June 7, 1938. G. HOLST ET AL 2,119,913

CATHODE FOR DISCHARGE TUBES

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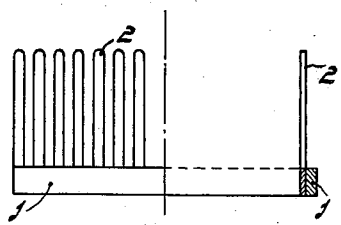


Fig. 1.

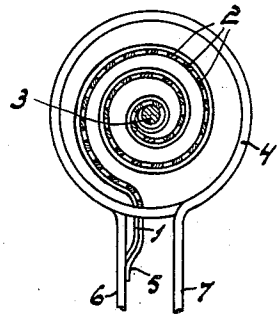


Fig. 2.

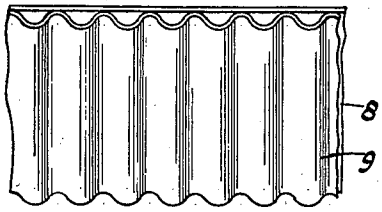


Fig. 3.

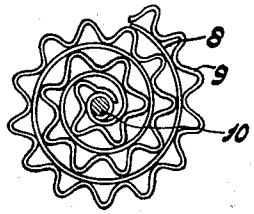


Fig. 4.

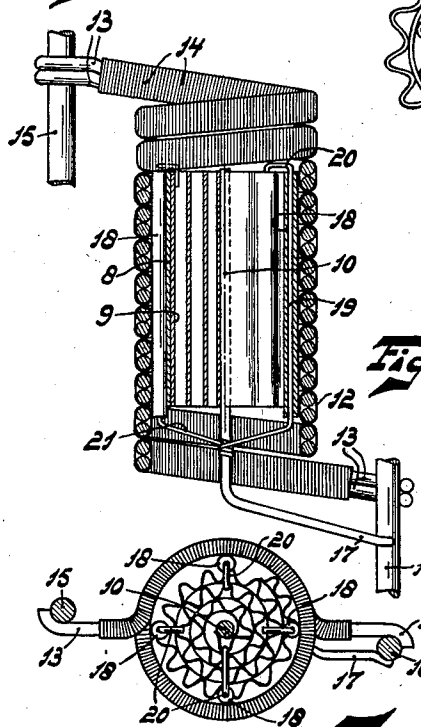


Fig. 5.

Fig. 6.

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CATHODE FOR DISCHARGE TUBES

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8 Claims. (Cl. 250—27.5)

The present invention relates to cathodes of discharge tubes and more particularly to incandescent cathodes having large electron-emitting surfaces as may be required for gas-filled discharge tubes, for instance rectifier tubes of large current capacities.

As is known, if such a cathode is to handle large currents it should have a large emitting surface and the electron emission per unit of cathode surface, for a given temperature, should be as high as possible.

To obtain, at a given temperature, a large specific emissivity of the cathode, the cathode surface is usually activated by providing same with a surface layer or coating of a material which has a high electron emissivity. Such surface layers or coatings as a rule consist of a highly emissive oxide, for instance of barium oxide.

Various constructions have been already suggested to obtain cathodes having large emitting surfaces. A suitable construction is, for instance, described in the copending application of Mulder et al., Ser. No. 536,270, filed May 9, 1931, now U. S. Patent No. 2,052,103, in which a large cathode surface is obtained by winding into a roll a metallic gauze, which carries a highly-emitting coating. However, such construction has certain drawbacks, especially due to the thinness of the wire forming the gauze, the gauze is subject to damage, and this is aggravated by the fact that the wire forming the gauze, instead of being made of tungsten or other highly refractory metal, is usually made of nickel or other lower melting point metal, to which the oxide layer adheres much better than to such refractory metals. With such low melting point metal wires the individual wires of the gauze are liable to melt, which may impair the operation of the entire cathode structure. The latter drawback can be partly removed by providing a plurality of supply wires connected to various points of the metal-gauze cathode and by weaving the gauze of alternately arranged tungsten and nickel wires. But even with the above provisions, such a cathode structure is not entirely satisfactory in the case of very large currents.

According to our present invention, these drawbacks are overcome by making a large surface cathode body, which may be either directly and/or indirectly heated, in the form of a composite band which is folded or wound into a compact form. This composite band has essentially two components, namely a single continuous support in the form of a metal wire or metal strip which extends the entire length of the band, and a large surface member which consists of a large number of projections which may be individual or be formed as a continuous member; the projections being mechanically and electrically connected with the support or may be even integral therewith.

Furthermore, in accordance with the invention the projections of the large surface member extend in a direction substantially perpendicular to the support, whereas the composite band forms a substantially flat structure which can be made in any length in a continuous operation and cut into the desired length and assembled into a compact assembly, for instance, wound into a roll.

The support is given a sufficient cross-section to handle the current as a supply conductor for the discharge current and if desired also for the heating current without danger of melting, and even should some of the projections melt away or break off, the support remains intact and the operativeness of the cathode is unaffected.

Preferably, the support itself is made of a high melting point metal, for instance of tungsten, whereas the projecting parts may be formed of a lower melting point metal, for instance of nickel, to which the oxide firmly adheres.

According to one embodiment of the invention, the composite band has the form of a comb, whereby the support forms the rib or base of the comb and the projecting parts form the teeth of the comb. If the support is to be made of the same material as are the projecting teeth, the composite band can be formed by a single stamping. However, we prefer that the support be given a greater thickness and be made of a higher melting point metal than are the teeth.

Another suitable form of construction of the composite band of the invention, is similar to that of corrugated cardboard, whereby the large surface member forms projections in the form of a continuous corrugated strip, and is supported by a metal strip acting as a backing of the corrugated strip. The individual corrugations are electrically and mechanically connected to the support strip, preferably by spot-welding; the support strip being preferably of sufficient width to extend substantially over the whole width of the corrugated strip, or may even extend beyond same. Thereby the support may be provided with two corrugated strips, one being secured to each side of the support or may be provided with only one corrugated strip secured to one side of the support.

The large surface band member may be heated by current passing through the support and for this purpose the support is provided with leads which are sealingly carried through the tube envelopes, or, if also a separate heating element, for instance a filament, is provided, the support ends are electrically connected to the ends of the heating element.

In a preferred embodiment of our invention the cathode is formed by a composite band, made in accordance with the invention, wound into a roll, this roll being surrounded by a helically wound, directly heated cathode.

By the use of the constructions described hereabove it is possible to obtain a five to tenfold increase of the emitter-carrying surface, which results in an equal increase of the discharge current capacity of the cathode.

The invention will be more clearly understood by reference to the accompanying drawing, which represents by way of example some embodiments thereof and in which:

Fig. 1 is a side view of a comb-shaped composite band for the cathode shown in evolution; also showing the cross-section of the support.

Fig. 2 is a top view of a cathode structure employing a cathode band according to Fig. 1.

Fig. 3 is a fractional prospective view of a corrugated composite cathode band according to the invention.

Fig. 4 is a top view of part of a cathode structure, employing a corrugated band in accordance with Fig. 3.

Fig. 5 is a partly sectionalized side elevation of a cathode structure comprising a corrugated band, as shown in Fig. 4, which is surrounded by a directly heated coiled cathode, and

Fig. 6 is a top view, partly in section, of Fig. 5.

Referring to Fig. 1, the composite band has the shape of a comb and consists of a supporting wire or band carrying laterally extending projecting teeth **2**. The composite band may be formed of a single piece of metal, but preferably the thickness of the support **2** is larger and also the support is made of a refractory metal, as tungsten, whereas the projecting teeth **2** are preferably made of nickel to which the oxide coating, for instance, barium oxide, readily adheres. However, the support may also be coated with an electron-emissive layer. Such a composite band may be formed in any desired length.

As shown in Fig. 2, the composite band is rolled into a spiral the inner end of which is secured to a central supporting rod **3**, the individual turns of the spiral being spaced from each other. The composite band is surrounded by a helically-wound heating wire **4**, which is provided with leads **6** and **7** for the supply of the heating current. The other end **5** of the support **1** is electrically connected, preferably by welding to the supply lead **6**. The composite band, preferably including the support **1**, is coated with an oxide layer and the heating wire **4** is similarly coated. When a heating current is passed through the heating wire **4** one part of the cathode assembly is heated directly and the other part is heated indirectly. If desired support rod **3** may be electrically connected to the supply wire **7** in which case the heating current is passed through both the heating wire **4** and the support **1**, thus giving a cathode assembly in which both the parts are heated directly and indirectly.

For the spacing of the turns of the composite band interposed rods (not shown) may be used, although good results can be obtained when the successive turns of the band contact each other, provided the apertures and teeth are properly staggered to expose substantially the entire cathode to the discharge.

The construction of the composite band of Fig. 3 is similar to that of corrugated cardboard. The large surface member is formed by a corrugated metal strip **9** and the support is formed by a metal strip backing **8**. The corrugated strip **9** is secured to and electrically connected with the support at each corrugation, for instance, by spot-welding.

Fig. 4 shows the composite band **8—9** spirally wound into a roll around the rod or pin **10**, which pin may also form one of the terminal leads of the support. The corrugated strip **9** provides for a proper spacing of the successive turns of the roll, which as appears, forms a body provided with a large number of cavities. The entire surface of the strip **9** and preferably also of the support **8**, is coated with a suitable oxide coating having a high emitting capacity, for instance with barium oxide.

Fig. 5 shows the combination of a cathode structure in accordance with Fig. 4, with a directly heated cathode **12**, the latter forming a coiled filament which surrounds and indirectly heats the composite band cathode body **8—9**.

The helically wound cathode may also be of a composite structure, and as shown, comprises two tungsten wires **13—13** juxtaposed and welded together, the wires **13—13** being coiled and being surrounded throughout their whole length with a thin helically wound nickel wire **14**, the turns of which lie in direct contact with each other. The unwound end portions of the tungsten wires **13—13** may be nickel-plated, so that the entire outer surface of the cathode structure **12** is provided with a nickel surface. The undulated surface of the nickel wire **14** is especially favorable for the firm adherence of an oxide coating. The ends of the tungsten wires **13—13** are welded or otherwise connected to lead-in rods **15—16**, which also serve as supports for the cathode.

The supporting strip **8** of the composite cathode band is welded at its inner edge to the rod **10** which serves as a supply conductor for the discharge current to the band, which rod is connected at its end **17** to the rod **16**. The support **8** may be directly heated in which case the outer edge of the support **8** may be electrically connected to the lead-in rod **15**.

Between the large surface body and the cathode **12** are provided four spacing tubes **18** of insulating material (see Fig. 6), for instance of porcelain, inside of which are disposed metal wires **19** the lower ends of which are secured to wire **17** and which have upper bent end portion **20**, which engage and fix the composite band **8—9** securely within the cathode **12**.

The cathode structure shown in Figs. 5 and 6 provides for an emission which, assuming that the same heating energy is used, may be three or four times the emission which can be obtained by merely using the helically-wound cathode **12**.

While we have described our invention on hand of a specific embodiment and in a specific application, we do not wish to be limited thereto, but desire the appended claims to be construed as broad as permissible in view of the prior art.

What we claim is:

1. A compact incandescible cathode structure comprising a composite band having an elongated support serving as a carrier for the emission current, and a large surface area member consist-

ing of a transversely-corrugated metal strip having the same width as said support, each corrugation of said strip being secured and electrically connected to said support along its crest, said composite band being provided on its surface with a highly electron-emissive material and being bent several times along lines perpendicular to the longitudinal axis of the support to form a series of convoluted portions and to form said band into a compact body, a rod of conductive material disposed in the center of said body and electrically connected to said support, a directly-heated helically-wound cathode surrounding said body to heat same to its proper electron-emitting temperature, said cathode having a large surface area provided with a highly electron-emissive substance, and means supporting said body from said rod and insulatingly spacing said body from said cathode, said means comprising a plurality of insulating members disposed between the corrugations of said strip, and supporting members secured to said insulating members and to said rod.

2. A compact incandescible cathode body comprising a composite band having an elongated support for carrying the emission current, and a large surface-area metal strip having substantially the width of said support and provided with a large number of transverse corrugations secured and electrically connected to said support along their crests, and a highly electron-emissive material on the surface of said strip, said band being bent along lines perpendicular to the longitudinal axis of the support and forming a series of convoluted portions constituting a body traversed by a large number of parallel ducts.

3. A compact incandescible cathode body comprising a composite band having an elongated support for carrying the emission current, and a large surface-area metal strip having substantially the width of said support and provided with a large number of transverse corrugations secured and electrically connected to said support along their crests, and a highly electron-emissive material on the surface of said strip, said band being helically wound upon itself to form a compact body having a large number of parallel ducts.

4. A compact incandescible cathode body comprising a composite band having an elongated support of high melting-point metal for carrying the emission current, and a large surface-area strip of a lower melting-point metal to which emission materials firmly adhere, said strip being provided with a large number of transverse corrugations secured and electrically connected to said support along their crests, and a highly electron-emissive material on the surface of said strip, said band being bent along lines perpendicular to the longitudinal axis of the support and forming a series of convoluted portions constituting a body traversed by a large number of parallel ducts.

5. A compact incandescible cathode body comprising a composite band having an elongated support of a high-melting-point metal for carrying the emission current, and a large surface-area metal strip having substantially the width of said support and provided with a large number of transverse corrugations secured and electrically connected to said support along their crests, and a highly electron-emissive material on the surface of said strip, said band being bent along lines perpendicular to the longitudinal axis of said support and forming a series of convoluted portions constituting a compact body provided over its entire cross section with parallel foramens extending through said body from end to end.

6. A compact incandescible cathode body comprising a composite band having an elongated support for carrying the emission current, and a large surface-area metal strip having substantially the width of said support and provided with a large number of transverse corrugations secured and electrically connected to said support along their crests, a highly electron-emissive material on the surface of said strip, said band being bent along lines perpendicular to the longitudinal axis of the support to form a series of convoluted portions constituting a body traversed by a large number of parallel ducts, and a rod of conductive material centrally disposed within said body and electrically connected to said support.

7. A compact incandescible cathode body comprising a composite band having an elongated support for carrying the emission current, and a large surface-area metal strip having substantially the width of said support and provided with a large number of transverse corrugations secured and electrically connected to said support along their crests, said band being bent along lines perpendicular to the longitudinal axis of the support and forming a series of convoluted portions constituting a body traversed by a large number of parallel ducts, a rod of conductive material centrally disposed within said body and electrically connected to said support, a directly-heated helically-wound cathode member of large surface area surrounding said body to heat the same to its proper electron-emitting temperature, and a highly electron-emissive material on the surface of said strip and cathode member.

8. A compact incandescible cathode body comprising a composite band having an elongated support for carrying the emission current, and a large surface-area metal strip having substantially the width of said support and provided with a large number of transverse corrugations secured and electrically connected to said support along their crests, said composite band being bent along lines perpendicular to the longitudinal axis of the support and forming a series of convoluted portions constituting a body traversed from end to end by a large number of parallel ducts, a rod of conductive material centrally disposed within said body and electrically connected to said support, a directly-heated cathode member helically-wound around said body to heat the same to its proper electron-emitting temperature, a highly electron-emissive material on the surfaces of said strip and cathode member, and means supporting said body from said rod and insulatingly spacing said body from said cathode member comprising a plurality of insulating members disposed between the corrugations of said strip, and supporting members secured to said insulating members and to said rod.

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