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INDIRECTLY HEATED CATHODES

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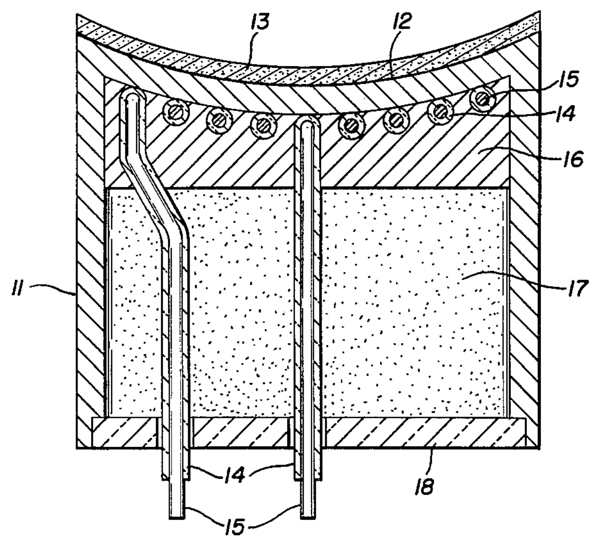

Fig.1

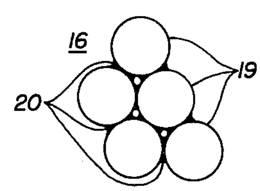

Fig.2

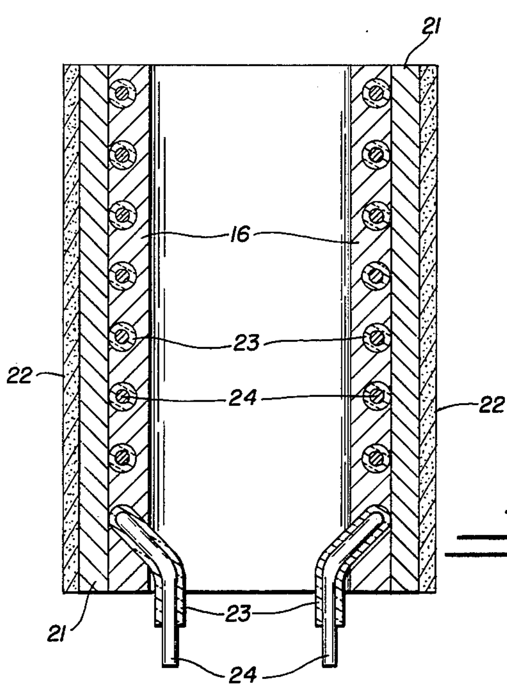

Fig.3

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INDIRECTLY HEATED CATHODES

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This invention relates to cathodes and more particularly to indirectly heated cathodes.

Generally, an indirectly heated cathode comprises a metal body having an emissive surface on the exterior thereof. The metal body surrounds a heater which may or may not contain electrical insulation thereon. Heretofore in the prior art, in order to increase the heat transfer properties and improve the mechanical stability of the cathode structure, an electrically insulated heater assembly has been imbedded in a metal powder, such as molybdenum or nickel, and sintered onto the metal cathode body. This type of cathode structure, however, has several disadvantages, such as the metal powder shrinking and cracking due to the sintering. The shrinking also tends to deform the metal cathode body thereby damaging the optical properties of the cathode particularly when the metal cathode body is fabricated from thin material in order to obtain a quick heat up time. Also, the sintered metal powder becomes very rigid and the difference in thermal expansion between the insulated heater assembly and the sintered metal, especially during heat up time, causes friction therebetween which limits the life of the insulation covering the heater wires. The present invention overcomes these and other disadvantages of the prior art and retains the desirable features of a mechanically rugged cathode structure having excellent heat transfer properties.

Accordingly, an object of this invention is to provide an improved indirectly heated cathode.

Another object of this invention is to provide a mechanically rugged indirectly heated cathode having improved heat transfer properties between the heater and emissive surface thereby permitting a reduction of the heater temperature which increases the life of the heater assembly.

Still another object of this invention is to provide an indirectly heated cathode wherein the heater assembly is firmly but flexibly retained adjacent an emissive surface.

These and other objects of this invention are accomplished by an indirectly heated cathode that includes a metal body having an emissive surface thereon. A heater assembly is located adjacent the emissive surface and in thermal contact with the metal body. A metal material encases the heater assembly and is attached to the metal body. The metal material is capable of following the expanding and contracting motions of the metal body and the heater assembly and still retain the heater assembly firmly adjacent the metal body. The metal material includes 10 to 150 micron size spheres of a first metal, such as nickel, which are bonded together by a second metal, such as molybdenum, and form an alloy therewith. If desired, heater power can be conserved by utilizing a heat insulator in the form of a quantity of alumina powder located adjacent the metal material at a point remote from the emissive surface.

This invention as well as other objects, features and advantages thereof will be readily apparent from consideration of the following detailed description relating to the following drawings in which:

FIGURE 1 illustrates a longitudinal cross-section of an indirectly heated cathode made in accordance with one embodiment of this invention;

FIGURE 2 is a schematic illustration of a metal material utilized in constructing the cathode shown in FIGURE 1; and

FIGURE 3 illustrates a longitudinal cross-section of an indirectly heated cathode made in accordance with another embodiment of this invention.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, there is illustrated in FIGURE 1 an indirectly heated cathode in accordance with the present invention that includes a cup shaped metal body 11 of nickel or other suitable material. The bottom or base 12 of the cup 11 is concave and has an electron emissive coating 13 on the exterior surface thereof which may be formed from barium, strontium and calcium oxides together with a suitable activator, such as zirconium, or from any other suitable electron emissive mixture or compound. As will be obvious to those skilled in the art, the bottom or base 12 of the cathode need not be concave for it may be flat, elliptical or any other desired geometric shape.

Adjacent the emissive coating 13 and within and in intimate thermal contact with the metal body 11 is a flat spiral heater assembly which includes a heater wire 15 of tungsten, or any other suitable material, coated with an insulating material 14, such as aluminum oxide (alumina ceramic). The spacing between the turns of the heater is preferably substantially uniform to aid in even heat transfer to the emissive surface.

Attached to the interior of the metal body 11 and encasing the flat spiral heater is a firm but flexible spongy metal material 16. The metal material 16 firmly retains the heater assembly in thermal contact with the metal body 11 during vibrations and/or shock due to rapid accelerations and decelerations but is flexible enough to follow the expanding and contracting motions of the heater assembly and the metal body 11. The metal material 16 is described in detail hereinbelow.

Also located and contained within the metal body 11 adjacent the metal material 16 at an area remote from the emissive surface 13 is a quantity of heat insulating material 17, such as finely powdered aluminum oxide (alumina), which conserves heater power by acting as a heat dam. The fine powdered aluminum oxide 17 is retained within the metal body 11 by a disk or membrane 18, which is made from any suitable material, such as a ceramic. In order to prevent the formation of air pockets or bubbles, it is important that the jointure or seal of the disk 18 to the metal body 11 not be vacuum tight but yet be tight enough to prevent any of the fine powder 17 from escaping from the metal cup 11. As is well known to those skilled in the art, such a jointure or seal may be obtained by various methods and designs. Also, heater leads extend through the disk 18 to permit easy electrical connection to the heater assembly.

The metal material 16 is formed by intimately mixing 65 to 95% by volume of 10 to 150 micron size microspheres or particles of a suitable metal, such as nickel, and 35 to 5% by volume of a suitable finely powdered metal, such as molybdenum or palladium. After the heater assembly, comprising the insulated 14 heater wires 15, is inserted within the metal cup or body 11, the surrounding space is filled with the nickel microsphere-molybdenum or palladium powder mix. The entire assembly is then heated to the melting point of the eutectic of the nickel microspheres and the molybdenum or palladium powder to form a firm but flexible spongy metal material 16 that encases the heater and attaches to the wall of the metal body or cup.

Referring now to FIGURE 2, which illustrates in enlarged schematic form the metal material 16, it is shown that the nickel microspheres **19** are permanently bonded together by the molybdenum or palladium powder **20** which forms a nickel-molybedenum or nickel-palladium alloy with at least a portion of the microspheres **19**. The spongy metal material **16** is not absolutely rigid, attaches to the walls of the metal body **11**, can follow the expanding and contracting motions of the heater assembly and metal body **11** and still firmly retain the heater assembly during vibrations. The nickel microspheres **19** also conduct heat away from the heater and uniformly distribute it to the emissive surface **13**.

The softness or rigidity of the metal material **16** can be controlled by the amount of metal powder **20** used with the metal microspheres **19** and by the duration and temperature of the heat treatment. The nickel microspheres **19** can be replaced by microspheres of molybdenum in which case the fine powdered metal **20** could be nickel or palladium; or the nickel microspheres **19** can be replaced by palladium microspheres in which case the fine powdered metal **20** could be nickel or molybdenum. Other fine metal powders can also be used as long as they form a lower melting alloy with the metal of the microspheres.

It was found desirable to use a vehicle for the metal microspheres and the fine metal powder, such as a nitrocellulose solution. However, when this binder was used, it was found to be advantageous to burn out the binder by placing the cathode assembly under a heat lamp prior to heating the metal microspheres and fine metal to the melting point of their eutectic in order to prevent an excessive burn out rate of the binder.

The indirectly heated cathode illustrated in FIGURE 1 and fully described hereinabove also has an extended heater life due to the lower operating temperature of the heater for a desired cathode operating temperature. This desirable result is achieved by the excellent thermal conductivity existing between the heater and the emissive surface **13**.

Referring now to FIGURE 3, which illustrates another embodiment of the present invention, there is shown a metal body or sleeve **21** formed from any suitable metal. such as nickel. The metal body **21** may assume any cross-sectional shape, such as an oval, circle, rectangle, square, etc. The exterior surface of the metal body **21** contains an electron emissive coating **22** which is formed from any suitable emissive material. Adjacent the emissive coating **22** and within and in thermal contact with the metal body **21** is a heater assembly which includes a heater wire **24** of tungsten, or any other suitable material, coated with an insulating material **23**, such as aluminum oxide. The spacing between the turns of the heater is preferably substantially uniform to aid in even heat transfer to the emissive surface. Attached to the interior of the metal body **21** and encasing the heater is the metal material **16** described hereinabove in detail. If desired, a quantity of heat insulating material, such as fine alumina powder (not shown), may be placed at opposite ends of the metal body **21** to act as heat dams.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is to be understood, therefore, that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. An indirectly heated cathode comprising a metal body having an emissive surface, a heater assembly in thermal contact with said metal body and located adjacent said emissive surface, and a metal material attached to said metal body and encasing said heater assembly, said metal material capable of following the expanding and contracting motions of said metal body and said heater assembly and including 10 to 150 micron size

particles of a first metal which are bonded together by a second metal which forms with said first metal particles an alloy having a lower melting temperature than said first metal, and said particles being bonded together along a portion of their peripheries by a eutectic alloy of said second metal and a portion of the metal of said particles.

2. The combination according to claim **1** further including a quantity of powdered alumina located within said metal body and adjacent said metal material at an area remote from said emissive surface.

3. An indirectly heated cathode comprising a metal body having an emissive surface, a heater assembly in thermal contact with said metal body and located adjacent said emissive surface, and a metal material attached to said metal body and encasing said heater assembly, said metal material capable of following the expanding and contracting motions of said metal body and said heater assembly and including 65 to 95% by volume of 10 to 150 micron size spheres of a first metal selected from the group consisting of molybdenum, palladium and nickel and which are bonded together by 35 to 5% by volume of a second metal which forms an alloy with said microspheres, and said spheres being bonded together along a portion of their peripheries by a eutectic alloy of said spheres with said second metal.

4. The combination according to claim **3** wherein said second metal is molybdenum, and said first metal is nickel.

5. The combustion according to claim **4** wherein said second metal is palladium.

6. An indirectly heated cathode comprising a metal body having an emissive surface, a heater assembly in thermal contact with said metal body and located adjacent said emissive surface, and a metal material attached to said metal body and encasing said heater assembly, said metal material capable of following the expanding and contracting motions of said metal body and said heater assembly and being formed from a powdered mixture including 65 to 95% by volume of 10 to 150 micron spheres of a metal selected from the group consisting of nickel, molybdenum and palladium and 35 to 5% by volume of an unlike finely powdered metal selected from the group consisting of nickel, molybdenum and palladium, and said spheres being bonded together along a portion of their peripheries by a eutectic alloy of said spheres with said unlike metal.

7. An indirectly heated cathode comprising a metal body having an emissive surface on an outside portion thereof, a heater assembly located within said metal body and adjacent said emissive surface, a firm but flexible spongy metallic material attached to said metal body and encasing said heater assembly, said metal material capable of following the expanding and contracting motions of said metal body and said heater assembly and including 10 to 150 micron spheres of nickel bonded together along a portion of their peripheries with a eutectic alloy of molybdenum and a portion of the nickel in said spheres.

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