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PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements in and relating to Indirectly Heated Cathodes for Vacuum Tubes.

We, ARCTURUS RADIO TUBE COMPANY, of 220, Elizabeth Avenue, Newark, State of New Jersey, United States of America, a corporation organized under the laws of the State of Delaware, United States of America, (Assignees of SAMUEL RUBEN, of No. 83, Fourth Avenue, New York City, New York, United States of America, a citizen of the United States of America), do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to vacuum tubes and particularly to that type of vacuum tube which has a cathode adapted to be heated by a filamentary heating wire coated with an insulating material.

Various materials have been suggested as insulating materials for this purpose but we have found that the insulating materials proposed and the manner of applying them which have been suggested do not give good results with certain types of vacuum tubes. Due to expansion or contraction from the heating of the filament or movement due to electrostatic or other forces, there is a tendency for the coated filament to rub against the inside wall of the cathode, and where the insulating material is friable the insulation chips off and causes short circuiting between the cathode and filament. Great difficulty has been found in manufacturing tubes in large numbers, due to this tendency to short circuit between the cathode and filament.

We have ascertained that we can produce a hard, strong and highly insulating surface for a filament in the manner hereinafter described.

To this end in accordance with the invention we first form an integral coating of an oxide on the wire by heating it in an oxidizing atmosphere. This oxide is very closely associated with the metal of the wire. We then apply a coating having a relatively high dielectric strength such as silicon dioxide. The particles of this oxide mesh with the particles of the oxide first formed to form a substantially integral coating surface which cannot be easily chipped off or otherwise damaged.

In carrying out the invention we prefer to use a filament of tantalum wire for the reason that tantalum has the property of absorbing gases when heated, which assists in maintaining the vacuum in the tube and because tantalum also has a high specific resistance. It is to be understood, however, that other materials such as nickel or tungsten might be used if desired. The tantalum wire is first placed in an oxidizing atmosphere and subjected to a temperature of about 600° C. until a dense coherent white coating of tantalum pentoxide (Ta_2O_5) is formed. The wire is then covered with a mixture of finely divided silicon dioxide (SiO_2) which is suspended in a very weak solution of sodium silicate having a specific gravity of 1.045, such suspension being more in the nature of a pasty mixture. The sodium silicate is used merely as a binder to hold the particles of silicon dioxide together on the filament until the same has been dried and heated. The silicon dioxide solution may best be prepared by grinding the silicon dioxide in a ball mill with the binder solution until a paste of the desired smoothness is obtained.

This coating of silicon dioxide quickly dries and remains on the filament until the filament is used. When the filament is mounted in a vacuum tube and the tube evacuated, it is heated to about 1600° C., which expels all occluded and chemically formed gases or volatile products from the coated filament and the heat also produces two important effects on the silicon dioxide coating. In the first place, there is a tendency for the silicon dioxide to combine chemically with the tantalum pentoxide so that the silicon dioxide coating not only becomes firmly attached to the filament by reason of the fact that it hardens against the roughened oxide surface but the tendency to combine chemically makes an integral connection between the two which cannot be impaired, due to differences of the coefficients of expansion of the metal and coatings. Another result produced by this

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temperature is that the particles of silicon dioxide at the outer surface thereof sinter or fuse together to form an extremely hard surface of silica which increases the dielectric strength of the coating and also provides a better radiating surface for the heat, which is desirable, as no matter how close the cathode is placed with respect to the filament, there will always be some places which do not touch and which will then depend on radiated heat for energization.

The coating on the filament has an extremely high dielectric strength and is also exceptionally thin, the thickness thereof not necessarily exceeding .05 millimeters. The filament so coated may be placed inside a cathode tube which is just sufficient in diameter to permit the filament to be slipped thereinto and which will closely engage the sides of the filament with no danger at all of the insulating coating breaking down with differences of potentials commonly used between the filament and cathode.

While we have described the use of silicon dioxide in a solution of sodium silicate, other substances may be used with good results, if desired. For instance, aluminium magnesium or boric oxides may be used, but silicon, having a very high dielectric strength, is preferable. Also, the binder of sodium silicate is preferred because it requires a very small concentration to bind the particles of silicon dioxide together and it releases a minimum of gas vapors during the life of the tube. Other binders, however, could be used, such as resinous or organic types, the necessary feature being merely that the binder holds the particles of silicon dioxide to the oxide coating of the filament until the filament is ready to be used.

The surface of the metal filament is best prepared to receive the silicon dioxide by forming an oxide upon it, as indicated above. It is possible, however, to place the silicon dioxide directly upon the metallic filament without forming the oxide. but we have found that in so coating the filament the silicon dioxide cannot be as uniformly distributed, nor will it adhere to the surface as well, due to surface tension and other effects, and the resulting coating is liable to chip and peel when the filament expands and contracts under temperature changes.

It is evident from the above description that we have provided an insulated coating for a filament wire which may be easily applied to the wire and which produces an insulation having a very high dielectric strength which will not break down under differences in potential of the cathode and filament which are ordinarily used in vacuum tubes, and which coating is so thin that the cathode may be positioned in close proximity to the filament, thus reducing the heat losses to a minimum.

The coating has in effect a homogeneous structure ranging from the metal core at the center to pure silica at the surface, the particles being either chemically combined or physically closely adherent.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In a vacuum tube of the type referred to, the method of insulating the filament which comprises heating said filament in an oxidizing atmosphere until an oxide is formed on the same, immersing said filament in a substance which has a relatively high dielectric strength and which tends to combine with the oxide formed on said filament, and heating said filament to effect said combination.

2. In a vacuum tube of the type referred to, the method of insulating the filament which comprises forming an oxide on the surface of said filament, immersing said filament in a solution of finely divided silicon dioxide suspended in a liquid binder, and heating said filament to harden said silicon dioxide and effect said combination.

3. In the method of insulating a metal filament as claimed in claim 2, using finely divided silicon dioxide suspended in a solution of sodium silicate.

4. In a vacuum tube of the type referred to, a filament, an oxide coating on the surface of said filament and a second coating of finely divided silicon dioxide closely associated with said first coating.

5. In a vacuum tube of the type referred to a tantalum filament, a coating of tantalum pentoxide on said filament, a coating of silicon dioxide physically and chemically associated with said oxide coating, and a hard, fused surface on said silicon dioxide.

Dated this 25th day of February, 1929.

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