METHOD OF ELECTROPOLISHING TUNGSTEN WIRE

Filed June 7, 1963
METHOD OF ELECTROPOLISHING TUNGSTEN WIRE

Alfonso A. Latawiewicz, Garwood, and George H. Lockwood, Bloomfield, N.J., assignors to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Filed June 7, 1963. Ser. No. 286,392

5 Claims. (Cl. 204—140.5)

This invention relates to electropolishing and, more particularly, to a method for electropolishing tungsten wire and the resulting product.

Tungsten wire, after drawing, has impurities such as carbides and graphite adhered to its surface. In addition, the wire surface is scratched, notched, and displays other physical imperfections. Before such wire is used as an incandescent lamp filament, it is desirable to remove substantially all surface impurities and physical surface imperfections and to provide the wire with a high degree of surface luster and a uniform diameter.

It is the general object of this invention to provide a method for electropolishing tungsten wire in order to deep clean the wire and provide it with a uniform diameter and a surface which has a high luster or specular appearance.

It is another object to provide a tungsten wire which has a uniform diameter and a surface which has a high degree of luster, and which wire has been electropolished in accordance with an improved method.

The aforementioned objects of the invention, and other objects which will become apparent as the description proceeds, are achieved by passing the wire to be cleaned at a predetermined rate of speed through an electrolytic bath which contains a predetermined concentration of selected electrolyte which will react with (or chelate) tungsten oxide to form tungsten compound which is soluable in the electrolyte. When first passing through the electrolytic bath, the wire is made the cathode and this forms atomic hydrogen at the wire surface and removes surface impurities therefrom. Thereafter, the wire is made an anode in the bath so that atomic oxygen is released at the wire surface and a film of reaction products is formed on the wire surface through oxidation and chelation of the formed oxide. Because of the differences in current densities on the wire surfaces, due to surface imperfections, the formed film of reaction products is thicker at the surface depressions in the wire than at any surface projections on the wire. This in turn provides a differential rate of electropolishing so that the wire projections are electropolished more rapidly than the depressions in the wire. After electropolishing, the wire is substantially uniform in diameter. Thereafter, any residual film of reaction products which remain on the wire surface are washed away, the wire is dried, and then spooled prior to further processing or use.

For better understanding of the invention, reference should be had to the accompanying drawing wherein the sole figure diagrammatically illustrates an electropolishing apparatus for carrying out the process of the present invention.

With specific reference to the apparatus illustrated in the accompanying drawing, the apparatus 10 for continuous wire polishing comprises a spool unwinding head 12 which has a conventional back-tension device 14 positioned associated therewith in order to keep the proper tension on the wire being polished.

A multi-cell electrolytic polishing tank 16 has stainless steel mesh electrodes 18 and 20 immersed therein, which electrodes are connected to the positive and negative poles of a rectifier 22. At the wire outlet side of the tank 16, there is provided a water wash 24, which removes any residual electrolytic material from the wire, followed by an infrared heater 26 for drying the wire, and a conventional wire re-spooling device 28.

The electrolytic tank 16 has a rectangular configuration and is formed of plastic or other suitable non-conducting, alkali-resistant material. There is desirably provided a dividing wall 30 which is placed midway of the length of the tank so as to permit free flow and mixing of the electropolishing bath throughout the entire bath length. The dividing wall 30 could be dispensed with, if desired, but serves a beneficial suppression of current neutralization between the electrodes 18 and 20.

There is also provided a reservoir 32 and the electrolyte is continuously pumped from the reservoir 32, to the electropolishing tank 16, and back to the reservoir 32.

The anode electrode 18 is connected to the positive side of the rectifier 22 and the cathode electrode 20 is connected to the negative side of the rectifier 22. During electropolishing, the wire 34 to be electropolished is passed from the spool 12, through the back-tension device 14, over the anode electrode 18, then over the cathode electrode 20, through the water wash 24, under the infrared drier 26, and then is re-spooling for further processing or use.

The electrolytic bath is specially chosen so that it will react with tungsten oxide or tungstic acid, formed on the surface of the wire, to form a complex tungsten compound which is soluble in the electrolytic bath. Apparently, the tungsten oxide or acid is chelated by the electrolyte to form the complex, soluble tungsten compound.

The bath comprises from 5% to 25% by weight of sodium hydroxide or potassium hydroxide, or mixtures thereof, and from 10% to 40% by weight sodium tartrate, potassium tartrate, sodium potassium tartrate or any mixtures thereof, with the balance of the bath being distilled water. If the concentration of either the hydroxide or the tartrate is greater than the indicated maximum, the electropolishing process is quite slow.

The specific electropolishing conditions can vary considerably depending upon the wire diameter and amount of cleaning which is desired. As a specific example, for electropolishing tungsten wire of 7 mils diameter in order to remove about 6% by weight of the wire, the tank 16 has a total length of 29" and is divided into two cells of equal length by the plastic partition 30, and the recirculating electropolishing liquid is common to both of the cells. The electrodes 18 and 20 are formed of stainless steel mesh. Each electrode has a length of 12" and the width of ½" is horizontally positioned half of the wire 34. The cathode is placed ¼" below the wire 34, and the electrodes are separated from each other at their nearest ends by a 4" gap. The bath is formed of 15% by weight sodium hydroxide, 30% by weight sodium potassium tartrate, and 55% by weight distilled water, with the bath temperature being between 70° and 100°F. The bath is circulated at the speed of 45 feet per minute. The voltage which is applied between the two electrodes 18 and 20 is from 16 to 18.5 volts, the current through the bath is 20 to 24 amperes, and the current density is 3,000 to 4,000 amperes per square foot of surface of wire in the bath.

In the electropolishing operation, when the wire 34 is proximate to the anode electrode 18, the wire acts as a cathode and atomic hydrogen is generated at the wire surface. This cleans substantially all impurities from the
wire surface by the combined chemical action of the atomic hydrogen and the scrubbing action of the hydrogen bubbles. Thereafter, when the wire becomes an anode as it is passed proximate to the cathode electrode 20, atomic oxygen is generated at wire surfaces. The surface portions of the wire are oxidized to form tungsten oxide, which is present at least in part as tungsten acid. The formed oxide compound chelates with the tartrate to form a film of reaction products on the surface of the wire, which formed reaction products are soluble in the electrolytic bath. Projecting portions on the surface of the wire are subject to greater current densities and are, therefore, selectively oxidized and then dissolved at a faster rate than the reaction products which are formed in the depression portions of the wire surface.

In addition, the reaction product of the oxide and tartrate apparently has a higher resistance to dissolution at the lower current densities which are found at the depressed areas on the surface of the wire. As a result, the film of reaction products is thinner at the depressed area of the wire than on the projecting portions of the wire. As a result, the projections on the wire are dissolved at a more rapid rate than the depressed portions and the wire is leveled to a uniform cross section as it is passed through the bath. On leaving the bath, all residual reaction products on the surface of the wire are removed by the water wash 24 and the wire is then dried and respooled.

The bath should be periodically changed. In the foregoing example, the polishing tank 16 holds two gallons of solution and the reservoir tank 32 holds three gallons of solution. The life of the bath will be determined by the amount of tungsten which is first oxidized and then dissolved and whenever the efficiency of electropolishing drops, the bath is replaced by a fresh solution.

It will be recognized that the objects of the invention have been achieved by providing an improved method for electropolishing tungsten wire. The resulting wire which is formed by the foregoing process has also been provided.

While a best example has been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

We claim as our invention:

1. The method of electropolishing tungsten wire to remove physical surface irregularities and surface impurities therefrom and to provide the wire with a smooth surface which has a high luster, which method comprises:
   (a) passing the wire to be cleaned at a predetermined rate of speed through an electrolytic bath containing an aqueous solution of from 5% to 25% by weight of at least one of the group consisting of sodium hydroxide and potassium hydroxide, and from 10% to 40% by weight of at least one of the group consisting of sodium tartrate and potassium tartrate;
   (b) first making the wire an anode for a predetermined period of time as it passes through the electrolytic bath to form atomic hydrogen at the wire surface and remove surface impurities therefrom;
   (c) thereafter making the wire an anode as it passes through the electrolytic bath to form a film of reaction products on the wire surface through oxidation of the wire surface and reaction of the formed oxide with the electrolyte, with the formed film of reaction products being thinner in any surface depressions in the wire than at any surface projections on the wire;
   (d) continuing to maintain the wire an anode as it passes through the electrolytic bath until the wire has a substantially uniform surface; and
   (e) after electropolishing, removing from the wire any residual film of reaction products which remain on the wire surface.

2. The method of electropolishing tungsten wire to remove physical surface irregularities and surface impurities therefrom and to provide the wire with a smooth surface which has a high luster, which method comprises:
   (a) passing the wire to be cleaned at a predetermined rate of speed through an electrolytic bath having an anode and a cathode immersed therein and which bath contains from 10 to 40% by weight of alkali-metal tartrate and from 5 to 25% by weight of alkali-metal hydroxide;
   (b) first passing the wire through the bath at a predetermined distance from the immersed anode for a predetermined period of time to form a predetermined amount of atomic hydrogen at the wire surface and remove surface impurities therefrom;
   (c) thereafter passing the wire through the bath at a predetermined distance from the immersed anode for a predetermined period of time to form a film of reaction products on the wire surface through oxidation of the wire surface and chelation of the formed oxide, with the formed film of reaction products being thicker in any surface depressions in the wire than at any surface projections on the wire;
   (d) continuing to pass the wire through the bath at a predetermined distance from the cathode until the wire has a substantially uniform surface; and
   (e) after electropolishing, removing from the wire any residual film of reaction products which remain on the wire surface.

3. The method of electropolishing tungsten wire to remove physical surface irregularities and surface impurities therefrom and to provide the wire with a smooth surface which has a high luster, which method comprises:
   (a) passing the wire to be cleaned at a predetermined rate of speed through an electrolytic bath having an anode and a cathode immersed therein and which bath contains an aqueous solution of from 5% to 25% by weight of at least one of the group consisting of sodium hydroxide and potassium hydroxide, and from 10 to 40% by weight of at least one of the group consisting of sodium tartrate and potassium tartrate;
   (b) first passing the wire through the bath at a predetermined distance from the immersed anode for a predetermined period of time to form a predetermined amount of atomic hydrogen at the wire surface and remove surface impurities therefrom;
   (c) thereafter passing the wire through the bath at a predetermined distance from the immersed anode to release atomic oxygen at the wire surface and to form a film of reaction products on the wire surface through oxidation of the wire surfaces and chelation of the formed oxide, with the formed film of reaction products being thicker in any surface depressions in the wire than at any surface projections on the wire;
   (d) continuing to pass the wire through the bath at a predetermined distance from the cathode until the wire has a substantially uniform surface; and
   (e) after electropolishing, removing from the wire any residual film of reaction products which remain on the wire surface.

4. The method of electropolishing tungsten wire to remove physical surface irregularities and surface impurities therefrom and to provide the wire with a smooth surface which has a high luster, which method comprises:
   (a) passing the wire to be cleaned at a predetermined rate of speed through an electrolytic bath having an anode and a cathode immersed therein and which bath contains an aqueous solution of from 5% to 25% by weight of at least one of the group consisting of sodium hydroxide and potassium hydroxide, and from 10 to 40% by weight of at least one of the group consisting of sodium tartrate and potassium tartrate;
(b) first passing the wire through the bath at a predetermined distance from the immersed anode for a predetermined period of time to form a predetermined amount of atomic hydrogen at the wire surface and remove surface impurities therefrom;

(c) thereafter passing the wire through the bath at a predetermined distance from the immersed cathode to release atomic oxygen at the wire surface and to form a film of reaction products on the wire surface through oxidation of the wire surfaces and chelation of the formed oxide, with the formed film of reaction products being thicker in any surface depressions in the wire than at any surface projections on the wire, and during the time said wire is immersed in said bath, maintaining the current density at from 3,000 to 4,000 amperes per square foot of wire surface in said bath;

(d) continuing to pass the wire through the bath at a predetermined distance from the cathode until the wire has a substantially uniform surface; and

(e) after electropolishing, removing from the wire any residual film of reaction products which remain on the wire surface.

5. The method of electropolishing tungsten wire having an initial diameter of 7 mils to remove physical surface irregularities and surface impurities therefrom and to provide the wire with a smooth surface which has a high luster, which method comprises:

(a) passing the wire to be cleaned at a predetermined rate of speed of 45 feet per minute through an electrolytic bath having a total length of 29 inches and having an anode and a cathode immersed therein, said bath containing an aqueous solution of from 5 to 25% by weight of at least one of the group consisting of sodium hydroxide and potassium hydroxide, and from 10 to 40% by weight of at least one of the group consisting of sodium tartrate and potassium tartrate, and said bath being maintained at a temperature of from 70° F. to 100° F.;

(b) first passing the wire through the bath at a predetermined distance of one-half inch from the immersed anode for a predetermined period of time of 45 minutes to form a predetermined amount of atomic hydrogen at the wire surface and remove surface impurities therefrom;

(c) thereafter passing the wire through the bath at a predetermined distance of one-half inch from the immersed cathode to release atomic oxygen at the wire surface and to form a film of reaction products on the wire surface through oxidation of the wire surfaces and chelation of the formed oxide, with the formed film of reaction products being thicker in any surface depressions in the wire than at any surface projections on the wire, and during the time said wire is immersed in said bath, maintaining the voltage between said cathode and said anode at from 16 to 18.5 volts, the current through said bath at from 20 to 24 amperes, and the current density at from 3,000 to 4,000 amperes per square foot of surface of wire in said bath;

(d) continuing to pass the wire through the bath at a predetermined distance of one-half inch from the cathode for a total period of 3/4 minute to provide the wire with a substantially uniform surface; and

(e) after electropolishing, water washing to remove from the wire any residual film of reaction products which remain on the wire surface.

References Cited by the Examiner

UNITED STATES PATENTS

1,731,269 10/1929 Rich 204—211
1,958,338 5/1934 Gwyn 204—140.5
2,902,419 9/1959 Carasse et al. 204—141
2,962,429 11/1960 Wicke 204—141

FOREIGN PATENTS

557,386 11/1943 Great Britain.

OTHER REFERENCES


Mohrheim, Metal Finishing, August 1962, pages 50 and 51.

JOHN H. MACK, Primary Examiner.

R. MIHALEK, Assistant Examiner.