Jan. 12, 1937. R. M. ZABEL 2,067,746

LAMP FILAMENT AND METHOD OF MANUFACTURE THEREOF

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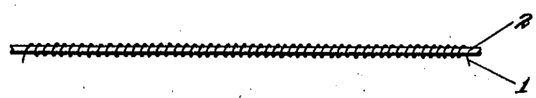

Fig. 1.

Fig. 2.

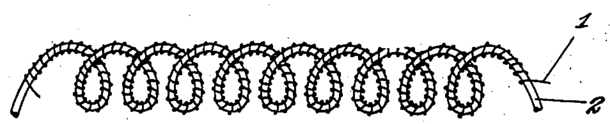

Fig. 3.

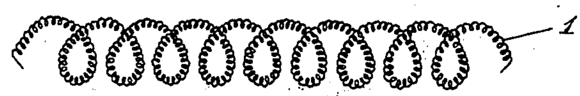

Fig. 4.

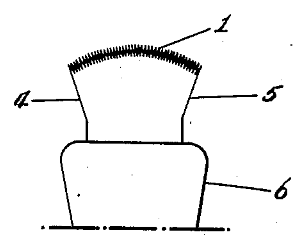

Fig. 5.

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LAMP FILAMENT AND METHOD OF MANUFACTURE THEREOF

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7 Claims. (Cl. 176—40)

This invention relates to filaments and with particularity to methods of manufacturing coiled filaments for lamps, space discharge tubes or the like.

A principal object of the invention is to provide an improved method of manufacturing a doubly convoluted wire for lamp or tube filaments.

A feature of the invention resides in the method of winding and forming a doubly convoluted filament employing winding mandrels of different characteristics which are correlated to the various steps in the winding method.

Another feature relates to the use of a molybdenum or similar refractory metal to form the primary convolutions of a doubly convoluted filament, and a mandrel of steel or other similar material to form the secondary convolutions of such filament.

A still further feature relates to the novel organization and succession of steps which enable doubly convoluted filaments to be wound and formed with accuracy and at low cost.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing Fig. 1 is a magnified diagrammatic view to explain the manner of forming the primary convolutions of the filament.

Fig. 2 is a magnified diagrammatic view to explain the formation of the secondary convolutions of the filament.

Fig. 3 is a diagrammatic view with one of the mandrels removed.

Fig. 4 is a magnified diagrammatic view showing the finished filament.

Fig. 5 is a diagrammatic view illustrative of one form of mounted filament in accordance with the invention.

In certain types of devices, for example incandescent lamps, it is desirable to employ a filament of relatively high resistance which at the same time is capable of producing a high concentration of light. For this purpose so-called doubly convoluted filaments have been employed wherein the wire constituting the filament is formed with initial convolutions of relatively small diameter, these convolutions being termed herein the primary convolutions; the initially coiled wire is then recoiled with relatively large convolutions which will be referred to herein as the secondary convolutions.

In order that the finished filament may produce a concentrated light area, it is necessary that the primary convolutions as well as the secondary convolutions be as close together as is feasible. At the same time it is important that both the primary convolutions and the secondary convolutions have a permanent set so that when the filament is in use at relatively high temperature there is little danger of the filament being distorted. In accordance with the present invention the primary coils of the filament are wound and formed on a specially chosen mandrel having a predetermined temperature characteristic while the secondary convolutions are wound and formed on a mandrel having different characteristics from the first mandrel. Thus as illustrated in Fig. 1 of the drawing the wire 1 constituting the filament is wound in any well-known manner around a mandrel 2 of the proper diameter. Preferably the wire 1 is of tungsten such as is ordinarily employed in the present day incandescent lamps. While the drawing shows the successive primary convolutions of the wire 1 relatively widely spaced, it will be understood that this is done merely for explanatory purposes and that any other spacing of the convolutions may be employed. In accordance with the present invention the mandrel 2 is preferably of molybdenum, is then wound around a second mandrel 3 of a different material preferably of steel or similar nonrefractory material as indicated in Fig. 2 of the drawing. Thus the filament or wire 1 is doubly convoluted, the primary convolutions being formed by mandrel 2 and the secondary convolutions being formed by mandrel 3 of larger diameter. The doubly convoluted filament together with the two mandrels is then fired or heated for a predetermined length of time for example about fifteen minutes to a temperature at which the molybdenum mandrel 2 is given a permanent set but preferably not to a temperature high enough to set the tungsten filament 1, this heating being preferably, although not necessarily, effected in a vacuum or muffle furnace. For example the assembly of Fig. 2 may be heated to a temperature of approximately 1100° C. which is lower than the melting point of the nonrefractory mandrel, to achieve the setting of the mandrel 2 but at this temperature the tungsten wire 1 is not set. The next step in the method is to remove the mandrel 3 as indicated in Fig. 3 of the drawing. This may be done by the usual method, known to the art and mentioned in United States Patent 1,599,241, issued September 7, 1926 to George Mery, of dissolving the mandrel in an acid. An acid such as hydrochloric may be used, which will dissolve the steel mandrel without appreciably affecting the molybdenum one. Because of the previously set condition of the molybdenum mandrel 2 the coiled tungsten wire 1 is retained in shape after the removal of the steel mandrel. The double convoluted tungsten filament 1 and its previously set molybdenum mandrel 2 are then fired for a short time, for example about two minutes, to a temperature at which the tungsten filament 1 is permanently set, for example the filament and the mandrel 2 may be heated to a temperature approximately 1650° C. When the tungsten filament has thus been given its desired set the assembly may be cooled and the mandrel 2 may be removed in any suitable manner thus leaving the doubly convoluted tungsten filament 1 with the primary and secondary convolutions in their set condition.

The molybdenum mandrel 2 may be removed by dissolving it in a suitable solvent, such as a combination of four parts of nitric acid and one part of sulphuric acid, as shown in United States Patent 1,650,605, issued November 29, 1927 to P. A. Campbell. The acid solvent is preferably used at a temperature just below its boiling point. It will dissolve the molybdenum without, of course, affecting the tungsten of the filament.

If during the second firing operation above described the molybdenum mandrel 2 tends to contract then this tendency may be compensated for, by winding the filament around the mandrel 3 with a fewer number of turns per inch so that when the assembly of Fig. 2 is fired to the higher temperature any contraction of the molybdenum mandrel will tend compensatively to increase the total number of turns thus producing the desired number of turns in the finished article. Instead of compensating for the contraction by initially winding the filament around the mandrel 3 with a fewer number of turns per inch, the initial winding may be effected around the mandrel 3 with the number of turns desired in the finished article and then the turns may be held to a fixed length in such a way that the molybdenum mandrel 1 may tend to contract but will be unable to do so because the ends are being held at a fixed distance.

The doubly convoluted filament after being removed from the mandrel 1 may be mounted in any well-known manner on a press or other finished portion of a lamp envelope. For example as indicated in Fig. 5 the filament 1 is supported by a pair of wires 4 and 5 which are sealed into a press diagrammatically indicated by the numeral 6. It will be understood of course that the finished filament may be given any desired shape other than the arcuate shape of Fig. 5. For example the finished filament shown in Fig. 4 may be bent at appropriate points to provide reversely extending parallel sections as is well known in the art.

While specific materials and firing temperatures have been mentioned herein, it will be understood that the invention is not limited thereto and that other materials both for the filament and for the mandrels may be employed so long as the materials and the mandrels are correlated to the firing temperatures in such a way that the mandrel on which the primary convolutions are formed is capable of being set without setting the filament material proper and so long as this primary mandrel is capable of retaining the doubly convoluted filament in its desired shape for the second heating operation.

Other changes and modifications may be made herein without departing from the spirit and scope of the invention.

What I claim is:

1. The method of forming a doubly convoluted filament which includes the steps of forming the primary convolutions on a mandrel having a lower setting temperature than the setting temperature of the filament, forming the secondary convolutions by winding the first mandrel with the primary convolutions thereon around a nonrefractory mandrel, heating the nonrefractory mandrel to set the first mandrel without setting the filament, removing the nonrefractory mandrel and heating the first mandrel and filament to a temperature to set the filament, and then removing the first mandrel.

2. The method of forming a doubly convoluted filament which includes the steps of forming the primary convolutions on a refractory wire mandrel, forming the secondary convolutions on a nonrefractory mandrel, heating the doubly convoluted filament while on said second mandrel to a temperature sufficient to set the refractory mandrel without setting the filament, removing the nonrefractory mandrel, heating the filament while on the refractory mandrel to a higher temperature to set said filament, and then removing the refractory mandrel.

3. The method according to claim 2 in which the final heating temperature is higher than the melting point of the nonrefractory mandrel.

4. The method of forming a doubly convoluted filament of refractory metal which includes the steps of forming the primary convolutions on a molybdenum wire mandrel, forming the secondary convolutions on a second mandrel having a melting point lower than the setting temperature of the filament material, heating the second mandrel with the filament and the first mandrel thereon to a temperature only high enough to set the first mandrel, removing the second mandrel and then heating the first mandrel with the filament thereon to a higher temperature to set the filament, and then removing the first mandrel.

5. The method of forming a doubly convoluted filament of refractory metal which includes the steps of winding the filament on a molybdenum mandrel to form primary convolutions, winding the molybdenum mandrel with the convolutions thereon around a nonrefractory mandrel, heating the nonrefractory mandrel with the doubly convoluted filament thereon to a temperature in the neighborhood of 1100° C. to set the molybdenum mandrel alone, removing the nonrefractory mandrel, heating the molybdenum mandrel with the filament thereon to a temperature in the neighborhood of 1650° C., and then removing the molybdenum mandrel.

6. The method of forming a doubly convoluted tungsten filament which includes the steps of winding the filament around a molybdenum mandrel to form the primary convolutions, winding the molybdenum mandrel and the primary convolutions around a steel mandrel of larger diameter to form the secondary convolutions, heating the steel mandrel with the molybdenum mandrel and filament thereon to a temperature in the neighborhood of 1100° C., removing the steel mandrel, heating the molybdenum mandrel with the filament thereon to a temperature in the neighborhood of 1650° C., and then removing the molybdenum mandrel.

7. The method according to claim 6 in which the first heating is maintained for a length of time sufficient to set the molybdenum mandrel without setting the filament.

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