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ELECTRON TUBE CATHODE

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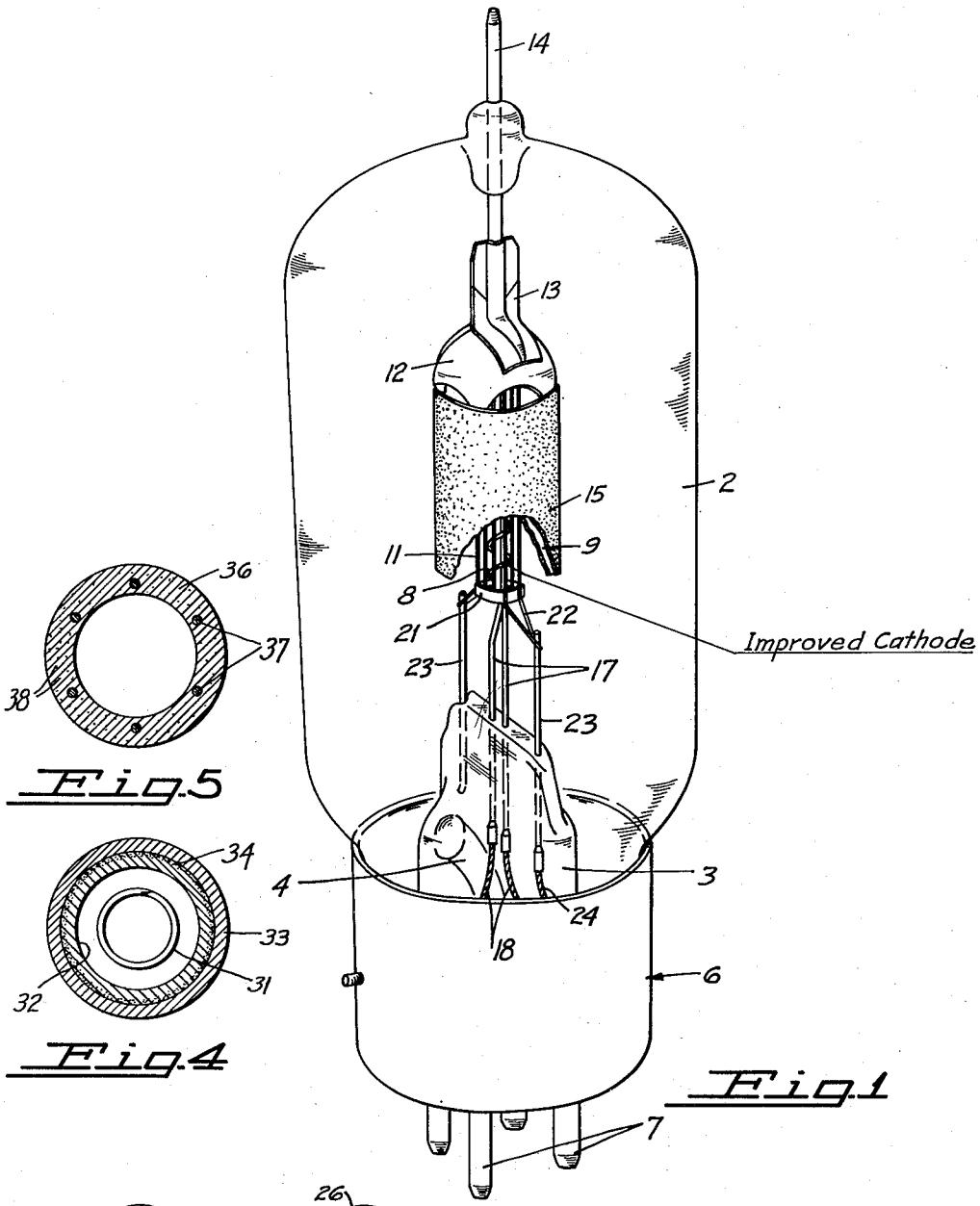


Fig. 1

Fig. 5

Fig. 4

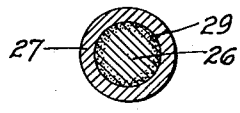


Fig. 3

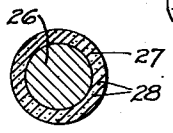


Fig. 2

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ELECTRON TUBE CATHODE

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5 Claims. (Cl. 250—27.5)

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My invention relates to cathodes for electron tubes, and more particularly to cathodes including thorium oxide.

In working with cathodes wherein the emitter comprises a body or layer of thorium oxide I have found that the electron emission properties of such cathodes are improved by the incorporation of certain other materials. An emitter body consisting of sintered thorium oxide exhibits reasonably good electron emission if it is operated at a sufficiently high temperature. The emission mechanism involved here is that enough of the active thorium metal is released by thermal dissociation high temperatures to support thermionic emission. Operational and life test data, however, show that these cathodes do not have satisfactory emission characteristics at normal cathode operating temperatures, say around 1600° C., and that they do not yield sustained emission with prolonged life.

Other limitations of these cathodes are that they have relatively poor thermal properties and that the emitter body is not a good electrical conductor.

The broad object of my invention is to improve cathodes of the character described by overcoming the disadvantages above mentioned.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of my invention. It is to be understood that I do not limit myself to this disclosure of species of my invention as I may adopt variant embodiments thereof within the scope of the claims.

Referring to the drawing:

Figure 1 is an elevational view of a tube embodying the improvements of my invention; and

Figures 2, 3, 4 and 5 are sectional views of four different types of cathodes illustrating the invention.

In terms of broad inclusion, my improvements comprise incorporating a reducing agent such as carbon in the cathode to promote reduction of the thorium oxide at lower operating temperatures. I also preferably include metallic particles with the thorium oxide to further enhance its electron emission characteristics and improve its electrical conducting and thermal properties. These features are preferably achieved by incorporating a metallic compound, such as a metallic carbide, in the cathode.

In greater detail, and referring to Figure 1 of the drawing, a tube showing a filamentary type

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of my cathode comprises an envelope 2 having a stem 3 carrying an exhaust tubulation 4. A base 6 with prongs 7 is provided at the lower end of the tube. The envelope encloses a plurality of electrodes including a helical filament or cathode 8 which is of a special composition hereinafter described.

Other electrodes include anode 9 and grid 11, the anode having a cap 12 supported by bracket 13 on lead 14 sealed to the envelope. If desired, a suitable coating 15 may be provided on the anode to improve its heat dissipation properties. Grid 11 has a base ring 21 supported by brackets 22 on rods 23, one of which serves as a grid lead connected to a base prong 7 by conductor 24. The filament is secured top and bottom to a pair of leads 17 sealed to stem 3 and connected to a pair of the base prongs by the conductors 18.

The above described tube structure is merely for purposes of illustration and may be varied within wide limits.

My improvements are better illustrated in connection with Figure 2 which is an enlarged sectional view of filament 8. The improved cathode comprises a body 27 of thorium oxide. In the filamentary type cathode being first described this body is in the form of a coating layer sintered on a metallic core wire 26, which core may be of any suitable refractory metal. By the term "refractory metal" I mean a metal having a high melting point and low vapor pressure such as tungsten, molybdenum or tantalum.

An important feature of my invention is that the cathode includes an agent to facilitate reduction of thorium oxide to metallic thorium. A reducing agent such as carbon is preferred, the requirements of the agent being that it be capable of performing the reducing function hereinbefore mentioned under normal operating temperatures.

The filamentary cathode shown in Figures 1 and 2 is preferably made by first winding a tungsten core wire 26 about a suitable mandrel to shape the filament. The filament core wire is then mounted on the filament stem by welding the wire to leads 17. Core wire 26 is next coated with a mixture of thorium oxide and carbon, the carbon being incorporated as finely divided carbon particles 28. The amount of carbon included with the thorium oxide is not critical.

The mixture may be coated on core 26 by any suitable means, as by spraying or by cataphoresis. The thickness of coating layer 27 may be varied, a layer .003 inch thick on a core wire

.013 inch in diameter having been found satisfactory. After coating, the filament is heated to a temperature of from 1800° C. to 2800° C. in an oxygen free atmosphere such as in vacuum or in an inert atmosphere. This heat treatment may be effected either before or after the filament stem is sealed into envelope 2. During this heating step the thorium oxide particles are sintered into a solid body or layer 27 throughout which carbon particles 28 are uniformly distributed. By the term "sintered" I mean sufficient fusion between adjacent particles in the mass to hold the particles together in a relatively rigid body.

Subsequent processing of the tube during the tube exhaust operation may be carried on in the usual manner.

The embodiment of my invention, above described, illustrates the incorporation of a reducing agent only, such as the particles 28 of pure carbon. This cathode has improved electron emission properties at lower operating temperatures because of the action of the reducing agent, as hereinbefore explained. I have been able to still further improve the cathode, however, by the further inclusion of finely divided particles of a refractory metal such as tungsten, tantalum, molybdenum, zirconium or titanium. This metal powder is preferably uniformly distributed throughout body 27 along with the carbon particles 28. I believe that the further improvement in the emission properties of the cathode, thus secured, is due to the fact that metal surfaces are provided in body 27 upon which the metallic thorium can deposit. Other advantages of including the refractory metal particles are that the thermal properties of the cathode are improved and that the electrical resistance of body 27 is decreased.

Instead of adding a mixture of the carbon and refractory metal particles, a similar result can be secured by incorporating particles of a refractory metal carbide, such as tantalum carbide, molybdenum carbide, zirconium carbide or titanium carbide. These carbides supply the necessary carbon for reducing the thorium oxide, and the residue particles of refractory metal perform the functions above mentioned. When the carbon is introduced in the form of a metallic carbide the heat treatment is preferably carried to the higher temperatures in the range indicated.

Instead of mixing the reducing agent with the thorium oxide in body 27 it may be incorporated in a layer contiguous with the body, such as in a layer on the surface of the body. For example, I have made cathodes by first applying a layer of thorium oxide and then applying a surface layer of carbon. The cathode was then heated to a temperature of from 1800° C. to 2800° C. as first described.

An alternative procedure is to apply the carbon as a coating on the core underlying the coating of thorium oxide. In this case, if pure carbon is applied, at least part of the carbon will combine as a carbide with the core metal during the initial heat treatment. This is indicated in Figure 3 as a metallic carbide layer 29 underlying the thorium oxide layer 27. With a core wire of tungsten, this layer would, of course, be tungsten carbide.

My improvements may be incorporated in cathodes other than the filamentary type. Figure 4 shows an indirectly heated cathode wherein the operating temperature of the cathode is maintained by a separate heater 31. The cathode illustrated comprises a cylindrical core 32 of a refractory metal such as tantalum, carrying a coating or body 33 of sintered thorium oxide. An underlying layer 34 of metallic carbide is shown, similar to that described in connection with Figure 3, but it is understood that any of the other cathode compositions hereinbefore discussed may be used.

Figure 5 shows a cathode comprising a cylindrical self-supporting body 36 of sintered thorium oxide in which heater wires 37 are embedded to maintain the cathode at operating temperature. The reducing agent is illustrated as particles 38 distributed throughout the body 36.

I claim:

1. A cathode for an electron tube comprising a body of sintered thorium oxide, and a metallic carbide incorporated in the cathode.

2. A cathode for an electron tube comprising a metallic core, an outer layer of thorium oxide, and carbon combined as a carbide with the core metal.

3. A cathode for an electron tube comprising a metallic core, an outer layer of thorium oxide, and an intermediate layer including carbon.

4. A cathode for an electron tube comprising a metallic core, an outer layer of thorium oxide, and an intermediate layer of metallic carbide.

5. A cathode for an electron tube comprising a metallic core, an outer layer of thorium oxide, and an intermediate layer of tungsten carbide.

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