Aug. 31, 1937. H. E. MENDENHALL 2,091,554

COMPOSITE REFRACTORY BODY

Filed Oct. 3, 1935

FIG. 1

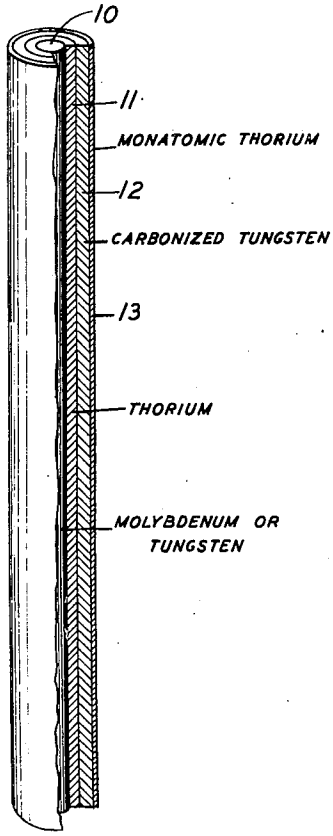


FIG. 2

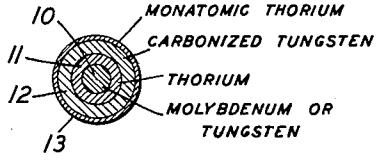


FIG. 3

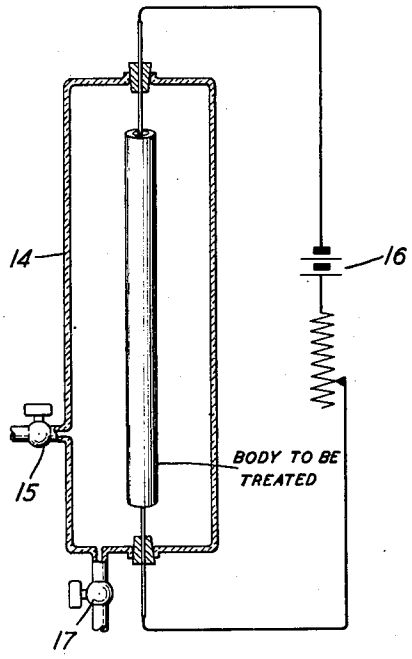
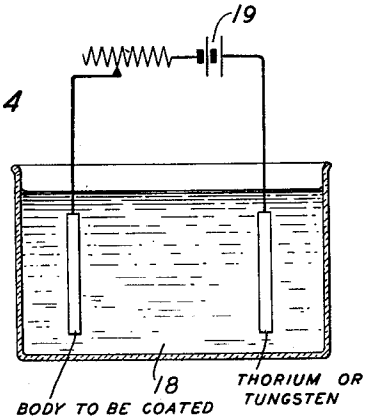


FIG. 4



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COMPOSITE REFRACTORY BODY

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8 Claims. (Cl. 250—27.5)

This invention relates to composite refractory bodies and more particularly to electron emitters for electron discharge devices.

One object of this invention is to increase the operating life of electron emitters.

Another object of this invention is to increase the ductility of composite refractory bodies including tungsten and thorium.

In one illustrative embodiment of this invention, an electron emitter for electron discharge devices comprises a metallic base or core, for example of tungsten or molybdenum, a layer of substantially pure thorium upon the base or core, and a layer of tungsten upon the thorium layer.

In the fabrication of the electron emitter, the layer of tungsten is wholly or partially carbonized as by treatment in a hydrocarbon atmosphere. Subsequently the several layers and the base or core are heated, as by the passage of a current therethrough, to diffuse some of the thorium through the carbonized tungsten layer and form a monatomic coating or layer of pure thorium upon the tungsten or outer tungsten carbide layers.

The inner thorium layer provides a reservoir from which thorium may be diffused through the carbonized tungsten layer during the operation of the emitter. There is thus provided a relatively large supply of thorium so that a long life for the emitter is attained.

The invention and the method of practicing it will be understood more clearly from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is an enlarged perspective view partly in cross section of an electron emitter illustrative of one embodiment of this invention;

Fig. 2 is an end view of the electron emitter shown in Fig. 1;

Fig. 3 is a diagrammatic view showing apparatus which may be used in fabricating composite refractory bodies, such as the electron emitter shown in Fig. 1, in accordance with this invention; and

Fig. 4 is another diagrammatic view illustrating other apparatus which may be used in fabricating composite refractory bodies, such as the electron emitter shown in Fig. 1, in accordance with this invention.

Referring now to the drawing, the electron emitter shown in Figs. 1 and 2 comprises a central metallic base or core 10, such as a rod or wire of tungsten or a rod or wire of molybdenum, having a layer of tungsten thereon, a layer or sleeve 11 of pure thorium about the base or core 10, a layer or sleeve 12 of carbonized tungsten about the thorium layer and an outer monatomic layer 13 of pure thorium.

In the fabrication of a composite refractory body, such as the electron emitter shown in Figs. 1 and 2, a sheet of pure thorium may be pressed about the core 10 and welded thereto. Alternatively the composite body composed of the core 10 and sheet of thorium may be heated in a vacuum to melt the thorium and cause it to adhere firmly to the base or core. For example, as illustrated in Fig. 3, the composite body may be enclosed in a container 14 which may be highly evacuated by a pump, not shown, connected to a port or outlet 15, and the body may be heated by connecting it in series with a suitable source, such as a battery 16.

Similarly, the tungsten layer 12 may be formed by welding a sheet or sleeve of tungsten to the thorium layer 11.

The composite body including the core and thorium and tungsten layers may then be inserted in the container 14 to which a hydrocarbon vapor, for example acetylene, has been introduced, as through a port or inlet 17. The body is then heated in this hydrocarbon atmosphere to carbonize the tungsten layer 12 wholly or partially. Subsequently the body is heated again in a vacuum whereby some of the thorium 11 diffuses through the carbonized tungsten layer and forms a monatomic layer 13 of pure thorium upon the carbonized tungsten layer.

The composite refractory body, such as the electron emitter shown in Figs. 1 and 2, may be formed also by electro-chemical processes. For example as illustrated in Fig. 4, the molybdenum or tungsten base or core 10 may be immersed in a bath 18 together with an electrode of thorium. The path may be a solution of a salt of thorium, for example thorium sulphate, thorium nitrate or thorium bromide, mixed with a suitable acid or the cyanide of thorium, sodium, or potassium. A suitable potential is applied between the electrodes, as by means of a battery 19, whereby a layer of pure thorium is deposited upon the molybdenum or tungsten base or core.

Similarly the tungsten layer 12 may be formed upon the thorium layer 11 by an electroplating process. In this case the base or core 10 with the thorium layer 11 thereon constitutes one of the electrodes in the system illustrated in Fig. 4 and the other electrode may be a rod of tungsten. The bath 18 may be a solution of tungsten sulphide or tungsten dioxychloride mixed with a

suitable acid or the cyanide of tungsten, sodium or potassium.

After the tungsten layer 12 has been formed as described in the preceding paragraph, it may be carbonized wholly or partially as described hereinbefore with reference to Fig. 3 and the composite body then heated to form the monatomic layer of thorium 13.

It will be understood, of course, that the thorium layer 11 and tungsten layer 12 may be formed in other ways as, for example, by thermal deposition in a vacuum.

It will be appreciated that this invention provides a refractory body having a relatively high thorium content. For example, whereas electron emitters previously available in the art may have a thorium content of less than two per cent, in the form of thorium oxide, electron emitters constructed in accordance with this invention may have a pure thorium content of more than two per cent, for example of the order of ten per cent or more. It will be apparent that the layer 11 acts as a reservoir of thorium which replenishes the monatomic layer 13 of thorium so that an electron emitter having a long operating life is obtained.

Furthermore, composite tungsten and thorium bodies constructed in accordance with this invention are more ductile than thoriated tungsten bodies previously known in the art so that they may be drawn to form filaments or wires of very small gauge.

Although a specific composite body and methods of fabricating it have been shown and described, it will be understood, of course, that modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims. For example, the composite body may be composed of a plurality of flat layers instead of circular layers as shown in Figs. 1 and 2.

What is claimed is:

1. A composite refractory body comprising a plurality of layers of pure thorium separated by a layer of tungsten.

2. An electron emitter comprising successive layers of thorium, carbonized tungsten and monatomic thorium.

3. An electron emitter comprising tungsten and thorium, the thorium content being of the order of ten per cent by weight.

4. An electron emitter comprising a core of a metal of the group including tungsten and molybdenum, a layer of pure thorium on said core, a layer of carbonized tungsten on said thorium layer, and a layer of thorium on said carbonized tungsten layer.

5. The method of fabricating an electron emitter which comprises forming a layer of thorium upon a metallic base, forming a layer of tungsten on said thorium layer, carbonizing said tungsten layer, and heating said layers whereby some of said thorium diffuses through the carbonized tungsten layer and forms a monatomic layer of thorium thereon.

6. The method of fabricating an electron emitter which comprises fusing a layer of thorium upon a metallic core, forming a layer of tungsten upon said thorium layer, carbonizing said tungsten layer, and diffusing some of said thorium through said carbonized tungsten layer to form a coating of thorium thereon.

7. The method of fabricating an electron emitter which comprises encompassing a metallic core with a sleeve of thorium, fusing said sleeve to said core, encompassing said sleeve with a sleeve of tungsten, heating the composite body including the core and said sleeves in a hydrocarbon atmosphere to carbonize said tungsten, and diffusing some of said thorium through the carbonized tungsten to form a layer of thorium thereon.

8. The method of fabricating an electron emitter which comprises immersing a metallic core and a thorium electrode in a bath including a thorium salt in solution, passing a current between said core and said electrode whereby a layer of thorium is deposited on said core to form a composite body, immersing said body and an electrode of tungsten in a bath including a tungsten salt in solution, passing a current between said body and said tungsten electrode whereby a layer of tungsten is deposited upon said thorium layer, heating the body composed of said core and thorium and tungsten layers in a hydrocarbon atmosphere to carbonize said tungsten layer, and further heating said second body in a vacuum to diffuse some of said thorium through the carbonized tungsten whereby a monatomic layer of thorium is formed on said carbonized tungsten.

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