

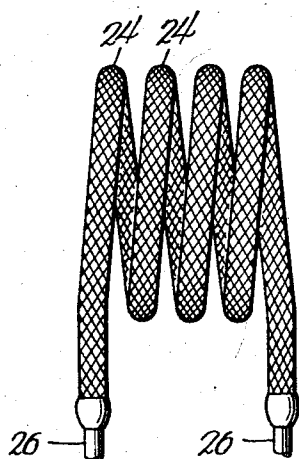
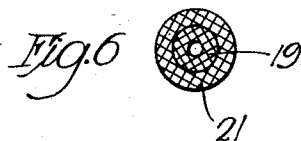
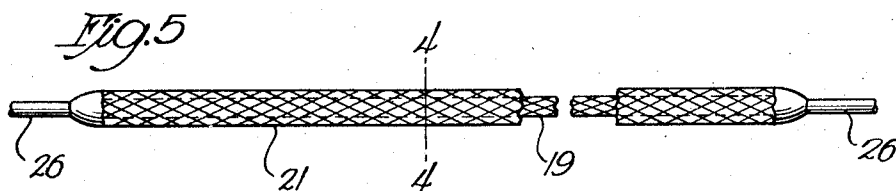
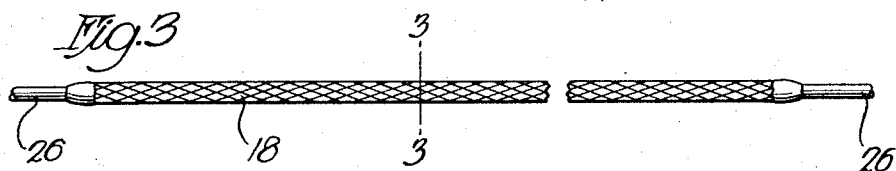
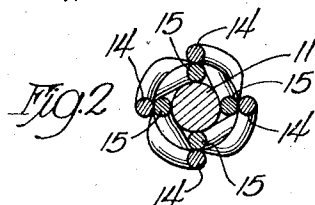
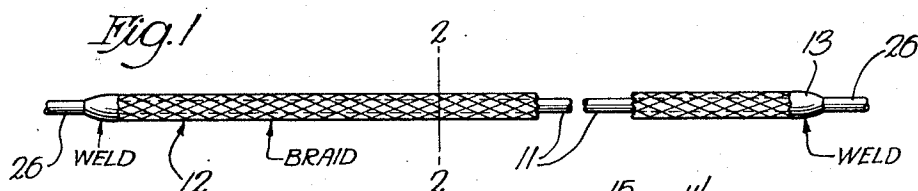
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CATHODE FILAMENT

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CATHODE FILAMENT

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5 Claims. (Cl. 176—126)

In electric space discharge tubes, particularly those in which a high current is conducted through the gas column as in cathode lamps, the cathode filaments have not heretofore been wholly satisfactory. Those which had adequate emissive properties have had a relatively short life, and many which have had adequate emissive characteristics under some conditions have not been dependable, even aside from their short life, because the heat which they generated was not adequately conserved at the proper point, usually because the emissivity was obtained only at the expense of a large heat-radiating and heat-dissipating area.

An object of the present invention is therefore to provide a filament which will be suitable for cathodes in a variety of purposes and which will be highly dependable in operation and will have extremely long life. In general the object is accomplished by forming the filament, or at least the outer layer thereof, by entwining and preferably braiding suitable wire and coating the wire of the braid with a suitable emissive material. At the present time the wire is preferably tungsten.

Further objects and advantages of the invention will be apparent from the following description and from the drawing, in which:

Fig. 1 is an elevational view of a length of one form of filament embodying the present invention, comprising a solid core surrounded by a braid represented diagrammatically.

Fig. 2 is a cross section of the filament of Fig. 1 taken approximately on the line 2—2 thereof.

Fig. 3 is a view similar to Fig. 1, representing another form of the invention in which the solid core is omitted.

Fig. 4 is a diagrammatic representation of the cross section of the braid of Fig. 3, taken approximately on the line 3—3 thereof.

Figs. 5 and 6 are views corresponding to Figs. 3 and 4 but showing a third form of the invention in which one braid is superimposed around another.

Fig. 7 is a representation of a helically wound filament which may embody any of the various forms of filament construction of this invention.

Three forms of the invention have been chosen for illustration and description, in compliance with section 4888 of the Revised Statutes, but persons skilled in the art will readily perceive other means for accomplishing the same results, and the claims are therefore to be construed as broadly as possible, consistent with the prior art.

One form of the filament is illustrated in Figs.

1 and 2. In this form a core 11 of solid wire, preferably tungsten, is provided, and a sleeve 12 is carried by the core, preferably in tight contact therewith and welded to the core at its ends as at 13. According to the present invention, the sleeve 12 is a braided wire sleeve, the braid being of the cylindrical or Maypole type which may also be called "tubular." Fine tungsten wires are preferably used for braiding the sleeve, the wires being finer than the core 11. As is well known, the cylindrical or Maypole braid is accomplished by winding half of the wires around the core in one direction and half in the other, each wire crossing alternately inside and outside of those which are wound in the other direction. Crossing over two wires and then under two has been found satisfactory, but this selection is not necessary. The cross section of this braid is seen in Fig. 2. In this figure it may be assumed that the wires 14 all recede in a clockwise direction from the section, while the wires 15 all recede in a counter-clockwise direction from the section. It will be observed that each wire is frequently crossed over by the others. An important result of this is that even if a wire burns through in the course of use it is held in place and the filament continues in service. Another result is that there is a great expanse of total area available on which the emissive coating may be effective, although the entire assembly is compact so that the effective radiation is relatively small. In other words, although substantially the entire area of each of the wires is available for emissivity, a relatively small part of this area is fully effective for radiation inasmuch as no surface is fully effective for radiation if part of the radiation therefrom strikes other parts of the filament so that it is absorbed thereby.

The wires 14 and 15 are preferably braided on the core 11 so as to have firm contact therewith. The emissive coating may be applied either before braiding or afterwards. The core 11 is preferably also coated with the emissive material.

Fig. 3 shows another form of the invention in which no core 11 is provided in the filament, but only a braided tube 18. A cross section of this tube is diagrammatically illustrated in Fig. 4. The braided tube 18 may be identical with the braided tube 12 or it may have somewhat smaller internal diameter. It will normally be braided on a core and slipped from the core as it is braided.

Fig. 5 shows a third form of the invention in which a core 19 similar to the tube 18 is provided, over which is braided a sleeve 21. The wires of

both braids are preferably coated with emissive material. Of course, a solid core could be positioned inside of the inner sleeve if desired, in which case the inner sleeve might be somewhat larger in internal diameter.

Fig. 7 illustrates the preferred shape for the tubular braid for the filament regardless of which of the three forms is used or even if some other form of braided or entwined filament is used. Of course, the shape of the finished filament will depend entirely on its use and to some extent on the mere preference of the particular manufacturer. The shape shown in Fig. 7 is designed for mercury vapor lamps and the like to conserve heat by positioning the various turns 24 of the helix quite close together so that each absorbs a considerable part of the heat radiated from the others. Turns of $\frac{1}{4}$ inch inside diameter have proved satisfactory for ordinary lamps. Other shapes which might be used besides the shape illustrated in Fig. 7 and the straight shape of Fig. 1 are those known as hairpin and conical, but of course the filament may be used in any shape desired.

The sizes of wire used will depend entirely on the uses for which the filament is intended. For a 100-ampere airport flood lamp the core 11 might be a $\frac{1}{8}$ inch rod and the diameter of the wires of the braid might well be as large as .020 to .030 inch or even larger. On the other hand, for a 3-ampere lamp the diameter of the wire in the braid would probably be about .002 or .003 inch, and for some purposes the wire could be even finer. A filament such as the 3-ampere filament described has been tested and indications are that it would operate satisfactorily for about 6000 hours.

The choice between the three forms of filament shown in Figs. 1 to 6 depends somewhat on the use to which they are to be put. In a one or two-ampere lamp a single braided tube would probably be sufficient. With over two amperes two layers would be desirable, either two layers of braid or a layer of braid on a solid core. At still higher values either two layers of braid or two layers of braid and a solid core should be used, or possibly even three layers of braid.

Any desired emissive materials may be used depending partly on the intended use of the cathode. Among those at present preferred for lamps are powdered carbonates and salts of barium or strontium. Compounds of magnesium and cesium might be used, respectively, for rectification and photoelectric cells. If applied after braiding, the emissive material should be applied in the form of a very thin solution or fluid mixture, dipping being preferred, using any suitable vehicle or binder and, if desired, an additional solvent for the binder. Solutions or mixtures of the powdered material in acetone, amyl acetate or alcohol are commonly used and are quite satisfactory. Cellulose acetate can sometimes be used as can vinyl resins, such as dimethyl-acrylate. A heavier paste can be used if the braiding is performed in the solution, and in that event the particle size may desirably be fairly large so that the braiding will tend to lock the particles in place.

The coated filament should be subjected to a conventional activating treatment, sometimes called heat treatment.

Before or after coating, the filament is preferably set to the desired shape by applying it to a suitably shaped mandrel and heating it to

1800-1900° C. in a hydrogen atmosphere. Radio frequency induction may be used for heating it. If it has been coated, this can sometimes serve as the activating treatment, this usually involving the evacuation of the envelope in which it is being heated, the evacuation progressing as the temperature rises.

The braiding of tungsten presents a problem, and in fact it has been said to be too brittle to braid. I have determined, however, that it will braid satisfactorily if it is not excessively twisted. Of course, it can be braided by hand without twisting. I have also devised a machine for braiding it. Such a machine may be any conventional braiding machine modified to avoid twisting the tungsten cumulatively or excessively. For example, the holder assembly of the braiding machine may be so made that the wire carrying and guiding portions thereof will be rotatable as a unit with respect to their revolving bases. The bases rotate once for each revolution. The holder and wire guide should revolve about the braid without rotating. They could also be so designed that the twisting tension on the wire could be relieved by rotation of the spool, if it is drawn off from the spool approximately coincident with an axis about which the spool can rotate.

Although the advantages of the invention are best obtained by braiding, they may be obtained also though perhaps to a lesser degree, by any other method of entwining in which each of a plurality of exposed wires is independent and capable of holding one or more others in place so that the structure will continue to operate satisfactorily even if one wire is burned out. Regardless of how they are entwined, the exposed wires should all be of substantially the same length and all welded to the lead-in wire, preferably at both ends, so that they will share the load evenly. It is not essential that the inner wires be entwined with one another, since they will be held in place by the outer sleeve.

The core 11 may be formed of refractory (sintered) metallic thorium. In that case the lead-in wires 26 will be separate, and the wires 14 and 15 should be welded directly to these lead-in wires so that the current will not have to flow through the thorium core.

It is also to be understood that thorium wire may be employed, alone or alloyed with other suitable metals, in forming the braided portion of the cathode, or only a portion of the wires forming the braided portion may be of thorium, as for example the wire 14. As a result of my invention the thorium or other above described activating compounds or elements are brought into operative combination with the other elements of the cathode as the cathode ages, thereby successively reactivating the cathode.

I claim:

1. A cathode filament including a tubular braid formed of conductive strands tubularly braided, a core of metallic wire within the tubular braid and in contact with the strands thereof, each strand of the braid being wrapped helically around the core, contacting the core at numerous points along its length, intertwined with other strands and welded at its ends to the core, and an emissive material interlocked within the braid and between the braid and core.

2. A cathode filament including a tubular braid formed of conductive strands tubularly braided, each strand being welded at each end to a lead conductor and between the welded ends extending helically in one direction only around a central

longitudinally extending zone and being interwoven with strands extending in a different helical direction, and an emissive material within the tubular braid and interlocked within its interstices.

3. A cathode filament including a tubular braid formed of conductive strands tubularly braided, each strand being welded at each end to a lead conductor and between the welded ends extending helically in one direction only around a central 10 longitudinally extending zone and being interwoven with strands extending in a different helical direction, and an emissive material within the tubular braid and interlocked within its interstices, the strands being formed of tungsten and 15 being substantially free from torsional strain.

4. A cathode filament including a coiled tubular braid formed of conductive strands tubularly braided, each strand being welded at each end

to a lead conductor and between the welded ends extending helically in one direction only around a central longitudinally extending zone and being interwoven with strands extending in a different 5 helical direction, and an emissive material within the tubular braid and interlocked within its interstices.

5. A cathode filament including a coiled tubular braid formed of conductive strands tubularly braided, a core of metallic wire within the tubular braid and in contact with the strands thereof, each strand of the braid being wrapped helically around the core, contacting the core at numerous points along its length, intertwined with other strands and welded at its ends to the core, and an emissive material interlocked within the braid and between the braid and core.

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