bare filament is positioned in close proximity to the cathode any movement of the filament with respect to the cathode may cause the two to touch and thereby short circuit the tube. It has been found advantageous to provide some insulating means between the cathode and filament to prevent such short circuiting and one way of providing such an insulation between the two elements is to coat it upon the filament itself. Such an insulating coating for filaments has been provided by mixing an insulating oxide as for instance, aluminum or magnesium oxide with a suitable binder, coating this mixture upon the filaments and heating to drive off the binder. There are certain disadvantages which follow from this method of insulation, the first being that it is extremely difficult to drive off all of the binder and in some instances where a little of one binder remains the conductivity of the insulation is increased thereby causing break down at relatively low temperatures. Another disadvantage of this type of insulation is that the particles of insulation materials are not in a molecular state but, even though ground in a ball mill and made exceptionally fine, tend to loosen up and absorb moisture so that the finished coating has a tendency to crumble off of the wire and when this happens in service a short circuit may result.

It is one of the objects of this invention to provide a method of coating an insulating material upon a filamentary wire in a molecular state so that the material forms a homogeneous, extremely compact surface tightly associated with the metal base.

Another object of the invention is to provide a hard, compact insulating coating for filaments capable of standing the temperatures of tube operation and manipulating of the filament before it is positioned in the tube without the coating crumbling or breaking down electrically under the potentials used.

Another object of the invention is to provide a method of attaching the oxide of a metal to a wire without any of the disadvantages arising from the use of binders.

Other objects and objects relating to methods of preparing the various ingredients of the coating and applying the coating to the wire will be apparent as the description of the invention proceeds.

Referring to the accompanying drawing, the figure therein illustrates in general a coated filament in accordance with my invention.

The specific showing in the drawing illustrates a filament 1 upon which is applied a coating 2. The filament comprises a length of wire of a suitable character to be heated by passing a current therethrough. The coating is preferably an oxide as will now be more fully described.

Among the oxides which form the best insulating material for use in vacuum tubes are those of aluminum, beryllium, magnesium, calcium, chromium, and titanium. Of these metals I prefer to use beryllium or aluminum because the compounds are commercially obtainable and as good results have been obtained with aluminum the method of obtaining a coating of aluminum oxide will be described.

I first prepare a saturated solution of aluminum nitrate and apply any desired number of even coatings of this solution upon the wire which is preferably heated after each coating has been applied to dry the material in place. The action of heat on the aluminum nitrate breaks it up into aluminum oxide, nitric oxide, and water, the last two being driven off in vapor form leaving a coating of aluminum oxide in its molecular state. I have used this coating on a tungsten filament

and because tungsten crystallizes at a temperature below the melting point of aluminum oxide it is not advisable to heat the tungsten to a high enough temperature so that the aluminum oxide will melt. A better coating could be obtained, however, which would adhere more closely to the wire if the oxide were melted. However, I have found that by adding a small percentage of an oxide to the coating which has a melting point considerably below the crystallization temperature of tungsten this oxide will melt when the filament is heated during the exhaustion process of the tube and cause the aluminum oxide to adhere very closely to the tungsten wire.

I have found that the degree of saturation of the aluminum nitrate solution is important as this determines the number of applications or layers necessary for a coating of the desired thickness and to a certain extent the character of the coating after it is applied. If the solution is weak, a large number of applications will be needed to give the necessary cross section. And if the solution is a supersaturated solution there is a tendency for the aluminum nitrate to crystallize and cause lumps and uneven ridges on the wire surface. A saturated solution having a specific gravity of 1.4 at 27° C. has been found to give good results. With a 6½ mil wire I have found that about 25 coatings of this solution are necessary to raise the diameter to from 13 to 15 mils.

To aluminum nitrate solution I add from 3 to 10% by weight of silicon dioxide which melts below the filament temperature during the exhausting of the vacuum tube, thereby forming the means to integrate the aluminum oxide more closely to the wire. It is important to get enough of the silicon dioxide to melt the coating so that it closely adheres to the wire and not enough to lower the dielectric.

After a filament is inserted in a vacuum tube the tube is exhausted at which time the filament is heated to a temperature in the neighborhood of 600° to 900° C. or to a dull red heat. I have found that this heating of the filament where aluminum nitrate has been coated thereon without any silicon dioxide causes a softening of the coating which renders it crumbly and undesirable to be used in a vacuum tube, and although I do not know the cause of this softening I have found that the addition of the silicon dioxide prevents it and hardens the coating into one that is extremely difficult to chip or crumble.

While I have described the invention in connection with aluminum any of the metals listed above may be used, and while I have specified silicon dioxide as preferable to mix with the material applied to the wire, any metallic oxide which is a good insulator and has a melting point at or below a dull red heat may be used for this purpose.

From the above it will be seen that I have provided a method of forming a metallic oxide upon a wire in its molecular form. The method is simple, inexpensive, and produces an insulating coating for the filament which will not crumble or break off when the filament is bent in the desired shape for positioning in a vacuum tube, nor will it crumble or break down when the filament is in actual service thereby greatly lengthening the life of the vacuum tubes using the invention, especially those of the heater type.

Modifications of the invention may be made without departing from the spirit thereof and I do not desire to limit the invention to what has been shown and described except as specified in the appended claims.

What I claim is:

1. The method of forming a coating of aluminum oxide in its molecular state on a tungsten filamentary wire which comprises applying a plurality of layers of a solution of aluminum nitrate and a small percentage of an oxide having a melting point below the crystallization temperature of the tungsten of said wire, heating said wire after each layer of the solution has been applied to reduce the aluminum nitrate to aluminum oxide, and subsequently raising the temperature of said wire to a point between the melting point of the first mentioned oxide and the crystallization temperature of said wire.

2. The method of coating a tungsten wire with a hard, homogeneous insulating coating which comprises applying layers of a solution of aluminum nitrate and a small percentage of silicon dioxide to the wire, heating the wire after each successive application to chemically change the aluminum nitrate to aluminum oxide, and subsequently heating the wire to a temperature above the melting point of silicon dioxide but below the crystallization temperature of tungsten.

3. The method of forming a metallic oxide on a filamentary wire which comprises coating the wire with a plurality of layers of a saturated solution of aluminum nitrate having a specific gravity of 1.4 at 27° C. mixed with from 3 to 10% by weight of silicon dioxide, heating the wire after each successive layer has been applied to reduce the aluminum nitrate to aluminum oxide, and subsequently heating the wire to a temperature above the melting point of silicon dioxide but below the crystallization point of said filamentary wire.

In testimony whereof, I affix my signature.

JOHN KAUL.