Nov. 29, 1955 A. N. GRAY 2,725,355

APPARATUS FOR ELECTROPOLISHING METALLIC ARTICLES

Filed July 21, 1950 3 Sheets-Sheet 1

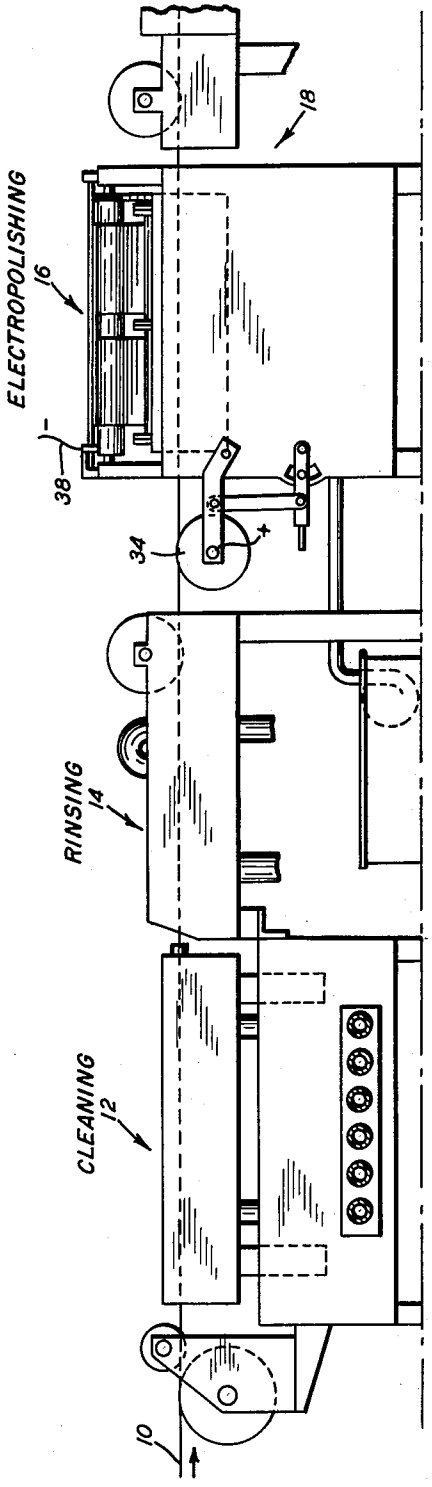


FIG. 1

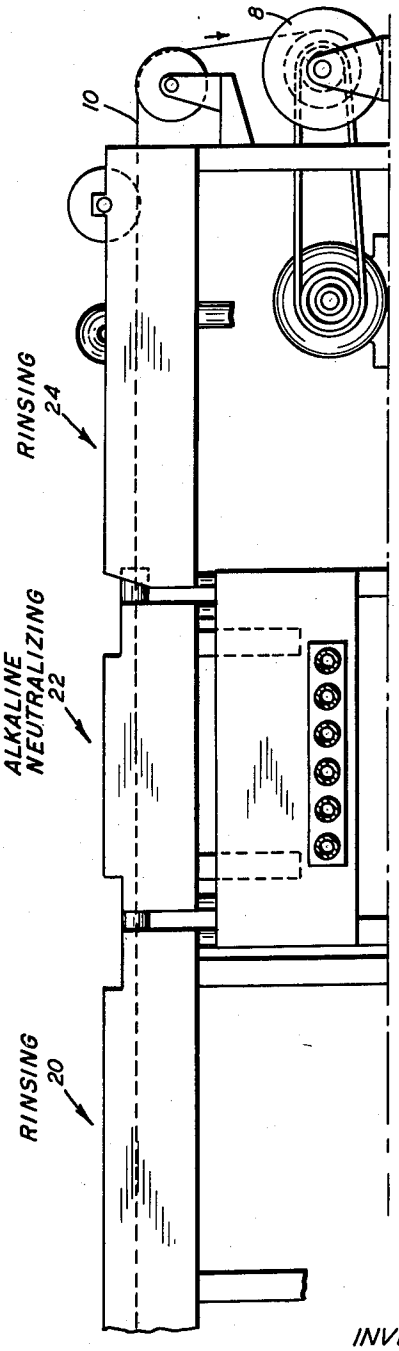


FIG. 2

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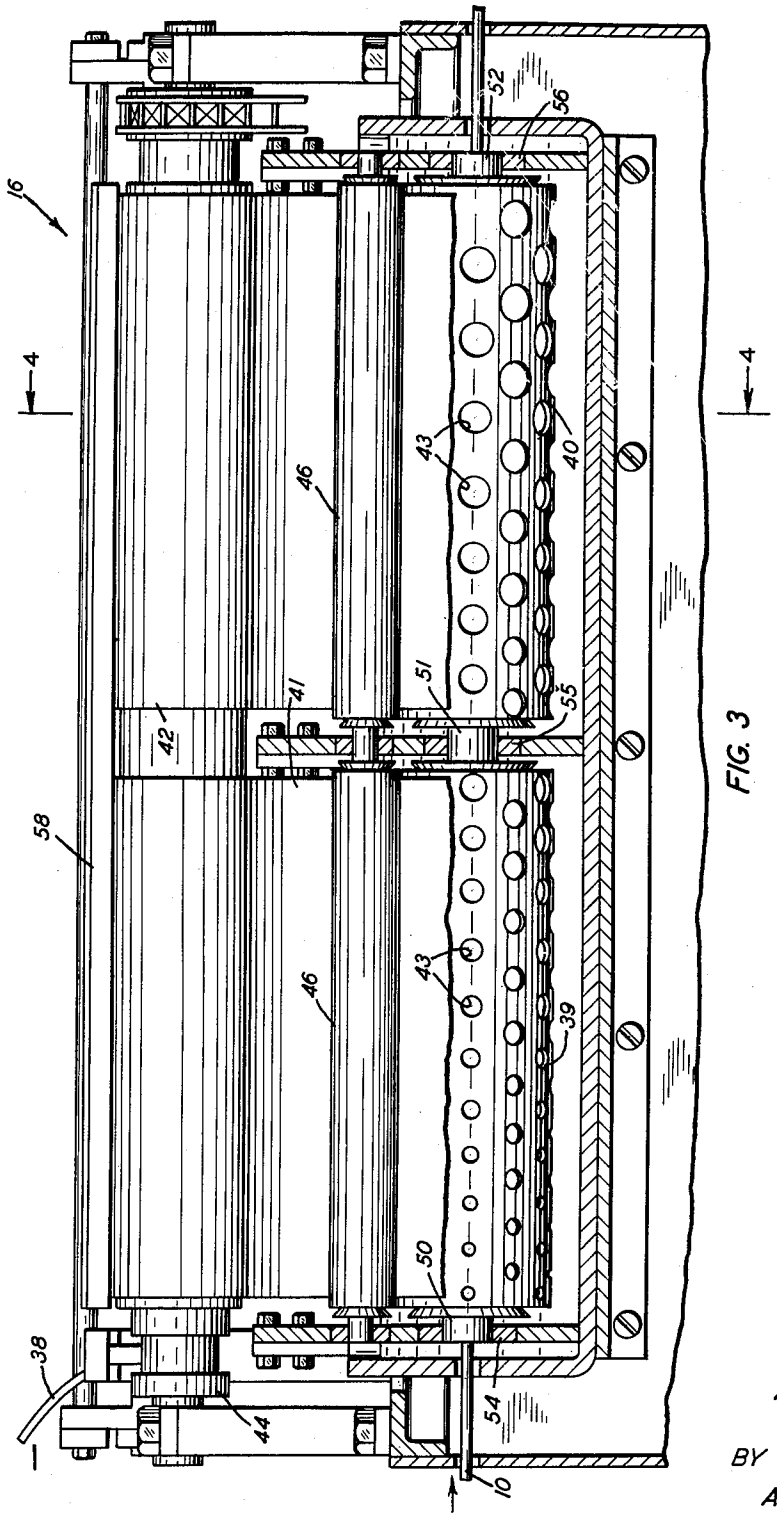


FIG. 3

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APPARATUS FOR ELECTROPOLISHING METALLIC ARTICLES

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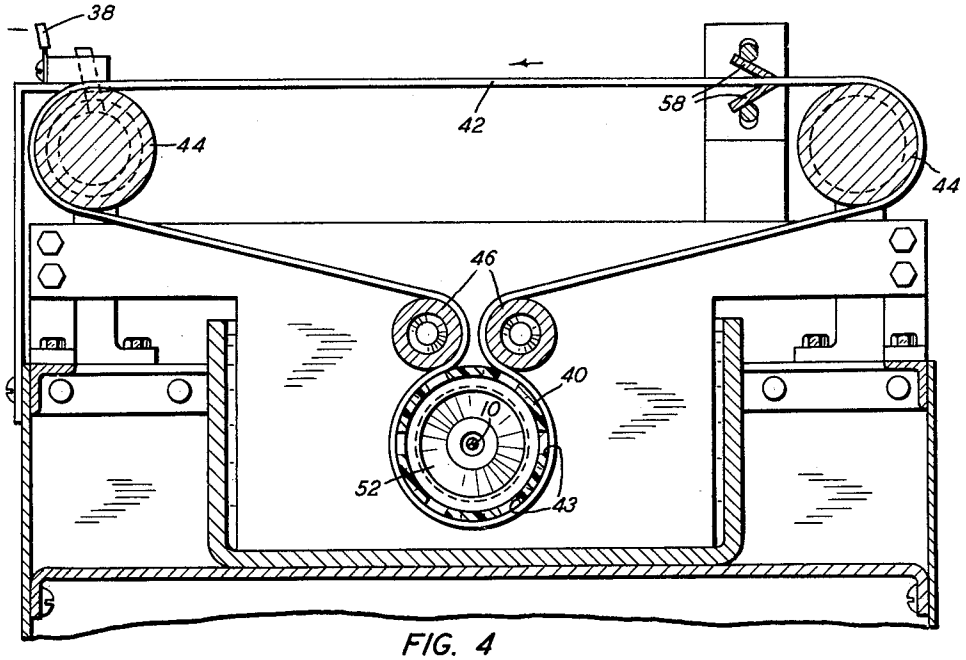


FIG. 4

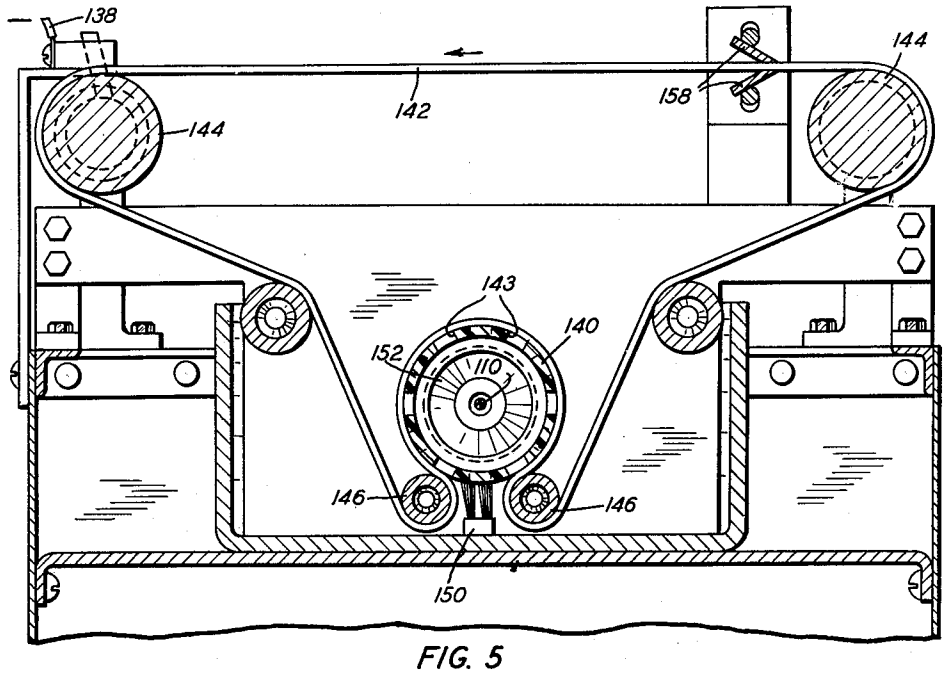


FIG. 5

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APPARATUS FOR ELECTROPOLISHING METALLIC ARTICLES

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Application July 21, 1950, Serial No. 175,189

7 Claims. (Cl. 204—208)

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

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

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

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

Another object of the invention is to provide new and improved apparatus for removing the splinters, metallic flakes, ridges and other projections from the central conductors of coaxial units.

An apparatus illustrating certain features of the invention may include an electrolytic bath, a cathode immersed in the bath, and means for immersing an article to be electropolished in the bath. Means are provided for impressing a D. C. difference of potential across the article and the cathode so that current flows from the article to the cathode, and masking means positioned between portions of the cathode and the article initially limits the current density on the article to a value below that necessary to rapidly passivate and then permits rapid passivation of the article.

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

Fig. 1 is a fragmentary, front elevation of a portion of an apparatus embodying the invention;

Fig. 2 is a corresponding view of another portion of the apparatus continued from the right-hand end of Fig. 1;

Fig. 3 is an enlarged, fragmentary, partially sectional view of a portion of the apparatus shown in Fig. 1;

Fig. 4 is an enlarged, fragmentary, vertical section taken along line 4—4 of Fig. 3, and

Fig. 5 is a fragmentary, vertical section of a portion of an apparatus forming another embodiment of the invention.

Referring now in detail to the drawings, a capstan **8** (Fig. 2) advances a filamentary conductor **10** of substantial length to be polished continuously through a cleaning bath **12** (Fig. 1), a rinsing bath **14**, a cathode device **16** immersed in an electropolishing bath **18**, a rinsing bath **20**, an alkaline neutralizing bath **22** (Fig. 2) and a rinsing bath **24**. At least the outer surface of the conductor **10** is composed of copper. A rotary contact sheave **34** (Fig. 1) contacts the conductor **10** at a point prior to the entrance thereof into the electropolishing bath **18**. The sheave **34** is connected to the positive conductor of a source of D. C. potential (not shown). A negative conductor **38** of the source of D. C. potential is connected to the cathode device **16**. The cleaning bath **12** is alkaline and serves to free the surface of the conductor of grease and foreign substances as it is advanced therethrough. The rinsing bath **14** is water, which rinses any alkali on the conductor therefrom.

The cathode device **16** (Figs. 3 and 4) includes hollow, cylinders **39** and **40** around which smooth, endless, stainless steel or copper sheet cathodes **41** and **42** are guided and advanced continuously. The cylinders **39** and **40** are composed of suitable nonconductive material, such as a strong plastic, and are provided with a series of perforations **43—43** extending therethrough. A phenol-formaldehyde condensation product such as "Bakelite" may be used to make the cylinders. A pair of cathode sheaves **44—44** advance and contact the cathodes **41** and **42**, and guide rolls **46—46** guide the cathodes around the cylinders. Arbors **50**, **51** and **52** having tapered ends and composed of hard rubber are mounted in bearings **54**, **55** and **56** composed of acid resistant material, and support the cylinders **39** and **40** rotatably.

The area of the perforations near the entrance end of the cylinder **39** per unit surface area of the cylinder, is sufficiently small to limit the flow of current between the conductor **10** and the cathode **41** to an amount less than that at which passivation of the surface of the conductor occurs. The area of the perforations per unit surface area of the cylinders **39** and **40** gradually increases from the entrance end of the cylinder **39** toward the exit end of the cylinder **40** to such an extent that from a point about midway between the ends of the cylinder **40** to the exit end thereof sufficient current flows from the conductor to the cathode **42** to passivate rapidly the surface of the conductor and to electropolish that surface. The cathodes are advanced continuously, and scrapers **58—58** scrape any copper deposited on the cathodes **41** and **42** from the smooth surfaces thereof.

The composition of the electropolishing bath **18** may be about 18% to 30% by weight copper nitrate, 6% to 2% by weight sulphuric acid and 76% to 68% by weight of water. The sulphuric acid increases the conductivity of the electropolishing bath, but the concentration thereof is sufficiently low to avoid pitting of the conductor by the electrolyte. The high concentration of copper nitrate supplies the necessary copper ions, and the nitrate radical serves to minimize etching. The addition to the bath of a small amount of chromic acid in amounts up to 2% by weight of the total electrolyte, and the presence of small amounts of suitable water soluble wetting agents, such as, for example, a sodium salt of an alkyl naphthalene sulphonic acid or an ester of a sulphonated dicarboxylic acid, which are commonly sold under the trade name "Aerosol," also reduce pitting action. One very successful electropolishing bath **18** consisted of 19% copper nitrate, 4.5% sulphuric acid and 76.5% water. The bath is cooled to a temperature not less than about 65° F. and not above about 110° F. by a cooling unit (not shown), and preferably is maintained at about 85° F.

Operation of embodiment shown in Figs. 1, 2, 3 and 4

The conductor **10** composed of copper is advanced continuously through the apparatus. The cleaning bath **12** cleans grease and foreign matter from the surface of the conductor, and the water rinsing bath **14** rinses any alkali on the conductor **10** therefrom. The conductor **10** then is advanced through the electropolishing bath **18** and the cathode device **16** immersed in the bath **18**. Near the

entrance end of the cylinder 40, the perforations 43—43 expose only sufficient area of the sheet cathode 42 to cause projections on the surface of the conductor 10 to erode away without passivating the surface of the conductor. The current density on this portion of the conductor is below 3,000 amperes per square foot. The exposed area of the cathode 42 becomes progressively greater from the entrance end of the cylinder 40 toward the exit end to such an extent that the current density on the portion of the conductor 10 along a portion of the cylinder from a point about one-third of the way from the entrance end of the cylinder 40 to the exit end thereof is high enough to cause the average current density on the conductor in this portion of the cylinder 40 to be at least 3,000 amperes per square foot.

After the larger projections on the surface of the conductor 10 have been eroded into the electrolyte in the cylinder 39 and in the portion of the cylinder 40 near the entrance end thereof, the increased current density electropolishes and passivates the surface of the conductor rapidly. As the electropolishing proceeds under high current density, the portion of the solution immediately surrounding the conductor is broken down sufficiently to make oxygen abundantly available at the surface of the conductor and oxides are formed thereon. By the time the copper oxides build-up sufficiently to passivate the surface of the conductor, that surface has received a high polish and the passivating oxide layer substantially prevents further erosion. The electrolyte is recirculated slowly to prevent agitation and is replenished, the conductor 10 is advanced through the bath 16 sufficiently slowly to avoid agitation of the electrolyte around the surface of the conductor, which facilitates passivation. In one specific example, the conductor 10 was composed of solid copper and was 0.1009 inch in diameter, the width of each of the sheet cathodes 41 and 42 was about eight inches and the time of the passage of the conductor through the electrode device 16 was between five and ten seconds. The cathodes 42—42 were spaced ⅝ inch from the conductor, and the potential difference between the conductor and the cathodes was 16 volts. The ratio of the exposed areas of the sheet cathodes to the surface area of the portions of the conductor 10 coextensive therewith varied from about 2 to 3 at the entrance end of the projection-dissolving portion of the bath to about 4 to 1 at the exit end of this portion of the bath. The average current density on the portion of the conductor 10 in the bath 18 was about 2,400 amperes per square foot.

The conductor 10 is advanced from the bath 18 into the alkaline cyanide bath 22 (Fig. 1) which removes the oxide layer to leave a bright polished surface, and from the bath 22 through the water rinsing bath 24.

Embodiment shown in Fig. 5

The apparatus shown in Fig. 5 is identical with that disclosed on Figs. 1 to 4, inclusive, except that guide rolls 146—146 are positioned below aligned plastic cylinders of which a plastic cylinder 140 is shown. A brush 159 is positioned between the guide rolls 146—146 and extends along the cylinders. The bristles of the brush enter a series of perforations 143—143 formed in the cylinders and keep the perforations clean and free of any metal and metal compounds. The bristles are composed of nylon or other suitable nonconductive material. As the cylinders are revolved by the tapes, the bristles enter the perforations and scour the walls thereof, any particles which have been disengaged from the cylinders dropping through the perforations to the bottom of the bath.

Certain features of the above-described methods and electrolytic baths are disclosed and claimed in copending application Serial No. 175,124, filed July 21, 1950 by H. R. Strobel for "Electropolishing Metallic Articles," and certain features of the above-described methods and apparatus are described and claimed in copending application Serial No. 175,125, filed July 21, 1950 by H. R. Strobel for "Methods of and Apparatus for Electropolishing Metallic Articles."

By the terms, such as "filament," "filamentary article" and the like, throughout the specification and claims, it is intended to include strips, tapes, wires, threads and the like.

The above-described methods and apparatus may also be used with suitable electrolytes to electropolish metals other than copper. For example, these methods and apparatus are highly satisfactory for electropolishing nickel, brass, stainless steel, steel, zinc, etc. Furthermore, while the conductor 10 has been described as composed of solid copper, these methods work equally well on composite conductors having copper outer surfaces and cores of a different metal, such as, for example, steel.

What is claimed is:

1. An apparatus form electropolishing articles, which comprises a tank containing an electrolytic bath, a cathode extending generally across the tank, means for advancing an article to be electropolished through the tank along a path substantially parallel to the cathode from the entrance end of the tank to the exit end thereof, means for impressing a difference of potential across the article and the cathode so that current flows from the article to the cathode, a nonconductive mask interposed between the cathode and the article, said mask being so perforated that a progressively increasing area of the cathode is exposed thereby to the article as the article is advanced from the entrance end to the exit end of the tank.

2. An electropolishing apparatus, which comprises a tank containing an electrolytic bath, a generally tubular cathode extending across the tank, means for advancing an article to be electropolished axially through the cathode, means for applying across the article and the cathode a D. C. difference of potential sufficiently high to cause rapid passivation of any unmasked portion of the article, and a tubular, nonconducting mask interposed between the cathode and the article, said mask having a plurality of perforations therethrough so arranged as to expose progressively more of the cathode to the article as the article advances from the entrance end to the exit end of the tubular mask.

3. An electrolytic apparatus, which comprises a tank containing an electrolytic bath, a cylindrical shell composed of electrical insulating material having a plurality of uniformly distributed openings throughout the length thereof immersed in the bath, a band of electroconductive material surrounding the shell, means for advancing an electroconductive article axially through the shell from the entrance end thereof to the exit end thereof, means for impressing a D. C. difference of potential across the band and the article, the size of the openings in the portion of the shell near the entrance end being sufficiently small to limit the current density on the portion of the article in the entrance end of the shell and the openings in the portion of the shell near the exit end thereof being sufficiently larger to permit free flow of current between the band and the portion of the article therein.

4. An electropolishing apparatus, which comprises an electroconductive strip movable through an electrolytic bath, means for advancing the strip therethrough, a nonconductive generally tubular shell having a plurality of uniformly distributed openings therein, means for guiding the strip around the shell in the bath, the area of the openings in the shell per unit area of the shell gradually increasing from the entrance end of the shell toward the exit end thereof, and means for applying a difference of potential across the strip and an article advanced axially through the shell.

5. An electropolishing apparatus which comprises an endless electroconductive strip movable in a predetermined path, a tank containing an electrolytic bath positioned in at least a portion of the path of the strip, a

nonconductive tube having a plurality of perforations uniformly distributed and gradually increasing in size from one end to the other thereof, means for rotatably supporting the tube in the bath so that an article to be electrolyically treated can be axially advanced therethrough, means for forming the portion of the strip in the bath into a loop substantially surrounding the tube, means for continuously advancing the strip through the bath so that the loop therein will rotate the tube, means for impressing a difference of potential across the loop in the strip and an article being advanced axially through the tube, and a brush positioned in the bath for cleaning the perforations in the tube as the tube rotates.

6. An apparatus for continuously electropolishing moving wires, which comprises a tank having an electrolytic bath therein, means for continuously advancing a wire to be polished in a straight path through the tank, a nonconductive tube mounted in the tank and concentrically surrounding the straight path of the wire, said tube having a plurality of perforations distributed uniformly in number but increasing gradually in size from the entrance end to the exit end of the tube, an electroconductive endless strip having a width approximately equal to the length of the tube substantially surrounding the tube, and means for impressing a difference of potential across the strip and a wire being advanced axially through the tube to electropolish the wire.

7. An apparatus for continuously electropolishing moving wires, which comprises a tank having an electrolytic bath therein, means for continuously advancing a

wire to be polished in a straight path through the tank, a nonconductive tubular mask mounted rotatably in the tank and concentrically surrounding the straight path of the wire, an endless electroconductive strip movable transversely through the bath in a predetermined path, a plurality of guide rolls mounted in the path of the strip and arranged to form a portion of the strip into a loop substantially surrounding the tubular mask, means for continuously advancing the strip through the bath so that the loop therein rotates the tubular mask, and means for impressing a difference of potential across the strip and a wire being advanced axially through the tubular mask to electropolish the wire, said mask having a plurality of perforations so arranged as to expose progressively more of the strip as the wire advances from the entrance end to the exit end of the tubular mask.

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