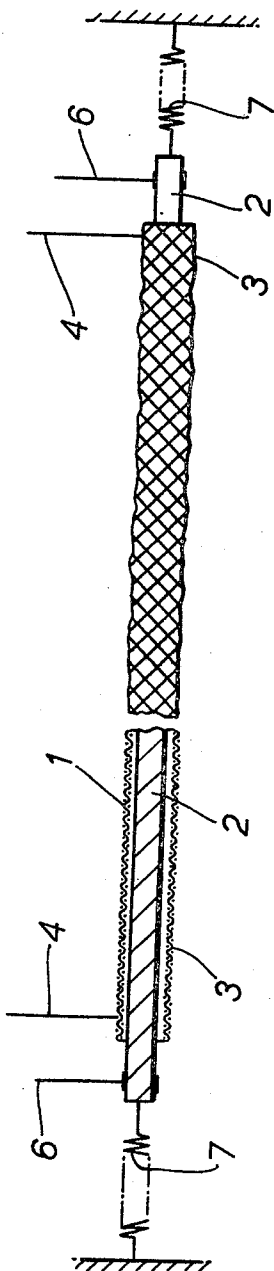


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ELECTRON EMITTING CATHODES HAVING A FLEXIBLE GRAPHITE
FILAMENT WITH AN EMISSIVE COATING THEREON
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ELECTRON EMITTING CATHODES HAVING A FLEXIBLE GRAPHITE FILAMENT WITH AN EMISSIVE COATING THEREON

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4 Claims

ABSTRACT OF THE DISCLOSURE

An electron emitting cathode comprises a flexible graphite filament having a coating of a material which emits electrons when heated. The filament may be tubular and loosely supported on a metal core wire.

This invention relates to electron emitting cathodes for electron guns and is particularly concerned with elongated emitting cathodes suitable for use in electron irradiation machines.

In an electron irradiation machine intended for industrial processing, it is most desirable to use an electron gun with an elongated emitting cathode since it is then possible to dispense with magnetic scanning as a means of spreading the electron beam over the material being processed.

Elongated emitting cathodes, generally referred to as emitters, have in the past been constructed from refractory metals such as tungsten or tantalum. These metals can be used pure or in a treated state such as thoriated tungsten or tantalum coated with lanthanum boride to provide a low work function emitting film, but many practical difficulties have arisen in attempting to provide a stable lanthanum boride coating on such materials.

Additionally, such metals are heavy and tend to be brittle after heating in vacuum. In consequence, if emitting filaments more than a few inches long are to be constructed, supporting and tensioning devices for the filament are included every few inches. Various suspension systems have been suggested to overcome the problems but the brittle nature of a thin filament, particularly when cold, remains as a limiting factor in filament life.

An object of the present invention is to provide a new and improved form of electron emitting cathode particularly suitable for use with electron irradiation machines.

According to the invention an electron emitting cathode comprises a flexible graphite or carbon filament having a coating of a material which emits electrons when heated.

Preferably the filament comprises a plaited or woven graphite cord of low mass/unit length.

According to one feature of the invention the plaited or woven cord is tubular and mountable on a wire such that an electron emitting cathode may comprise a central core of refractory metal and a loose fitting graphite or carbon sleeve surrounding said core.

Preferably the core is formed of tungsten or tantalum wire, and the sleeve is provided with a coating of a material which emits electrons when heated.

The sleeve may be provided with a coating of lanthanum boride.

To enable the nature of the invention to be more readily understood one embodiment of the invention will now be described, solely by way of example, with reference to the accompanying drawing which illustrates a preferred form of cathode construction.

The graphite or carbon sleeve materials are available commercially in the form of tubular plaited cords of 1 mm. and 2 mm outside diameters. The electrical resistance of the carbon cord is 1.5–2.5 ohms/cm. and for the graphite 0.5–2 ohms/cm. Weights for 2 mm. diameter cords are approximately 1.4 grams/metre.

In the preferred form of the invention as shown in the drawing the tubular sleeve 1 is loosely mounted on a core wire 2 and the ends 3 of the sleeve are copper plated to provide suitable end connections to the filament electrical supply leads 4. The ends of the core wire are held in conventional clamps and connected via leads 6 to an electrical supply to provide a core heating current. The core wire may be tensioned by using a simple spring mounting 7 or the core wire and sleeve may be supported magnetically in a manner substantially as described in our co-pending British patent application 35,474/66 which describes means of providing a magnetic field transverse to the axis of an emitter cathode such that the interaction between the field and the emitter cathode, when carrying its operating current, supports the weight of the emitter cathode along its length.

One method of coating the graphite or carbon sleeve comprises applying a slurry, formed from lanthanum oxide, boron and carbon in water, to the cord, drying the cord in air, placing the cord in a vacuum vessel and outgassing using external heaters and subsequently raising the temperature of the sleeve to 1700° C. for a few seconds by passing an electrical current through the wire core.

The slurry may be prepared by grinding together lanthanum oxide, boron and carbon in the proportions 9:3:1 by weight and adding distilled water.

In one example the core wire and sleeve is supported in a filament holder and brush coated with a prepared slurry. The sleeve is allowed to dry in air and the assembly subsequently placed within a vacuum enclosure. The enclosure is pumped down to a hard vacuum, i.e. 10⁻⁶ torr approximately, and the cord outgassed for several hours using an external heating source. Formation of an emitter coating is achieved by passing an electrical current through the core wire to raise the temperature to approximately 1700° C. for a few seconds, whereby a small amount of lanthanum boride is formed on the surface layer of the sleeve. The sleeve is allowed to cool before application of a high tension voltage to the filament assembly and the filament is preferably operated at a temperature 1000–1100° C.

Other coating methods may include

(a) Painting the cord with a slurry of lanthanum boride in amylacetate.

(b) Cataphoretic deposition of lanthanum boride using an electrolyte of methyl alcohol with a minor proportion of sulphuric acid or

(c) Painting the cord with a dilute organic cement to produce a tacky surface and subsequently dusting with a dry lanthanum boride powder, allowing the cord to dry, and subsequent heat treating the coated cord at about 1500° C. for 20 minutes in a vacuum approaching 10⁻⁶ torr.

It will be appreciated that the cord may be used without a central core wire, for example the coated cord may be formed as an elongated electron emitting cathode by taking a suitable length of cord and copper plating each end to provide electrical connection points or alternatively the cord may be left unplated and the ends clamped between suitable soft meal members.

The cathode may be tensioned by using a simple spring mounting since the weight of a coated graphite cord 2 mm. dia. approaches 1½ ozs. per 100 ft. length and the cathodes vary from a few inches in length to about 10 feet.

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With a 4 ft. length of cathode the tension required to keep the cathode within acceptable limits of straightness does not exceed $\frac{1}{10}$ of the breaking strength of the cord which is 10 lb. at room temperatures and increases up to double this amount at elevated temperatures, say 1600° C. Advantageously, the coefficient of linear expansion of the coated cord is low being approximately $4 \times 10^{-6} \text{ } ^\circ \text{C.}^{-1}$ and thus tensioning devices do not have to counter instabilities due to excess changes in length. A cord 1 mm. diameter and weighing approximately 1 oz./100 ft. has also proved suitable for some application.

We claim:

1. An electron emitting cathode comprising a flexible carbonaceous filament having a coating of a material which emits electrons when heated.

2. An electron emitting cathode according to claim 1 wherein the filament comprises a plaited or woven cord of low mass/unit length.

3. An electron emitting cathode according to claim 2 wherein the cord is tubular.

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4. An electron emitting cathode according to claim 2 wherein the cord is coated with lanthanum boride.

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