Nov. 29, 1955 G. E. MURRAY 2,725,354

METHODS OF AND APPARATUS FOR ELECTROPOLISHING METALLIC ARTICLES

Filed Oct. 18, 1951 2 Sheets-Sheet 1

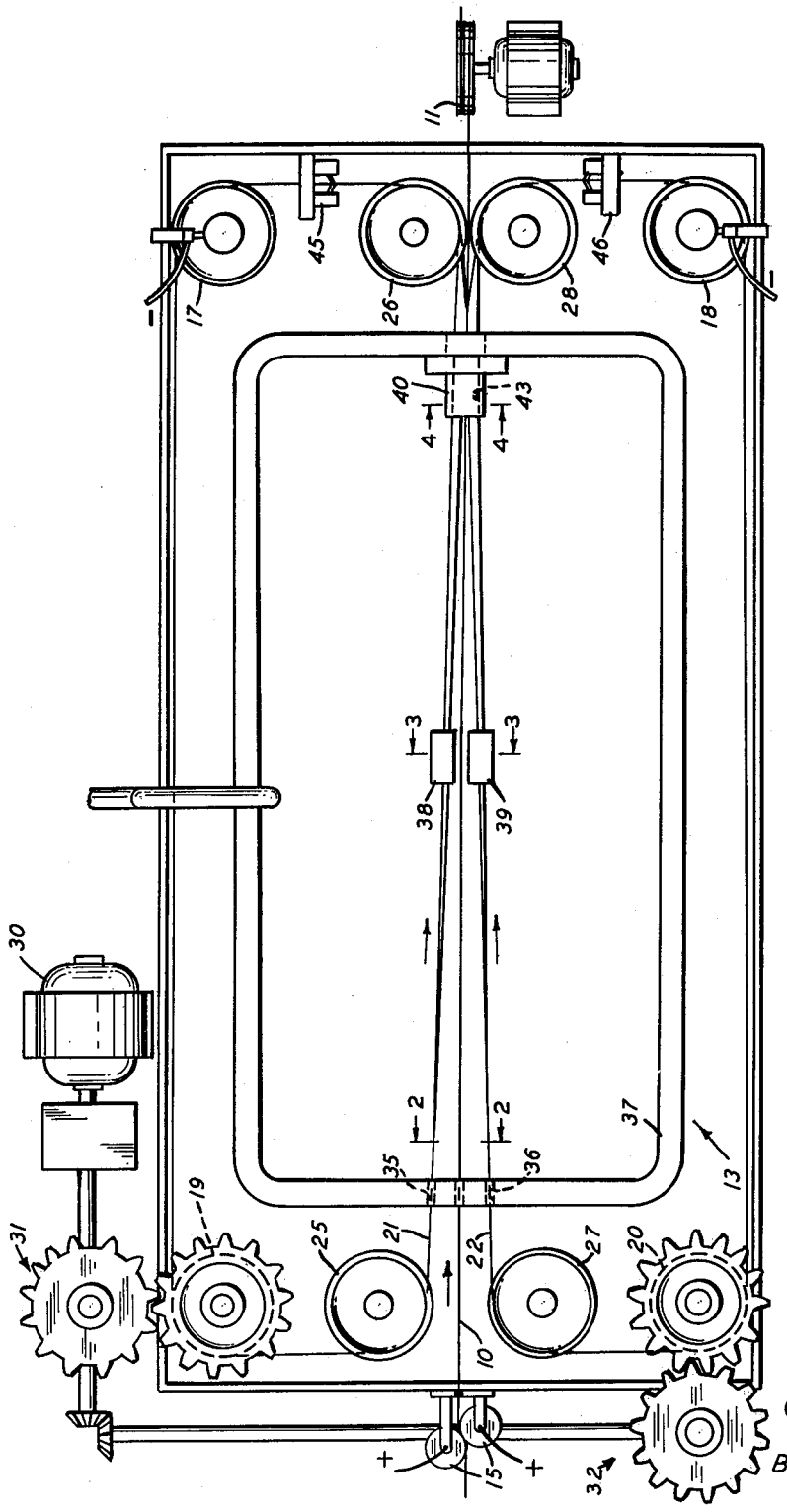


FIG. 1

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METHODS OF AND APPARATUS FOR ELECTROPOLISHING METALLIC ARTICLES

Filed Oct. 18, 1951 2 Sheets-Sheet 2

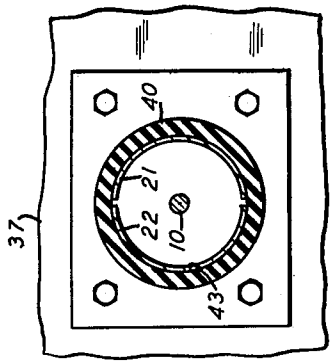


FIG. 4

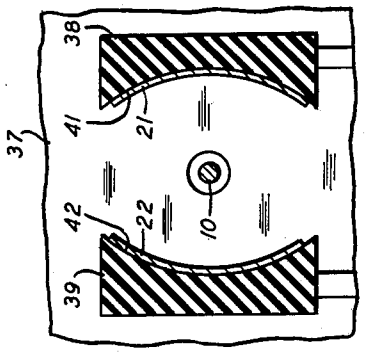


FIG. 3

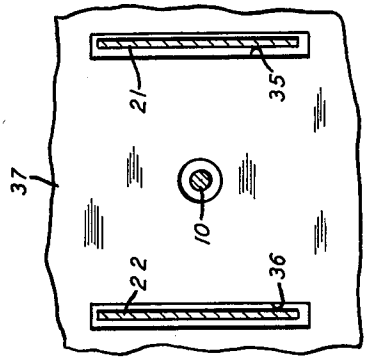


FIG. 2

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2,725,354

METHODS OF AND APPARATUS FOR ELECTROPOLISHING METALLIC ARTICLES

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Application October 18, 1951, Serial No. 251,884

10 Claims. (Cl. 204—140.5)

This invention relates to methods of and apparatus for electropolishing metallic articles, and more particularly to methods of and apparatus for electropolishing metallic filaments, such as wires, and the like.

In the manufacture of coaxial cable units of the type in which an outer tubular conductor made from a metallic tape is supported concentrically on a central, wire-like conductor by insulating discs or the like, it is important that the surface of the central conductor used in making such a unit be free of ridges, splinters, bumps and other types of projections in order for the electrical characteristics of the unit to be uniform throughout the length of the unit. In the past, this result has been difficult to achieve. Other industries also require filamentary metallic elements having smooth, polished surfaces.

An object of the invention is to provide new and improved methods of and apparatus for electropolishing metallic articles.

A further object of the invention is to provide new and improved methods of and apparatus for electropolishing metallic filaments such as wires, and the like.

Another object of the invention is to provide new and improved methods of and apparatus for removing splinters, metallic flakes, ridges and other projections from copper wires used in making coaxial cable units.

A method illustrating certain features of the invention may include advancing a filamentary metallic article as an anode through an electrolytic bath along an electrode. One or more cathode tapes may be disposed in the bath in converging relationship with the article, and preferably are formed around the article.

An apparatus illustrating certain features of the invention may include an electrolytic bath, means for immersing a filamentary metallic article in the bath, and means for advancing the article through the bath along a predetermined path. One or more cathode tapes may be immersed in the bath and extended along the bath convergingly with respect to the path of the article.

A complete understanding of the invention may be obtained from the following detailed description of a method and an apparatus forming specific embodiments thereof, when read in conjunction with the appended drawings, in which:

Fig. 1 is a top plan view of a portion of an apparatus for effecting one method embodying the invention;

Fig. 2 is a fragmentary, vertical section taken along line 2—2 of Fig. 1;

Fig. 3 is a fragmentary, vertical section taken along line 3—3 of Fig. 1, and

Fig. 4 is a fragmentary, vertical section taken along line 4—4 of Fig. 1.

Referring now in detail to the drawings, there is shown therein an electropolishing apparatus, which serves to electropolish the surface of a solid copper conductor **10**. The conductor **10** is advanced continuously by a capstan **11** through suitable cleaning and rinsing baths (not shown), an electropolishing bath **13**, and suitable rinsing and neutralizing baths (not shown). The bath **13** preferably is an electrolyte having a composition the same as that of, and held in the temperature ranges of, the electropolishing electrolyte disclosed in copending application Serial No. 175,124, filed July 21, 1950, for "Electropolishing Metallic Articles" by H. R. Strobel. The electrolyte may consist essentially of about 18% to 30% by weight copper nitrate, 6% to 2% by weight sulphuric acid and 76% to 68% by weight water, and the temperature of the electrolyte preferably is from 65° F. to 110° F. One very successful electrolyte consisted of 19% copper nitrate, 4.5% sulphuric acid and 76.5% water, and was maintained at a temperature of from about 80° F. to 85° F. If desired a suitable water soluble wetting agent, such as, for example, a sodium salt of an alkyl naphthalene sulphonic acid or an ester of a sulphonated bicarboxylic acid, which are commonly sold under the trade name "Aerosol," may be used in the electrolyte.

Contact sheaves **15**—**15** contact the conductor **10** at a point prior to the entrance of the tape into the bath **13**, and are connected to the positive side of a source of D. C. potential (not shown), the negative side of which is connected to contact rolls **17** and **18**. Driven rolls **19** and **20** advance cathode tapes **21** and **22** through the bath **13** in the same general direction as that in which the conductor **10** is advanced therethrough, and sheaves **25**, **26**, **27** and **28** guide the cathode tapes in directions converging with respect to the conductor **10** from the entrance end of the electropolishing bath **13** to the exit end thereof. An electric motor **30** drives the rolls **19** and **20** at the same peripheral speed through gearing **31** and **32**.

As the conductor passes through the bath **13**, the voltage between the cathode tapes and the conductor **10**, the spacing between the two tapes and the conductor and the conductivity of the bath are such that any projections on the surface of the conductor are first dissolved therefrom by electrolytic action under an anode current density that is high but below 3,000 amperes per square foot. This anode current density is increased as the tape approaches the exit end of the bath to over 3,000 amperes per square foot to form a layer of copper oxides on the surface face of the conductor **10** to polish and passivate that face by the time the conductor **10** leaves the bath **13**.

The tapes **21** and **22** enter the bath **13** through slots **35** and **36** formed in a container wall **37** composed of electrical insulating material, and travel through guides **38**, **39** and **40** composed of electrical insulating material. The guides **38** and **39** have arcuate guiding surfaces **41** and **42**, and the guide **40** has a frustoconical passage **43** therein. The tapes **21** and **22** are bent gradually from planar at the sheaves **25** and **27** to semicircular cross-sectional shapes at the exit of the guide **40**, and lie in opposed walls of a frustum. Thus, the portions of the tapes farthest from the conductor **10** are the least curved, and the curvature progressively increases, with the conductor as the axis of curvature, as the tapes approach the conductor. Scrapers **45** and **46** scrape the tapes **21** and **22**, respectively, to remove electrodeposits from the surfaces of the tapes.

Operation

As the conductor **10** is advanced continuously through the baths prior to the bath **13**, the conductor is cleaned and rinsed in a conventional manner. The conductor is advanced through the bath **13**, and the cathode tapes **21** and **22** are advanced along the conductor at the same rate of speed as that of the conductor. During the initial portion of the passage of the conductor **10** through the bath **13**, the resistance between the conductor and the two tapes is sufficiently high to prevent rapid passivation

of the surface of the conductor, and is sufficiently low to cause all larger projections on the surface of the conductor 10 to be dissolved electrolytically. Since there is a substantial space between these portions of the tapes and the conductor, there is little difference in the resistance path between all points on this portion of the conductor and the tapes. The tapes become progressively more curved around the conductor as the tapes become progressively closer to the conductor so that there is no material difference in the resistance paths from all points on the conductor to the tapes. Hence, the current densities all around the conductor at any point therealong are substantially equal.

The current density on the surface of the conductor 10 progressively increases as the conductor 10 moves from the entrance end of the bath 13 toward the exit end thereof because of the continuous shortening of the path between the conductor and the cathode tapes. As the current density increases, the portion of the electrolyte immediately adjacent to the surface of the conductor is broken down to provide oxygen, which reacts with the copper coming from the conductor to form copper oxides on the surface of the conductor, and the surface of the conductor below the copper oxides is polished highly by the time the oxides build up to a passivating condition. Slightly before the conductor leaves the bath 13, this passivating condition is reached which reduces current flow to a small value. Thus, the passivation acts as a control to stop substantially further dissolution of copper from the conductor.

After passivation, the surface of the conductor 10 has a lustrous, light green coating thereon composed of copper oxides. This oxide layer later is removed from the conductor to leave a smooth golden surface. The movement of the conductor through the electropolishing bath 13 is sufficiently slow to prevent agitation around the surface of the conductor. As a result, the breakdown of electrolyte produced along this surface by the electrolytic action is such that there is sufficient supply of oxygen available at this surface to form the copper oxides. The copper oxides passivate this surface to limit polishing when the surface has become smooth.

The above-described method and apparatus rapidly form lustrous, highly polished surfaces on conductors originally having projections on the surfaces thereof, and the polished surfaces have no pits therein.

Certain features of the above-described bath, method and apparatus are disclosed and claimed in the above-mentioned application Serial No. 175,124 filed by H. R. Strobel, copending application Serial No. 175,125, filed July 21, 1950 by H. R. Strobel for "Methods of and Apparatus for Electropolishing Metallic Articles" and copending application Serial No. 175,189, filed July 21, 1950, by A. N. Gray for "Methods of and Apparatus for Electropolishing Metallic Articles."

While in the apparatus shown in the drawings and described hereinabove, there are two metal tapes employed as cathodes, it is obvious that any desired number of tapes could be used for that purpose. Thus, three or four such tapes could be arranged symmetrically about a moving metal filament to be electropolished, and guided so that they converge toward the filament and simultaneously form a tube surrounding the filament. In certain cases, one metal tape could be guided so as to converge toward and ultimately encircle a moving metal filament to be electropolished.

The metallic tape cathodes described hereinabove are endless and are constantly advanced through the electropolishing bath as the conductor to be electropolished is passed therethrough. The principal purpose of having these cathode tapes moving is to permit the continuous removal therefrom of copper that is deposited thereon due to the fact that they are connected as cathodes in the electropolishing circuit. However, it would be possible to position one or more stationary cathode tapes in the electropolished bath and to so support the tapes that they assume the same position and have the same contours as do the moving tapes shown in the drawing and described previously. Obviously, the metal deposited on these stationary tapes would have to be removed at intervals.

In the use of the terms "filament" and "filamentary article" in the specification and claims it is intended to include rods, wires and the like.

Articles composed of metals other than copper may be successfully electropolished with the above-described method and apparatus in conjunction with a suitable electrolyte. For example, articles made of steel, stainless steel, zinc, brass, nickel, etc. may be successfully polished with this method and apparatus. Furthermore, this method and apparatus successfully electropolishes composite articles having an outer covering of one metal enclosing an inner core of another metal. One particular material that may be thus electropolished is a composite wire composed of a steel core incased in a copper sheath.

What is claimed is:

1. The method of electropolishing metallic filaments, which comprises continuously advancing a metallic filament longitudinally along a predetermined straight path through an electrolytic bath, advancing a pair of flat metal tapes through the bath along straight paths converging with respect to the path of the filament and on opposite sides thereof from the entrance end to the exit end of the bath, progressively bending the tapes transversely into a tube surrounding the filament as they are advanced along said paths thereof, and creating a sufficient difference of potential between the filament and the tapes to polish the surface of the filament.

2. An apparatus for electropolishing metallic articles, which comprises a tank containing an electrolytic bath, means for advancing a filamentary metallic article as an anode through the bath along a predetermined straight path, a cathodic tape immersed in the bath and converging gradually with respect to the path of the article from the entrance end to the exit end of the tank, means for bending the tape progressively into a tube surrounding the path of the article, and means for impressing across the article and the tape a difference of potential sufficiently high to polish the surface of the article.

3. An apparatus for electropolishing metallic articles, which comprises a tank containing an electrolytic bath, means for advancing a filamentary metallic article longitudinally through the bath along a predetermined straight path, means for advancing a flat metal tape through the bath adjacent to and converging with respect to the path of the article, means for progressively bending the advancing tape into a frustoconical shape surrounding the path of the article, and means for causing a D. C. current to flow through the bath between the article and the tape with the article the anode.

4. An electropolishing apparatus, which comprises a tank containing an electrolytic bath, a cathodic tape immersed in the bath and extending substantially from the entrance end of the tank to the exit end thereof, means for advancing a metallic anodic filament to be polished along a path extending along and spaced from the tape, means for positioning the tape and for guiding the filament in a manner such that the filament and the tape are gradually convergent from the entrance end to the exit end of the tank, a plurality of guides composed of electrical insulating material for gradually forming the tape into a frustoconical shape surrounding the path of the filament, and means for impressing a difference of D. C. potential across the filament and the tape.

5. An electropolishing apparatus, which comprises a tank containing an electrolytic bath, a pair of endless conductive tapes each having a portion thereof immersed in the bath and extending substantially from the entrance end to the exit end of the tank, means for advancing a metallic filament to be polished along a path extending along and

between the tapes, means for positioning the tapes and for guiding the filament in a manner such that the filament and the immersed portions of the tapes are gradually convergent, means for advancing the endless tapes through the bath at the same speed and in the same direction as the filament, a plurality of guides composed of electrical insulating material for progressively forming the immersed portions of the tapes into a frustoconical shape surrounding the path of the filament, and means for impressing a difference of D. C. potential across the filament and the tapes with the filament the anode.

6. An electropolishing apparatus, which comprises a tank containing an electropolishing bath, means for advancing a filamentary copper conductor as an anode through the bath, a plurality of cathode tapes immersed in the bath, means for advancing the cathode tapes through the bath in the same direction and spaced radially around the conductor, means for guiding the conductor and the cathode tapes in paths gradually converging from the entrance end to the exit end of the tank, means for progressively bending the tapes into longitudinal segments of a tube surrounding the conductor as the tapes are advanced through the bath, and means for impressing a difference of potential across the conductor and the tapes.

7. An electropolishing apparatus, which comprises a tank containing an electropolishing bath, means for advancing a copper conductor as an anode through the bath, a pair of flat metallic tapes immersed in and extending from the entrance end to the exit end of the tank, means for advancing the tapes as cathodes through the bath spaced along opposite sides of and in the same direction as the conductor, means for guiding the tapes so that they progressively converge toward the conductor from the entrance end to the exit end of the tank, means for progressively forming the advancing tapes into a tube surrounding the conductor, and means for impressing a D. C. voltage across the conductor and the tapes so as to make the conductor an anode.

8. The method of electropolishing metallic articles, which comprises continuously advancing a filamentary metallic article longitudinally as an anode and a flat tape as a cathode through an electrolytic bath in converging straight path which result in progressively decreasing the

spacing between the tape and the article from the entrance end to the exit end of the bath, transversely bending the tape progressively into a tube around the article as the distance between the article and the tape decreases, and impressing across the article and the tape a difference of potential sufficiently high to polish the surface of the article.

9. The method of electropolishing filamentary metallic articles, which comprises continuously advancing a filamentary copper article longitudinally as an anode and a flat tape as a cathode through an electropolishing bath in converging straight paths which result in progressively decreasing the distance between the article and the cathode tape from the entrance end to the exit end of the bath, transversely bending the tape into a frustoconical shape surrounding the article, and impressing a difference of potential across the article and the cathode tape sufficiently high to polish the surface of the article.

10. The method of electropolishing filamentary copper conductors, which comprises continuously advancing a filamentary copper conductor and a plurality of flat cathode tapes longitudinally in converging straight paths through an electrolytic bath so that the spacing between the tapes and the conductor progressively decreases from the entrance end to the exit end of the bath, progressively transversely bending the tapes arcuately so that eventually they form a tube surrounding the conductor, and impressing a difference of potential across the tapes and the conductor, the value of the difference of potential, the conductivity of the bath and the spacing of the tapes from the conductor being such that the current density on the surface of the conductor most adjacent to the cathode tapes has an initial value sufficient to polish the surface of the conductor but too low to cause passivation of that surface and increases gradually to a value at which rapid passivation of that surface occurs.

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