Sept. 29, 1942. H. BERGER 2,297,454

CATHODE

Filed Jan. 16, 1941

Fig.1

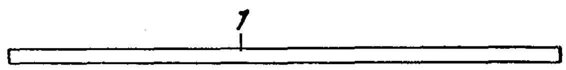


Fig.2

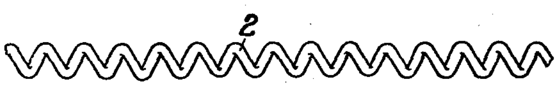


Fig.3

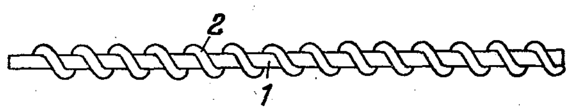


Fig.4

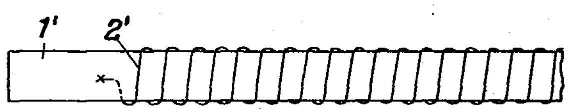


Fig.5

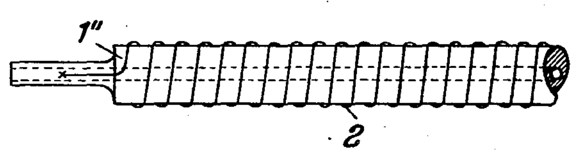


Fig.6

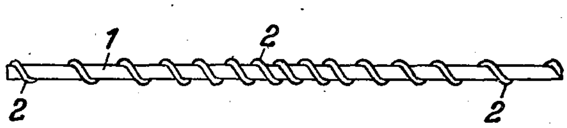
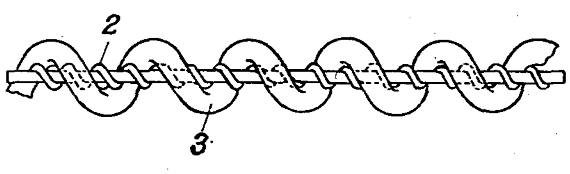


Fig.7



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UNITED STATES PATENT OFFICE

2,297,454

CATHODE

Hermann Berger, Berlin, Germany; vested in the Alien Property Custodian

Application January 16, 1941, Serial No. 374,655
In Germany January 20, 1940

3 Claims. (Cl. 250—27.5)

The invention relates to thoriated tungsten cathodes, and in particular to such cathodes having relatively high resistance and increased emissive power.

It has not been possible so far to make a practical cathode having large emissive area from thoriated tungsten, the ohmic resistance of such cathodes being too low and too dependent upon temperature in most cases.

According to the invention a highly emissive cathode comprises a thoriated tungsten wire wound in the shape of a helix upon a suitable core and arranged so that its windings do not contact with each other. The core is preferably of a material having relatively high resistance, and in a preferred form comprises tantalum carbide.

In the drawing, Figs. 1 and 2 show the constituent parts of a cathode as represented in Fig. 3. Figs. 4 to 7 illustrate other examples of cathodes as provided by the invention.

A straight thoriated tungsten wire 1, Fig. 1, has a certain ohmic resistance. A helix 2 of tungsten wire, Fig. 2, is adapted closely to contact with wire 1 when inserted over it, whereby the cathode structure shown in Fig. 3 is formed. This structure constitutes a parallel connection of a wire coil and a core wire. As the helix has an ohmic resistance much higher than that of the core wire the total resistance of a cathode according to Fig. 3 is about 25% less than the resistance of the core wire alone. However, the effective surface of such a cathode is approximately four times as large as that of the core 1 alone, whereby also the filament power and emission thereof are four times that of the core.

From the foregoing, it will be seen that the ohmic resistance of the composite cathode is mainly determined by the core wire. In the case of tungsten described for the core, resistance is far too low and too dependent upon temperature. Therefore, in order to minimize the decrease of the ohmic resistance of the core 1 due to the thoriated tungsten helix, this core should be made of a material of relatively high ohmic resistance. A helix wound upon a core of tantalum has been found to have a total resistance higher by about 25% than in the case of a core made of tungsten, and the resistance of such a combination may be greatly increased by carburizing the tantalum core. At the same time the core decreases in rigidity. Such decrease, however, may be compensated by employing cores of correspondingly larger cross-sectional area.

The reason for the selection of a core of tantalum carbide is essentially twofold. First, as explained above it is necessary that a larger resistance be offered by the cathode than in the tungsten core case of Fig. 3 and that this resistance be relatively stable throughout a range of operating temperatures. Tantalum carbide at room temperature has a resistance 19 times that of tungsten and at 1900° K., due largely to the change in resistance of the tungsten, this factor is on the order of 3. Moreover, throughout this temperature range current will vary by a factor of 10 for tungsten cores in accordance with Fig. 3, and will be substantially constant for the tantalum carbide structures of the succeeding figures.

Secondly, it is necessary to provide a core material that will not decompose thermally in vacuum. Naturally this requirement eliminates the use of hard-metal oxides, such as thorium oxide, zirconium oxide, etc., since they are reduced very readily in the presence of tungsten at elevated temperatures and oxygen is given off. Moreover, these metal oxides exhibit too high resistance with the result that the inductance of the tungsten winding may become too substantial, and other undesirable effects may result. The most stable and practical carbide I have found to be tantalum carbide, which has a melting point in the neighborhood of 4150° K.

Tantalum carbide has the advantage that the ductile metal tantalum may be first formed into the shape of the core and then carburized to form the carbide. Since the thoriated tungsten wire must also be carburized to increase the specific emission of the structure, there is no danger of the tantalum carbide being decarburized due to the presence of tungsten carbide. Thus the structure, in accordance with the invention, lends itself to particularly simple manufacture.

Fig. 4 shows a strong core 1', made of tantalum, and a coil of comparatively thin thoriated tungsten wire, the turns of which are each supported by the core. By carburizing this complete structure a cathode is obtained that comprises a core of tantalum carbide and a carburized helix of thoriated tungsten. Cathode structures as provided by the invention allow of carburizing them to a much higher degree than devices in which the helix is not supported as described. A high carburization enables the use of a high operating temperature, whereby a higher specific emission of electrons may be obtained. The overall resistance of such a carburized tantalum and thoriated tungsten cathode does not vary appreciably from its relatively high value throughout the complete range of operating temperatures and will not decompose at the highest operating temperatures.

As represented in Fig. 5, a tubular core 1'' of tantalum or of a similar material may be employed instead of a solid one. Core 1'' and the tungsten helix 2 are connected in parallel and are heated by an electric current passing through them.

The cathode shown in Fig. 6 has a wire helix 2 of different pitches, the pitch increasing from the middle of the cathode toward the ends thereof, that is to say, toward the points where the current leads, not shown, are joined to the cathode. This arrangement, which may be adopted in the case of all the cathodes before described, acts to reduce the size of the emitting surface of the cathode toward the ends thereof.

Furthermore, as illustrated in Fig. 7, the core supporting a wire helix 3 may itself be a coil 2 or may comprise a combination of coil and solid wire, the coils 2, 3 constituting a sort of double helix. In the former case, that is, where the core is itself a coil, the thoriated tungsten may be wound thereon in the same manner as in the case of Figs. 4, 5 and 6. Such a structure provides a more compact cathode having greater emissive power, as will be clear.

What is claimed is:

1. A large surfaced thoriated tungsten cathode comprising a core of tantalum carbide and a thoriated tungsten wire wound upon and in direct contact with said core.

2. A cathode according to claim 1, wherein the said core itself is coil-shaped.

3. A cathode according to claim 1, wherein the tungsten wire is wound as a helix and has a pitch increasing from the middle of the cathode to the ends thereof.

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