Aug. 6, 1940. E. F. HENNELLY 2,210,761

CATHODE

Filed Oct. 7, 1936

Fig. 1.

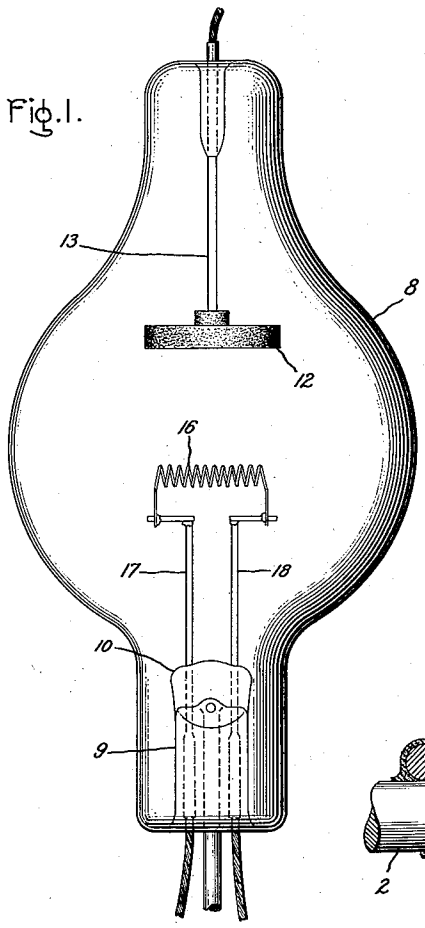


Fig. 3.

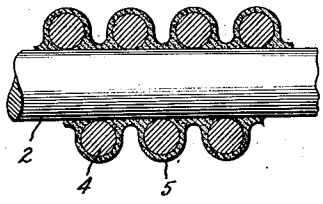
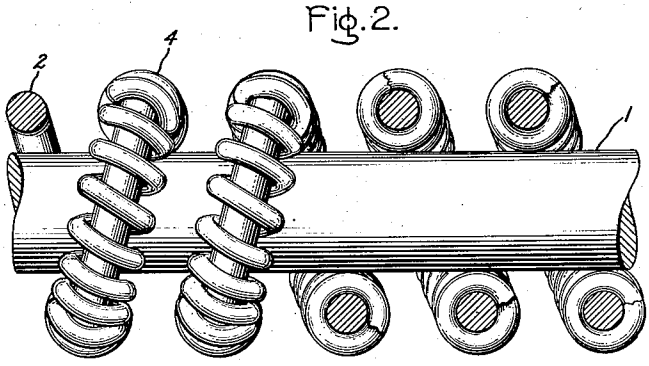


Fig. 2.



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Patented Aug. 6, 1940 2,210,761

UNITED STATES PATENT OFFICE

2,210,761

CATHODE

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Application October 7, 1936, Serial No. 104,465

12 Claims. (Cl. 250—27.5)

The present invention relates to improvements in cathodes for electric discharge devices.

It is an object of the invention to provide in a filamentary type cathode an improved combination of base and coating materials conducive to long life, improved emission, and stability of emission.

It is a further object to provide an improved cathode structure which will produce a given thermionic electron emission with less power input, or which with a given power input will produce greater emission than the cathodes heretofore available.

An important aspect of the invention consists in improvements in the structure and materials of cathodes of the so-called "overwound filament" type. A specific feature which is considered to be of particular importance in this connection consists in the application to a conductive core member of a composite overwinding structure which consists of a plurality of separate wires assembled in inter-engaging relation to form a framework having a large number of crevices suitable for the retention of emissive material. The novel features of my invention which I desire to protect herein will be pointed out with particularity in the appended claims. The invention itself, however, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the drawing, in which Fig. 1 is a side elevation of a discharge device suitably incorporating my invention; Fig. 2 is a view in partial section showing in enlarged detail the structural features of the invention; and Fig. 3 is a sectional view of a fragmentary portion of the structure of Fig. 2.

Referring first to the cathode structure shown in Fig. 2, there is illustrated a central supporting member 1 which for convenience may be referred to as a wire mandrel and which preferably consists of a refractory electrical conductor such as tungsten wire. It will be understood that the drawing greatly magnifies the dimensions of this mandrel, and that its actual diameter may be on the order of a small fraction of an inch, for example, 4 mils.

In the example illustrated the structure which overlies the central element 1 is of complex nature comprising a filamentary core 2 having a second filament 4 helically wound in open convolutions thereon. The composite structure is coated with a quantity of highly electron emissive material 5 which preferably only partially fills the spaces or grooves formed between the various turns of the overwound filaments. For the sake of simplicity this coating is illustrated only in Fig. 3 which shows a straightened section of the core 2 and the filamentary overwinding 3. In actual use, however, the emissive material preferably covers all parts of the cathode including the wire mandrel 1.

In preparing composite cathodes in accordance with my invention best results are obtained if the various filaments, including the core member 1, are of the same material and comprise a metal of the group comprising tungsten and molybdenum. The fulfillment of this condition assures maximum total emission since the fact that all parts of the cathode are of identical composition makes it certain that the entire exposed surface will take part in the electron emission.

While other electron emissive substances may be used, for example, barium oxide, I prefer to employ a compound of thorium, such as thoria, as the coating material. With such a material in combination with an overwound cathode of tungsten or molybdenum, extremely long life is realized as well as excellent ability to resist stripping of the cathode surface under the influence of positive ion bombardment. Furthermore, an overwound cathode comprising tungsten coated with thorium oxide (thoria) is characterized by unusual stability or constancy of emission throughout its operative life.

The thorium oxide may be applied in any known manner as by spraying or dipping the base metal. Thereafter the thorium may be "activated" by heating the filament to a temperature less than that at which substantial evaporation of the thoria takes place, for example, at about 1600° C., and passing through the cathode a discharge current considerably in excess of its normal rating, such current being maintained only for a relatively brief period of time. The activating process may be carried out either in vacuum or in a blanketing atmosphere such as an atmosphere of argon gas.

The high efficiency obtained by the combination of materials as set forth in the preceding paragraphs is still further enhanced by using complex overwinding such as is illustrated in Fig. 2. In addition to the increase in the emitting surface produced by this structure, the heat required to maintain a given cathode emission may be considerably reduced. This latter effect appears to be due to the mutual heat shielding provided by the opposed surfaces of adjacent turns of each winding layer, so that an appreciable amount of heat is retained or conserved in

the grooves. Otherwise expressed, the portion of the surface of the combined assembly capable of losing heat by free radiation may be made a small part of the total surface which contributes to the electron emission. In consequence, a given operating temperature may be maintained with from 10 to 20 per cent less wattage input than would be required for equivalent smooth or plane surfaces of equal electron emission.

The preferred arrangement of the overwinding for producing both maximal emission and heat conservation is that in which the spacing between adjacent filamentary turns is on the order of but somewhat less than the diameter of the wires themselves. Thus, the desired conditions with respect to spacing will be satisfactorily fulfilled if the product of the wire diameter, expressed in mils, times the number of turns of wire per inch is approximately 600. For example, a particular cathode constructed in accordance with this formula may suitably comprise a filament of 2 mil tungsten wound with about 300 turns per inch of a 4 mil tungsten core, the core in turn being wound on a 4 mil wire mandrel in a helix having about 70 turns per inch. From the standpoint of economy of base material best results are obtained when the various filaments used in the overwound assembly are of as nearly the same size as is mechanically practicable.

A typical mode of use of my improved cathode is illustrated in Fig. 1. In this figure there is shown a sealed envelope 8 suitably of glass having at the lower end a reentrant stem 9 terminating in a press 10. At the upper end of the envelope is mounted a conventional anode 12, for example, of graphite supported on and supplied with energizing current through a suitable lead-in conductor 13. In cooperative relation with the anode is provided a cathode 16 supported on lead-in conductors 17 and 18 which in turn are sealed into the press 10. It will be noted that, in the case illustrated, the cathode as a whole is of helical configuration, the helix being formed by bending the central element of the cathode, corresponding to the mandrel 1 of Fig. 2, into the desired shape.

For one field of use the envelope 8 may suitably enclose an ionizing medium comprising gas or vapor at a pressure of from a fraction of a millimeter to a few centimeters. For example, one may employ argon having a pressure of from 1 to 2 millimeters in combination with mercury having at the operating temperature of the device a vapor pressure of from about ½ millimeter to about 3 millimeters. It should be understood, however, that the cathodes of my invention are not limited to this particular field but are equally useful in connection with high vacuum discharge devices such as are conventionally used in radio and therapeutic applications.

The principle of double overwinding may advantageously be extended to include a series of any number of filaments in successively overwound relation, the only limitation being a mechanical one disposed by the difficulty of fabricating the more complex structures. Furthermore, while I have illustrated a particular form of the invention many modifications may be made by those skilled in the art without departing from the invention, and I aim in the appended claims to cover all such equivalent constructions as come within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a cathode structure, a first wire serving as a core member and having a second wire overwound thereon in such a manner that the spacing between adjacent turns is of the order of but somewhat less than the diameter of the second wire, and a quantity of highly electron emissive material only partially filling the grooves formed between such adjacent turns.

2. An electrode structure comprising a tungsten wire having wound thereon an open helix comprising a first filament serving as a core member and a second filament helically wound in open convolutions on said core member, said first and second filaments also consisting of tungsten, and means for augmenting the electron emissivity of said filaments.

3. A cathode comprising two or more filaments each constituted of a metal of the group consisting of tungsten and molybdenum, said filaments being arranged in successively overwound relation and being provided with a coating of highly electron emissive material.

4. In a cathode the combination which includes a wire core member having a second wire helically wound in open convolutions thereon, and a quantity of thorium oxide disposed in the grooves formed by said convolutions, said wires being constituted of a metal of the group consisting of tungsten and molybdenum.

5. A cathode comprising an elongated metal wire having applied thereto a composite structure including a first metal filament serving as a core member, a second metal filament wound on said core member and means for augmenting the electron emissivity of said filaments.

6. A cathode comprising a tungsten wire having wound thereon a composite structure consisting of a first tungsten filament serving as a core member, a second tungsten filament wound on the core member and a coating of thorium oxide applied to said filaments.

7. An incandescible cathode comprising a metal core wire, a helix of thin metal wire, said helix being helically wound on said core wire and embracing same therewith, and a highly electron-emissive substance carried by said helically wound helix.

8. An incandescible cathode comprising a metal core wire, a coil of thin metal wire, said coil being coiled around said core wire and forming a coiled coil, each turn of the outer coil being in contact with the core, and a highly electron-emissive substance carried by said coiled-coil and at least partly filling the hollows and recesses thereof.

9. An incandescible cathode comprising a metal core wire serving as a support and current conductor, a skeleton wire structure surrounding said core wire and having a plurality of apertured layer-like portions formed of helically-wound metal wire, adjacent portions being electrically connected only at interspaced points and the inner portion embracing said core wire, and a highly electron-emissive substance at least partly filling the spaces formed within said structure and securely held thereby.

10. A cathode including an elongated metal core serving as a support and current conductor, a metallic overwinding closely embracing the core so as to be in contact with the core throughout a substantial portion of its length, the member forming the said overwinding being characterized by irregularities from point to point along its length so as to provide a materially larger number of crevices than would be provided by a helically applied overwinding of straight wire,

and a quantity of electron emissive material at least partly filling the crevices.

11. An incandescible cathode comprising an elongated metal core serving as a support and current conductor, a discontinuous metallic structure closely embracing the core so as to be in contact therewith throughout a substantial portion of its length, the said structure being constituted of a plurality of wires assembled in interengaging relation to form a framework which provides a large number of crevices both at and slightly spaced from the surface of the core, and a quantity of highly emissive material at least partially filling the said crevices.

12. A cathode comprising an elongated metal core serving as a support and current conductor, a metallic structure closely embracing the core so as to be in contact therewith throughout a substantial portion of its length, the said structure being constituted of a plurality of interengaging wires assembled in repetitively intersecting relation to form a framework which provides a large number of crevices both at and slightly spaced from the surface of the core, and a quantity of highly emissive material at least partially filling the said crevices.

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