July 3, 1934. H. G. WEHE 1,965,399

METHOD OF AND APPARATUS FOR ELECTROCHEMICALLY PRODUCING ARTICLES

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Fig. 1.

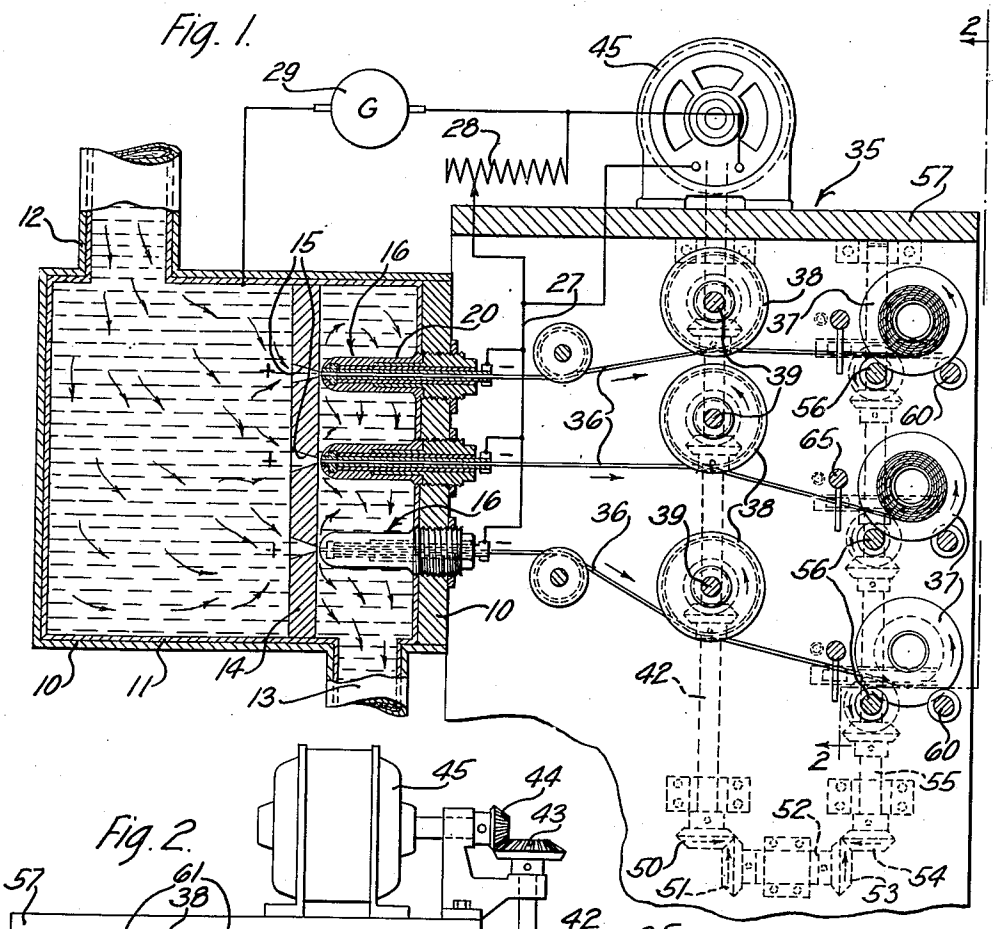

Fig. 2.

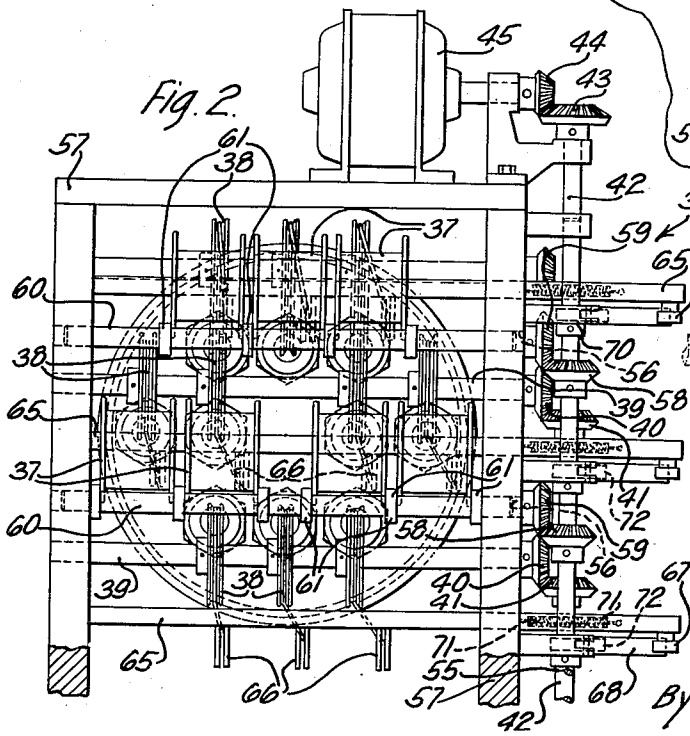

Fig. 3.

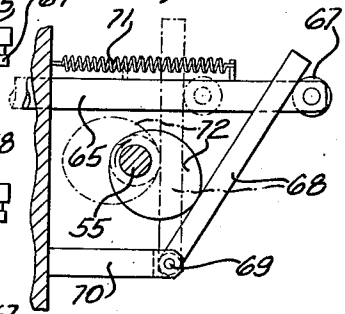

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Fig. 4.

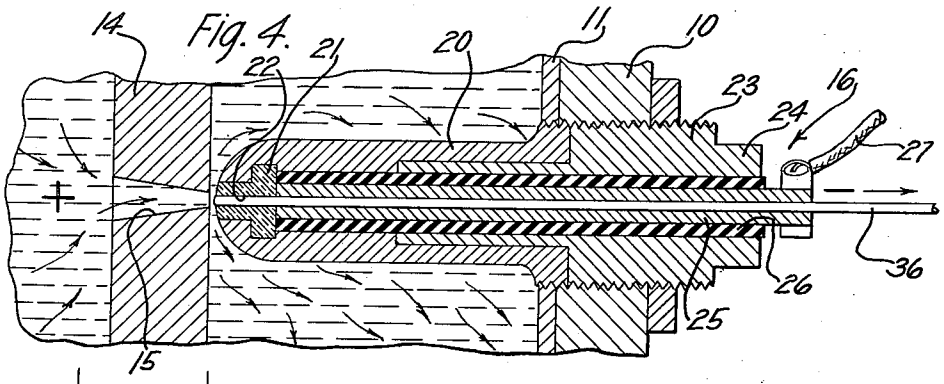
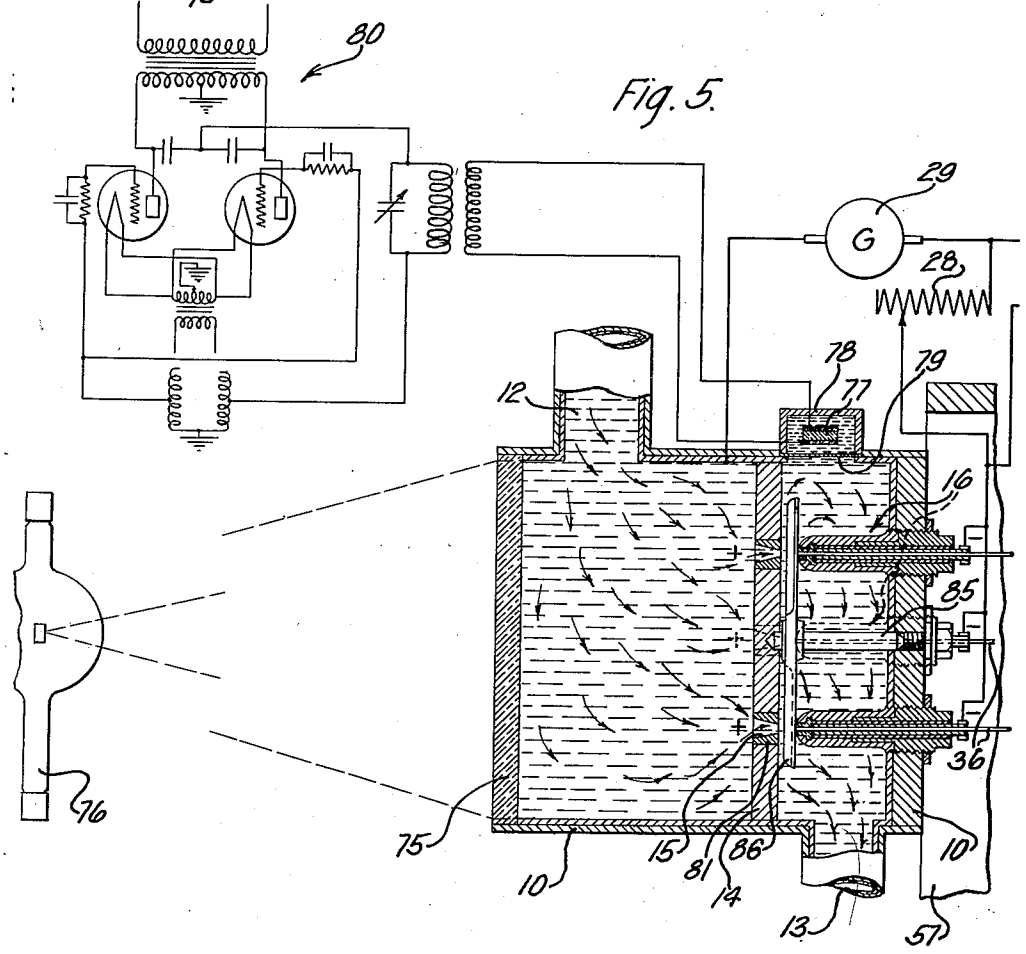


Fig. 5.



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METHOD OF AND APPARATUS FOR ELECTRO-CHEMICALLY PRODUCING ARTICLES

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Application June 25, 1929, Serial No. 373,656

14 Claims. (Cl. 204—11)

This invention relates to a method of and apparatus for electro-chemically producing articles, and more particularly to a method of and apparatus for manufacturing wire by electro-deposition.

The principal objects of this invention are to provide an electro-chemical method of and apparatus for accurately and efficiently producing an article.

One embodiment of the invention consists of an apparatus whereby the method may be practiced for producing copper wire by electro-deposition. In this embodiment of the invention hot filtered streams of acidified solution of copper sulphate ($CuSO_4$), carrying pulsating direct current, are projected against insulated openings containing embedded electrodes to deposit copper upon the ends of starting wires to increase their mass, which wires are withdrawn therefrom as continuous wire at a rate controlled by the electrolytic current. In order to expedite the process, the electrolyte ($CuSO_4$) may be agitated by high frequency mechanical vibrations produced by an electrically operated quartz crystal submerged in oil; increased ionization may be obtained by subjecting the electrolyte to electro-magnetic radiations; the quality of the deposited copper may be improved by burnishing the copper at predetermined intervals; and permanent magnets or solenoids may be used in the vicinity of the insulated openings to increase the conductivity of the electrolyte and of the deposited copper.

It is believed that a clear understanding of the invention may be had by reference to the following description taken in conjunction with the accompanying drawings, showing apparatus by means of which the method embodying the invention may be practiced and in which

Fig. 1 is a fragmentary side elevational view, partly in section, of an apparatus for manufacturing wire by electro-deposition;

Fig. 2 is a fragmentary end view thereof;

Fig. 3 is an enlarged fragmentary plan view of the mechanism for distributing the finished wire upon take-up spools;

Fig. 4 is an enlarged fragmentary sectional view of a cathode tube in which the wire is formed, and

Fig. 5 is a fragmentary schematic view, partly in section, of an apparatus which includes the structures shown in Figs. 1 to 4, inclusive, and has additional devices for expediting the process.

Referring now to the drawings in which like reference numerals designate similar parts, a steel tank 10 lined with a lead sheath 11 and having inlet and outlet pipes 12 and 13, respectively, is provided with a conducting partition 14 of non-magnetic, acid resistant material having conical shaped apertures 15—15. The inlet and outlet pipes are connected to any suitable purifying, filtering, heating and pumping system (not shown) whereby a purified and hot filtered, acidified copper sulphate ($CuSO_4$) solution is forced through conical apertures 15 against cathode tubes 16—16 adjustably mounted in the right hand wall of the tank 10, as shown in Fig. 1.

Each of the cathode tubes (Fig. 4) comprises an outer lead sleeve 20 in the front end of which is embedded a hard glass or quartz die 21 having an opening 22 of a size corresponding to the diameter of the wire or rod to be produced. The outer sleeve 20 is secured to an inner steel sleeve 23 threaded in the wall of the tank 10 and terminating in a hexagonal shank 24 whereby a wrench can be used to adjust the position of the tube 16 longitudinally. Abutting the inner end of the die 21 and extending centrally of the inner sleeve 23 is a bronze tube 25 which is surrounded by an insulating cylinder 26. To the outer end of the bronze tube 25 is clamped a conductor 27 connected through a resistance 28 (Fig. 1) to the negative terminal of a pulsating direct current generator 29.

A reeling mechanism, designated generally by the numeral 35 (Fig. 1), is positioned in front of the outer ends of the tubes 16—16 for winding the wires 36—36 as they are produced, on take-up spools 37—37. The reeling mechanism includes a plurality of capstans 38—38 secured to shafts 39—39 which carry bevel gears 40—40 (Fig. 2) meshing with bevel gears 41—41 fastened to an upright shaft 42; the upper end of the shaft 42 has a bevel gear 43 meshing with a bevel gear 44 secured to the driving shaft of a motor 45 which is constructed and connected in the generator circuit so that the speed of the motor can be controlled by the intensity of the current passing through the electrolyte.

Fastened to the lower extremity of the vertical shaft 42 is a bevel gear 50 (Fig. 1) meshing with a bevel gear 51 secured to an idler shaft 52 which has another bevel gear 53 meshing with a bevel gear 54. The gear 54 is secured to a shaft 55 which drives shafts 56—56 horizontally positioned in a frame 57 through gears 58—58 and 59—59 (Fig. 2). The horizontal shafts 56—56 in conjunction with rollers 60—60 (Figs. 1 and 2) serve to support and rotate the take-up spools 37—37 and maintain them in spaced re-

lationship during rotation due to collars 61—61 of the rollers 60 engaging the faces of the spool heads.

Distributor rods 65—65 slidably mounted in the frame 57 are provided with forks 66—66 for distributing the wire as it leaves the capstans 38 and is wound on the take-up spools 37. Each of the rods 65 carries a roller 67 (Fig. 3) at its left hand extremity which engages a lever 68 pivoted at 69 to a bracket 70 which is secured to the frame 57. The lever 68 moves the rod 65 toward the right against the tension of a spring 71 secured thereto, when a cam 72 fastened to the shaft 55 actuates the lever 68 as shown in Fig. 3. As the cam rotates further the spring 71 gradually moves the rod toward the left and the wire guided by the fork 66 is distributed on the take-up spool.

In practicing the method with the apparatus disclosed the copper sulphate solution is forced at a high velocity through the conical apertures 15 against the mouths of the cathode tubes 16 in which are positioned the ends of copper wires 36 previously inserted and passed around the capstans 38 and onto the take-up spools 37. The lead lining 11 is then connected to the positive terminal of the pulsating direct current generator 29 and the negative terminal thereof is connected to the bronze tubes 25 contacting with the starting wires 37. With the direct current motor 45 of a watt-hour meter type connected in the generator circuit as shown in Fig. 1, the speed of the motor is controlled by the intensity of the current passing through the electrolyte and the adjustment of the resistance 28. As each pulse of direct current passes through the copper sulphate electrolyte the copper is plated out onto the ends of the starting wires to increase their mass and as the wires are produced the reeling mechanism actuated by the motor 45 controlled by the electrolytic current pulls the wire from the dies 21 and winds it on the take-up spools. The electrolyte is continuously circulated by a pump through a purifier where excess sulphuric acid is removed and copper sulphate is added and then is filtered and heated whereby the electrolyte is maintained at a uniform concentration.

In order to expedite the process of producing the wire by electro-deposition the end of the tank 10 may be equipped with a quartz window 75 (Fig. 5) so that electromagnetic radiations from an X-ray tube 76 or radiations of other frequencies from any suitable source will pass into the electrolyte to increase the ionization thereof and thus cause a greater amount of copper to be deposited on the cathode or starting wires. Also, as shown in Fig. 5, a quartz crystal 77 is immersed in an oil bath within a steel box 78, on the bottom of which is a thin flexible diaphragm 79 separating the oil from the electrolyte within the tank 10. The quartz crystal is connected to the terminals of a high frequency vacuum tube oscillator 80 of any suitable character. The electrical oscillations cause the crystal to alternately expand and contract to produce mechanical vibrations which are transmitted through the oil and flexible diaphragm 79 to thoroughly agitate the electrolyte and thus increase the rate and quality of electro-deposition onto the cathodes or starting wires 36. By embedding lead covered, permanent magnets 81 or solenoids about the conical apertures 15 of the tank 10, concentrated electromagnetic fields can be produced to decrease the resistance of the electrolyte within the vicinity of the mouths of the cathode tubes and of the finished wire by modifying the grain structure, thus facilitating the plating process and improving the quality of the product.

The quality of the copper wire can also be improved by intermittently burnishing the surfaces on which the copper is being deposited. This is accomplished by rotatably mounting a shaft 85 (Fig. 5) in the partition 14 and the right hand wall of the tank 10 and securing to the shaft a non-conducting propeller 86. The edges of the propeller are positioned to burnish the ends of the wires 36 at the mouths of the cathode tubes 16 when the propeller is rotated by the streams of electrolyte from the conical apertures 15 striking the inclined blades of the propeller. Thus by modifying the apparatus disclosed in Fig. 1 to include the use of the X-rays, high frequency vibrations, permanent magnets and burnishing propeller, as shown in Fig. 5, a fine grade of copper wire by electro-deposition can be quite rapidly produced.

The electro-chemical method hereinbefore described is also applicable for manufacturing rods, sheets, and tubing from various alloys, metals, and non-metals which can be deposited electro-chemically. Hence, by using a nozzle to direct a stream of electrolyte, defective metal castings can be repaired since metal is deposited only at the point of impingement of the stream of electrolyte. By reversing the direction of the flow of current through the electrolyte, metal can be removed so that cavities of any desirable contour can be produced in a material. Therefore, although the invention herein described and illustrated is particularly well adapted for producing wire, it will be understood that the invention is capable of many other modifications and applications without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A method of electro-chemically producing an article, which consists in subjecting an article being produced to a stream of electrolyte, agitating the electrolyte by high frequency vibrations, and applying an electrical current to effect an electrode deposition of metal upon the article.

2. A method of electro-chemically producing an article, which consists in projecting a stream of electrolyte against a cathode movably positioned within an insulator to define the area of deposit, applying an electrical current to the electrolyte to deposit material on the cathode member to produce an article and moving the article in the insulator to obtain a predetermined form.

3. A method of electro-chemically producing an article, which consists in projecting a stream of electrolyte against a cathode member positioned within an insulator, subjecting the stream of electrolyte to an electrical current of high density, and controlling the movement of the cathode member through said insulator to produce an article of predetermined form as the electro-deposition of material takes place on the cathode member.

4. A method of electro-chemically producing wire, which consists in projecting a stream of electrolyte against a cathode member positioned within an insulator having an opening of a predetermined size, and applying an electrical current to the electrolyte and the cathode member to deposit material on the cathode member to continuously produce a wire.

5. A method of electro-chemically producing wire, which consists in projecting a stream of electrolyte against a starting wire positioned within an insulator, applying an electrical current to the starting wire connected as the cathode and the electrolyte, and controlling the movement of the starting wire to produce a continuous wire.

6. A method of electro-chemically producing wire, which consists in projecting a stream of electrolyte against the end of a starting wire positioned within an insulator, subjecting the stream of electrolyte and the starting wire connected as the cathode to pulsating current to increase the length of said wire, and removing the wire from the insulator in accordance with the rate of its production.

7. A method of electro-chemically producing wire, which consists in directing a stream of electrolyte against the end of a starting wire, intermittently burnishing the end of the wire at the point of contact with the electrolyte, subjecting the electrolyte to an electro-magnetic field, passing electro-magnetic radiations through the electrolyte, agitating the electrolyte by high frequency vibrations from an electrically operated quartz crystal, simultaneously applying an electrical current to the electrolyte and the starting wire connected as the cathode to continuously increase the length thereof and controlling the movement of the wire to produce a continuous wire.

8. In an apparatus for electro-chemically producing an article, means for directing a stream of electrolyte at high velocity against a material, means for exposing a predetermined portion of the material to the electrolyte, means for applying an electrical current to the electrolyte and the material, and means controlled by the density of the current passing through the electrolyte to change the position of the material.

9. In an apparatus for electro-chemically producing an article, means for directing a stream of electrolyte against a material, means for subjecting the electrolyte to X-ray radiations, and means for applying an electrical current to the electrolyte and the material.

10. In an apparatus for electro-chemically producing wire, means for confining an electrolyte to a predetermined path, cathode means positioned adjacent said confining means to slidably support a starting wire, means for burnishing the end of the starting wire at predetermined intervals, means for subjecting the electrolyte to an electrical current, and means controlled by the electrolytic current for receiving the wire as its length is continuously increased.

11. In an apparatus for electro-chemically producing wire, a cathode tube for positioning a starting wire, means for directing a stream of electrolyte against the end of the starting wire, means for producing electrical oscillations to agitate the electrolyte, and means for subjecting the electrolyte and the starting wire to electrical impulses to continuously increase the length of the wire.

12. In an apparatus for electro-chemically producing a wire, a container for an electrolyte, a tube extending through the wall of said container and having a tubular aperture therethrough for supporting the wire, means for causing a current of said electrolyte to impinge upon the end of said wire, means for applying an electrical current to said electrolyte and wire, and means for withdrawing the wire through said tube as it is formed.

13. In an apparatus for electro-chemically producing an article, means for supporting a material in a bath of electrolyte, means for impinging a current of electrolyte on said material to form a deposit thereon, means actuated by the current of electrolyte for burnishing said deposit, and means for applying an electrical current to said electrolyte and material.

14. A method of electro-chemically producing an article which comprises the steps of directing a hot stream of filtered electrolyte against a movable end of said article, applying an electric current to the electrolyte and said article to effect electrodeposition of metal upon said end and simultaneously moving said article away from said stream of electrolyte at a rate proportional with the rate of metal deposition upon the article.

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