



- (51) **International Patent Classification:**
B23H 9/00 (2006.01) **B23H 3/02** (2006.01)
C25F 7/00 (2006.01)
- (21) **International Application Number:**
PCT/US2012/035537
- (22) **International Filing Date:**
27 April 2012 (27.04.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
201110110513.4 29 April 2011 (29.04.2011) CN
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(81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO,

[Continued on next page]

(54) **Title:** APPARATUS AND METHOD FOR REDUCING OUTER SHELLS OF METAL OR METAL COMPOSITION WIRES

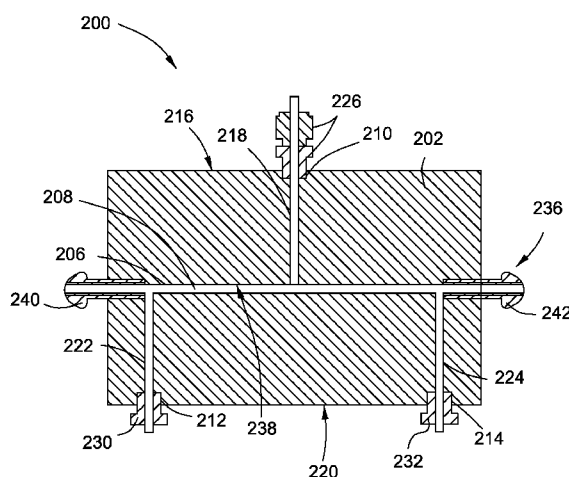


FIG. 2

(57) **Abstract:** An apparatus (200) for electrochemically reducing an outer shell of a metal or metal composition wire is provided. The apparatus (200) comprises a cathode member (202) which comprises a passageway (206) through the cathode member (202) having an opening (208) capable of passing a wire through, an electrolyte inlet (210) and an electrolyte outlet (212, 214) in fluid communication with the passageway (206). The apparatus further comprises a spacer member (236, 240) capable of maintaining an electrotype space between a wire passing through the apparatus and an inner surface of the passageway (206). An outer shell reduction system or method is also provided.



DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,

LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

Published:

- with international search report (Art. 21(3))

APPARATUS AND METHOD FOR REDUCING OUTER SHELLS OF METAL OR METAL COMPOSITION WIRES

BACKGROUND

[0001] The present invention relates generally to apparatus and methods for reducing outer shells of metal or metal composition wires, and, more specifically, to apparatus and methods for reducing outer shells of metal or metal composite wires based on electrochemical dissolution.

[0002] Metal and metal composite wires are commonly drawn or swaged to a given dimension in industrial operations. Under certain circumstances it is desirable to have a segment or portion of a given batch or wire section with a smaller outer shell after the wires are drawn or swaged. In some cases the change in dimension may only require altering the dimensions by a small amount, for example, reducing about 50 microns or less in compared to a starting of about 1mm. Therefore, a simple apparatus and method for precisely removing this small amount of material without incurring significant cost is desirable.

BRIEF DESCRIPTION

[0003] In one embodiment, the present invention provides an apparatus for electrochemically reducing an outer shell of a metal or metal composite wire. The apparatus comprises a cathode member which comprises a passageway through the cathode member having an opening capable of passing a wire through, an electrolyte inlet and an electrolyte outlet in fluid communication with the passageway. The apparatus further comprises a spacer member capable of maintaining an electrolyte space between a wire passing through the apparatus and an inner surface of the passageway.

[0004] In one embodiment, the present invention provides method for electrochemically reducing an outer shell of a metal or metal composite wire. The method comprises: passing the wire through a cathode member from a passageway

defined in the cathode member, while spacing the wire from an inner surface of the passageway; subjecting the space between the wire and inner surface of the passageway to an electrolyte fluid; applying an electric potential to the cathode member and the wire serving as an anode member to generate an electrical current between the anode and cathode members through the electrolyte fluid; and electrochemically reducing the outer shell of the wire.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The above and other aspects, features, and advantages of the present disclosure will become more apparent in light of the subsequent detailed description when taken in conjunction with the accompanying drawings in which:

[0006] FIG. 1 is a schematic front view of an exemplary apparatus for electrochemically reducing outer shells of metal or metal composite wires in accordance with one embodiment of the present disclosure.

[0007] FIG. 2 is a schematic section view showing an inside structure of the apparatus of FIG. 1.

[0008] FIG. 3 is a schematic diagram of a system for automatically reducing outer shells of metal or metal composite wires in accordance with one embodiment of the present disclosure.

[0009] FIG. 4 is a schematic diagram of a system for automatically reducing outer shells of metal or metal composite wires in accordance with one embodiment of the present disclosure.

[0010] FIG. 5 is a schematic diagram of a method for reducing outer shells of metal or metal composite wires in accordance with one embodiment of the present disclosure.

DETAILED DESCRIPTION

[0011] Embodiments of the present disclosure will be described hereinbelow with reference to the accompanying drawings. In the subsequent description, well-known functions or constructions are not described in detail to avoid obscuring the disclosure in unnecessary detail.

[0012] An aspect of the invention provides apparatus or systems for electrochemically reducing outer shells of metal or metal composite wires, for example, in order to thin down the wires. Referring to FIG. 1, an apparatus 200 for electrochemically reducing outer shells of metal or metal composite wires is provided. The apparatus 200 comprises a cathode member 202 that allows the passage of both a wire 204 and a fresh electrolyte fluid (not shown). In one embodiment, the cathode member 202 is a metal cell which can serve as a cathode when it is coupled to a power supply which is also coupled to a wire passing through the cell, as an anode, and used to generate a current between the wire and the cell through an electrolyte fluid there between.

[0013] Referring to FIG. 2, the cathode member 202 comprises a passageway 206 through the cathode member 202 and defining an opening 208 capable of passing a wire (not shown) through, an electrolyte inlet 210 and a pair of electrolyte outlets 212 and 214 in fluid communication with the passageway 206. In the illustrated embodiment, the passageway 206 extends through the cathode member 202 substantially along a horizontal direction. The electrolyte inlet 210 is defined from an upper surface 216 of the cathode member 202 and is connected to the passageway 206 through a substantially vertical channel 218 that joins the passageway 206 around a midpoint along a length of the passageway 206. The electrolyte outlets 212 and 214 are defined from a lower surface 220 of the cathode member 202 and are connected to the passageway 206 through substantially vertical channels 222 and 224 that join the passageway 206 around two longitudinal ends along a length of the passageway 206, respectively. The electrolyte inlet 210 can be coupled to an electrolyte fluid reservoir (not shown) via a coupling member 226. The electrolyte outlets 212 and 214 can be coupled to an electrolyte fluid draining device (not shown) via coupling members 230 and 232, respectively. The coupling member includes but not limited to one or more pipes, joints, nuts, bolts, screws or the likes.

[0014] The apparatus 200 further comprises a spacer member 236 capable of maintaining an electrolyte space between a wire passing through the cathode member 202 and an inner surface 238 of the passageway 206. The electrolyte space is a space within the passageway 206 and substantially surrounding a periphery surface of the wire passing through the cathode member 202 for receiving an electrolyte fluid used for electrochemically reducing the outer shell of the wire passing through the cathode member. In the illustrated embodiment, the spacer member 236 comprises a pair of non-conducting wire guides 240 and 242, each of which is disposed around an inlet and an outlet of the passageway 206 and defines a through-hole aligning with the opening 208 for the wire to pass through. The wire guides 240 and 242 may be made from elastic or deformable non-conducting materials, which are capable of adjusting their through-hole dimensions in response to small dimension changes of the wires passing therethrough, such as plastic, or other non-conducting materials, such as ceramic.

[0015] During operation, a wire (not shown) passes through the opening 208 of the passageway 206 while being spaced from the inner surface 238 of the passageway 206, and an electrolyte fluid (not shown) is introduced from the electrolyte inlet 210 into the electrolyte space between the wire passing through the passageway 206 and the inner surface 238 of the passageway 206. The electrolyte fluid passes through the electrolyte space and flows to the electrolyte outlets 212 and 214 where it exits from the cathode member 202. Once an electric potential is applied to the cathode member 202 and the wire serving as an anode member, an electrical current is generated between the cathode member 202 and the wire through the electrolyte fluid to electrochemically reduce an outer shell of the wire passing through the cathode member 202.

[0016] Without being limited to the illustrated structures, the passageways or channels for the wire and/or electrolyte fluid may be configured in such a way to allow the wire to pass through the cathode member and the electrolyte fluid to pass through the electrolyte space surrounding a periphery surface of the wire and, as such, implement outer shell reduction of the wire. For example, in one embodiment, the

electrolyte inlet and outlet may be disposed around the wire inlet and outlet, respectively, and connected by the wire passageway.

[0017] In use, additional devices may be coupled to the apparatus 200 to enhance operation facilities. For example, a housing may be used to house the apparatus, such that, once an electrolyte leakage from the cathode member 202 occurs, the leaked electrolyte fluid can be prevented from contaminating an exterior of the housing, and/or, a wire driver for driving the wire through the apparatus and a control system for controlling process parameters may be used, in order to enable an automatic continuous operation. Moreover, additional devices may be utilized to apply post treatments to the wire following the outer shell reduction. For example, devices for cleaning, anti-tranishing and/or drying the wire following outer shell reduction may be utilized.

[0018] Referring to FIG. 3, a system 400 for automatically reducing outer shells of the metal or metal composite wires is provided. The system 400 comprises a outer shell reduction device 402 similar to the apparatus 200, which is used for electrochemically reducing outer shells of wires passing therethrough, a power supply 404 for generating a current for the electrochemical outer shell reduction, an electrolyte fluid reservoir 406 for providing an electrolyte fluid to the outer shell reduction device 402, a wire driver 408 for driving the wire through the outer shell reduction device 402, and a control system 410 for controlling the outer shell reduction process. The system 400 further comprises a post treatment system 412 for applying treatments to the wire following the outer shell reduction.

[0019] In one embodiment, as illustrated in FIG. 4, a system 600 for automatically reducing outer shells of the metal or metal composite wires comprises an outer shell reduction device 602, a power supply 604, an electrolyte fluid reservoir 606, a wire driver 608, a control system 610 and a post treatment system 612. The wire driver 608 comprises a drag machine 616 for dragging the wire in front of the outer shell reduction device 602 and a payoff machine 618 for taking up the wire at back of the outer shell reduction device 602. The control system 610 comprises a first measurer 620 used for measuring a dimension of the wire before the outer shell

reduction, a second measurer 622 used for measuring a dimension of the wire after the outer shell reduction, and a parameter control device 624 used for controlling parameters of the outer shell reduction process in response to data fed back from the first and second measurers. The measurer may comprise a laser micrometer. The post treatment system 612 comprises a cleaning device 626 for cleaning the wire following the outer shell reduction, an anti-tarnish device 628 for applying anti-tarnish treatment to the wire following the cleaning and a dryer 630 for drying the wire following the anti-tarnish treatment. In a preferred embodiment, each of the outer shell reduction device 602, cleaning device 626, anti-tarnish device 628 and dryer 630 is disposed in a sump which is used to collect undesirable liquids and prevent the undesirable liquids from contaminating an exterior of the sump. Each of the sumps defines openings for the wire to pass through. The sumps containing the electrochemical reduction device 602, the cleaning device 626, the anti-tarnish device 628 and the dryer 630, respectively, are together disposed in a containment pan 636. The sumps and the apparatus and devices therein are mounted in a manner to allow the wire to pass through them in a substantially straight direction.

[0020] In certain embodiments, for example, a wire may be dragged by the drag machine 616 and successively pass through the electrochemical reduction device 602, the cleaning device 626, the anti-tarnish device 628 and the dryer 630. The first measurer 620 may measure a wire dimension before the wire enter the sump containing the electrochemical reduction device 602, the second measurer 622 may measure a wire dimension after the wire exits the sump containing the dryer 630, and the measured change in dimension may be fed back to the parameter control device 624 to control the outer shell reduction process takes place in the electrochemical reduction device 602. Based on the reductions in wire dimension, one or more of the process parameters, including but not limited to, spacing between the wire and inner surface of the passageway, applied potential, wire speeds, and electrolyte compositions and fluid velocities, may be adjusted.

[0021] Another aspect of the invention provides methods for reducing outer shells of metal or metal composite wires, for example, in order to thin down the wires,

based on electrochemical dissolution. Referring to FIG. 5, a method 800 for reducing an outer shell of a metal or metal composite wire is provided.

[0022] In a first step 802 of the method 800, a metal or metal composite wire is reduced in dimension based on electrochemical dissolution. In one embodiment, the step 802 comprises: passing the wire through a cathode member from a passageway defined in the cathode member, while spacing the wire from an inner surface of the passageway; subjecting the space between the wire and inner surface of the passageway to an electrolyte fluid; applying an electric potential to the cathode member and the wire which serves as an anode member, to generate an electrical current between the anode and cathode members through the electrolyte fluid; and electrochemically reducing the outer shell of the wire.

[0023] For example, in one embodiment, a wire may pass through the cathode member at a speed ranging from 0 to 12 cm/s while being spaced from the inner surface of the passageway. That is to say, the wire may be substantially stagnant or may pass through the cathode member at a speed approximately of 12 cm/s or less, and preferably at a speed ranging from 1 to 12 cm/s. The wires may be spaced approximately 1mm or less from the inner surface of the passageway. The electrolyte fluid may have a velocity ranging from 0 to 12 cm/s. That is to say, the electrolyte fluid may be substantially stagnant or may pass through the space between the wire and the inner surface of the passageway at a fluid velocity approximately of 12 cm/s or less, and preferably at a fluid velocity ranging from 1 to 12 cm/s. The applied potential may be ranging from 0.001 to 20 V, preferably from 0.001 to 5 V.

[0024] The outer shell reduction apparatus, systems or methods described herein can be applied to reduce outer shells of any suitable metal or metal composite wires, without being limited in their detail compositions, shapes and/or dimensions. For example, the apparatus, systems or methods may be adapted to handle both circular wires and non-circular (such as ovals, squares, rectangles, or octagons) wires, or both solid and hollow wires. For example, the apparatus, systems or methods may be adapted to handle wires, which have a diameter or an equivalent diameter as large as 1 meter, or preferably as large as 0.5 meter, wherein equivalent diameter used

herein refers to a diameter of the circumscribe circle of the non-circular wire cross section. Different electrolyte fluids may be used in response to different types of wires. For example, suitable electrolyte types include but not limited to salt based electrolytes, acids, or bases.

[0025] Usually, the wire after electrochemically outer shell reduction may be applied with additional treatments. In a second step 804 of the method the wire, after electrochemically outer shell reduction, is cleaned. In a third step 806 of the method, the cleaned wire is applied with anti-tarnish treatment. In a fourth step 808 of the method, the anti-tarnished wire is dried.

[0026] Example

[0027] A 1.13 mm outer diameter copper wire was passed through a copper cell from a passageway defined in the cell at a speed about 2 cm/s, while the wire was spaced 1mm from an inner surface of the passageway, and the space between the wire and the inner surface of the passageway was subjected to an electrolyte solution of 10wt% sodium nitrate (NaNO_3) and deionized water at a fluid velocity of about 12 cm/s. A potential of 4 volts was applied to the cell and the wire passing through the cell, which served as cathode and anode respectively, to generate an electrical current between the cell and the wire through the electrolyte solution.

[0028] The wire exited the cell entered a wire cleaning device and was cleaned by a mild acid copper cleaning solution under a temperature approximately 130 °C. The cleaned wire then entered an anti-tarnish device which contained a sulfur based anti-tarnish solution and was set at a temperature approximately 95 °C for an anti-tarnish treatment in order to protect the wire from oxidation. The anti-tarnished wire was dried. The dried wire had an outer diameter of about 0.82 mm.

[0029] The outer shell reduction apparatus/systems or methods described herein are capable of precisely removing a small amount of material without incurring significant cost, and allow drawn or swaged wires to be further reduced in dimensions to produce desired wire dimensions. It is particularly useful when an outer shell of a wire is needed in its drawing process but is useless in its applications. Moreover, as to

a wire reduced in dimension by said process, an additional process is possible, i.e., reversing the polarity of the applied potential and carefully selecting an appropriate electrolyte would allow deposition processes on the wire to increase the dimension.

[0030] While the disclosure has been illustrated and described in typical embodiments, it is not intended to be limited to the details shown, since various modifications and substitutions can be made without departing in any way from the spirit of the present disclosure. As such, further modifications and equivalents of the disclosure herein disclosed may occur to persons skilled in the art using no more than routine experimentation, and all such modifications and equivalents are believed to be within the spirit and scope of the disclosure as defined by the subsequent claims.

WHAT IS CLAIMED IS:

1. An apparatus for electrochemically reducing an outer shell of a metal or metal composite wire, comprising:

a cathode member comprising:

a passageway through the cathode member having an opening capable of passing a wire through;

an electrolyte inlet;

an electrolyte outlet; and

wherein the electrolyte inlet and the electrolyte outlet are in fluid communication with the passageway ; and

a spacer member capable of maintaining an electrottype space between a wire passing through the apparatus and an inner surface of the passageway.

2. The apparatus of claim 1, wherein the cathode member is a metal cell.

3. The apparatus of claim 1, wherein the spacer member comprises a pair of non-conducting wire guides, wherein each wire guide is disposed around an inlet and an outlet of the passageway.

4. The apparatus of claim 1 further comprising a power supply coupled to the cathode member; and wherein the power supply is capable of generating a current when also coupled to a wire passing through the cathode member.

5. The apparatus of claim 1, further comprising a wire driver for driving the wire through the cathode member.

6. The apparatus of claim 5, wherein the wire driver comprises a drag machine for dragging the wire in front of the cathode member and a payoff machine for taking up the wire at back of the cathode member.

7. The apparatus of claim 1, further comprising an electrolyte fluid reservoir coupled to the electrolyte inlet, said reservoir capable of transferring an electrolyte fluid into the electrotype space.

8. The apparatus of claim 1, further comprising a control system for controlling the outer shell reduction process taking place in the apparatus.

9. The apparatus of claim 8, wherein the control system comprises a first measurer for measuring a dimension of the wire before the wire enters the cathode member, a second measurer for measuring a dimension of the wire after the wire exits the cathode member, and a parameter control device for controlling parameters of the apparatus based on data fed back from the first and second measurers.

10. A system comprising the apparatus of claim 1, further comprising a cleaning device for cleaning the wire that exits the apparatus, an anti-tarnish device for applying anti-tarnish treatment to the cleaned wire and a dryer for drying the anti-tarnish treated wire.

11. The system of claim 10, wherein each of the apparatus, the cleaning device, anti-tarnish device and dryer is disposed in a sump.

12. The system of claim 11, wherein the sumps containing the apparatus, the cleaning device, the anti-tarnish device and the dryer, respectively, are disposed in a containment pan.

13. A method for electrochemically reducing an outer shell of a metal or metal composite wire, comprising:

passing the wire through an cathode member from a passageway defined in the cathode member, while spacing the wire from an inner surface of the passageway;

subjecting the space between the wire and inner surface of the passageway to an electrolyte fluid;

applying an electric potential to the cathode member and the wire serving as anode member to generate an electrical current between the anode and cathode members through the electrolyte fluid; and

electrochemically reducing the outer shell of the wire.

14. The method of claim 13, wherein the wire is spaced no more than 1mm from the inner surface of the passageway.

15. The method of claim 13, wherein the wire passes through the cathode member at a speed ranging from about 0 to 12 cm/s.

16. The method of claim 13, wherein the electrotype fluid is a solution of sodium nitrate and deionized water.

17. The method of claim 13, wherein the electrotype fluid in the space between the wire and inner surface of the passageway has a fluid velocity ranging from about 0 to 12 cm/s.

18. The method of claim 13, wherein the applied potential is ranging from about 0.001 to 20 V.

19. The method of claim 13, further comprising: successively cleaning the wire, applying anti-tarnish treatment to the wire and drying the wire after the wire exits the cathode member.

20. The method of claim 13, further comprising measuring reductions in dimension of wire, and adjusting one or more of process parameters, said parameters comprising, spacing between the wire and inner surface of the

passageway, applied potential, wire passing speeds, and electrotype compositions and fluid velocities.

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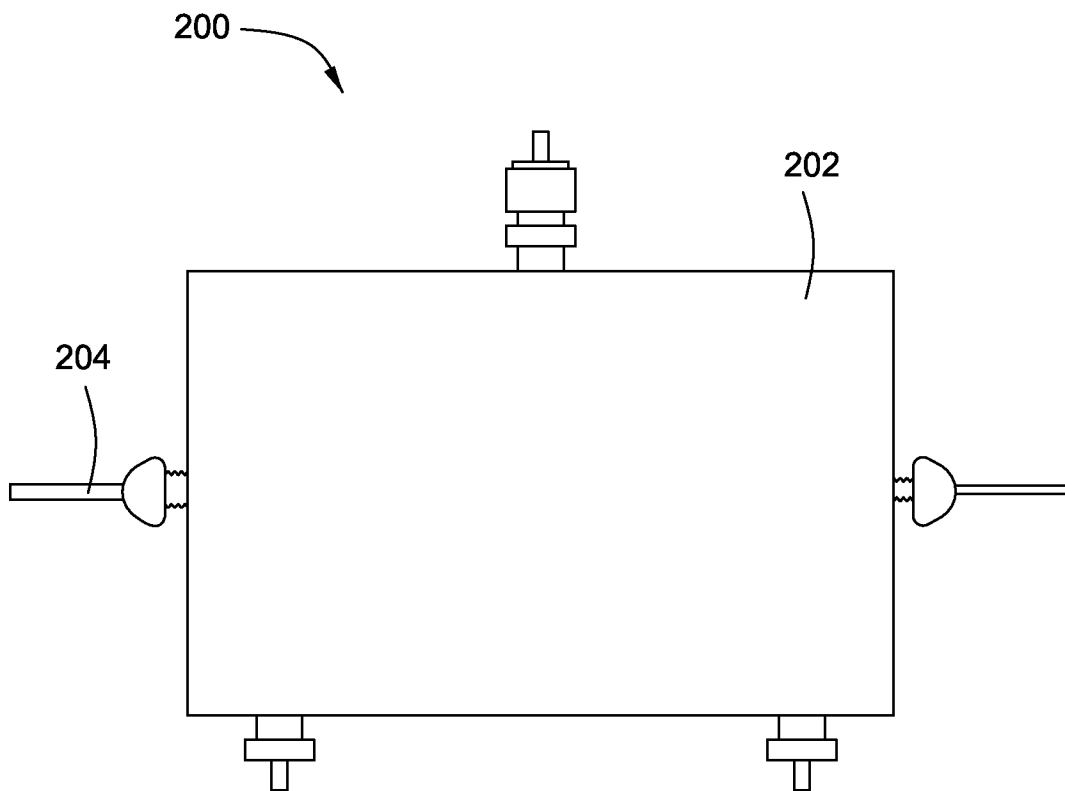


FIG. 1

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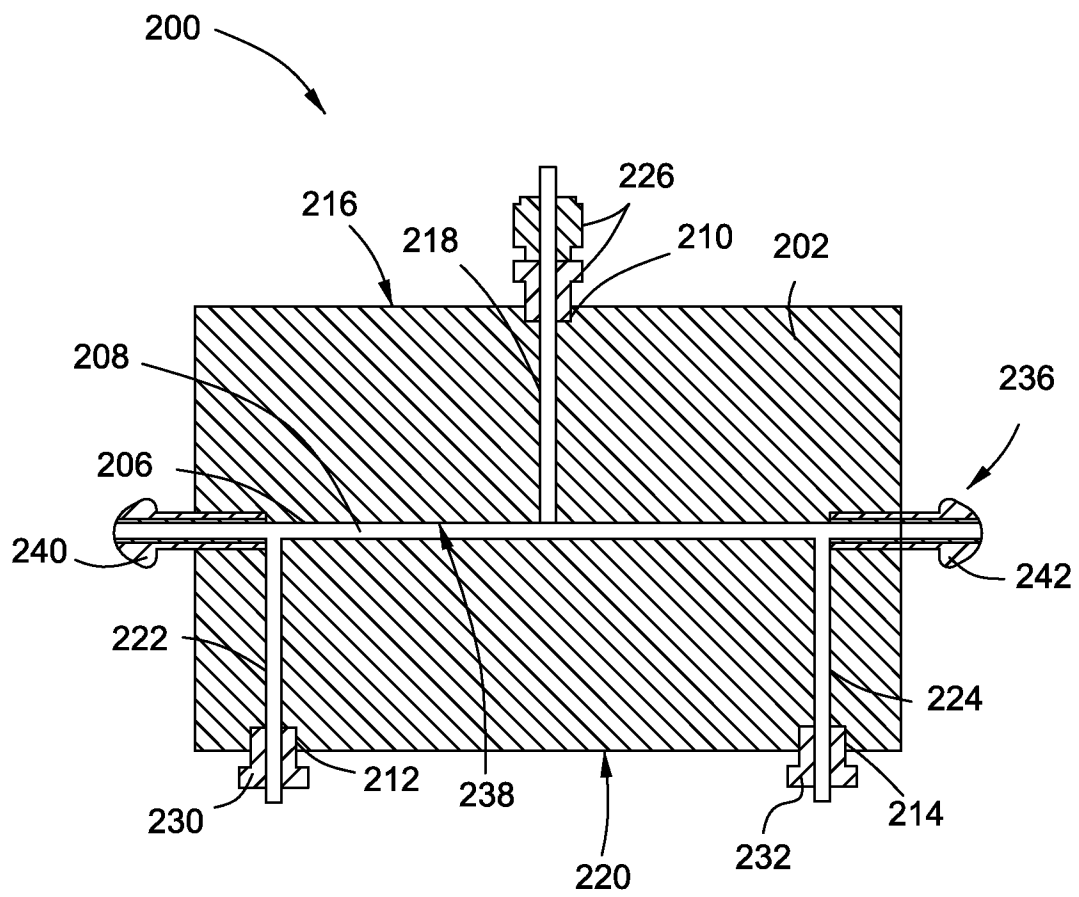


FIG. 2

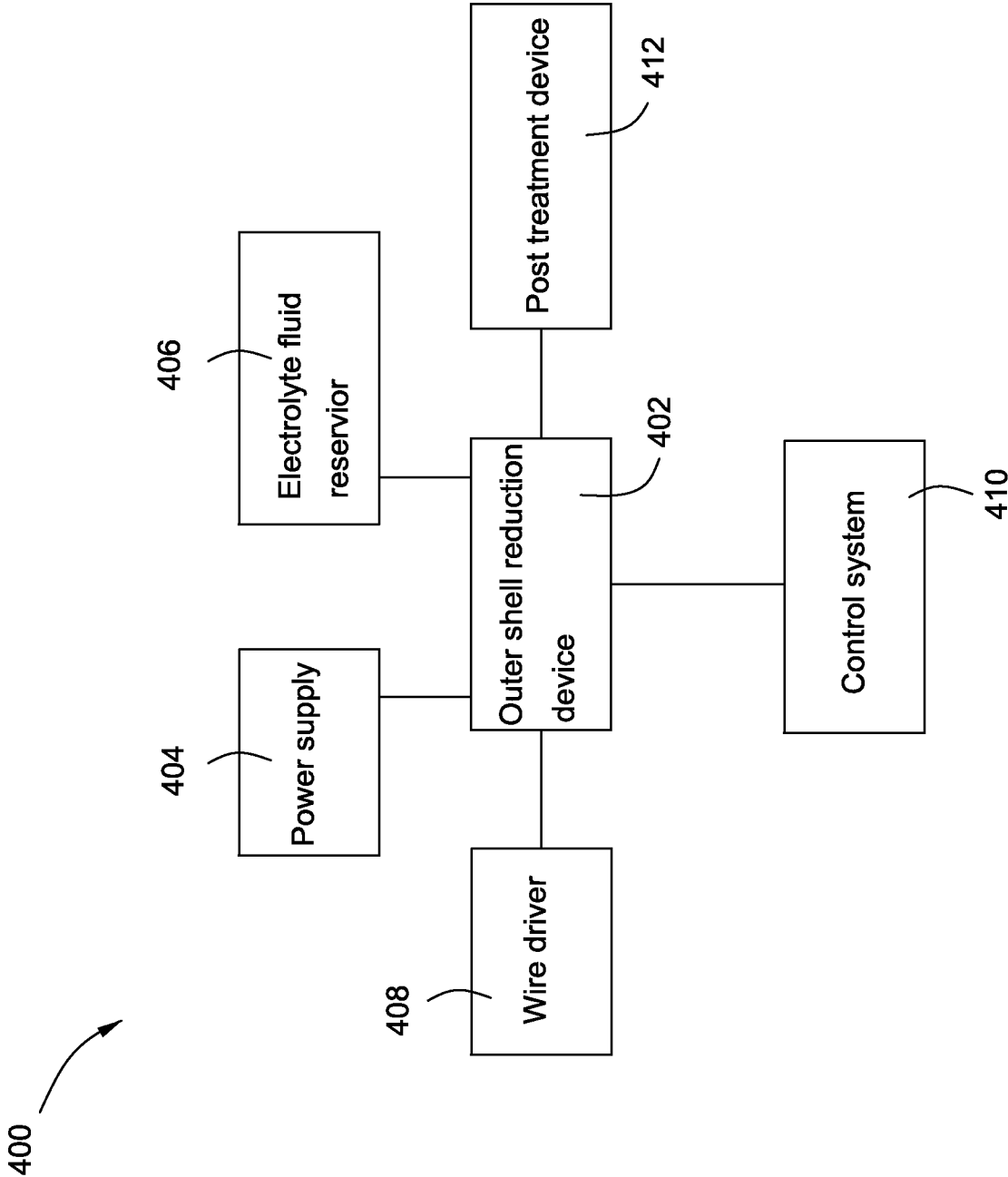


FIG. 3

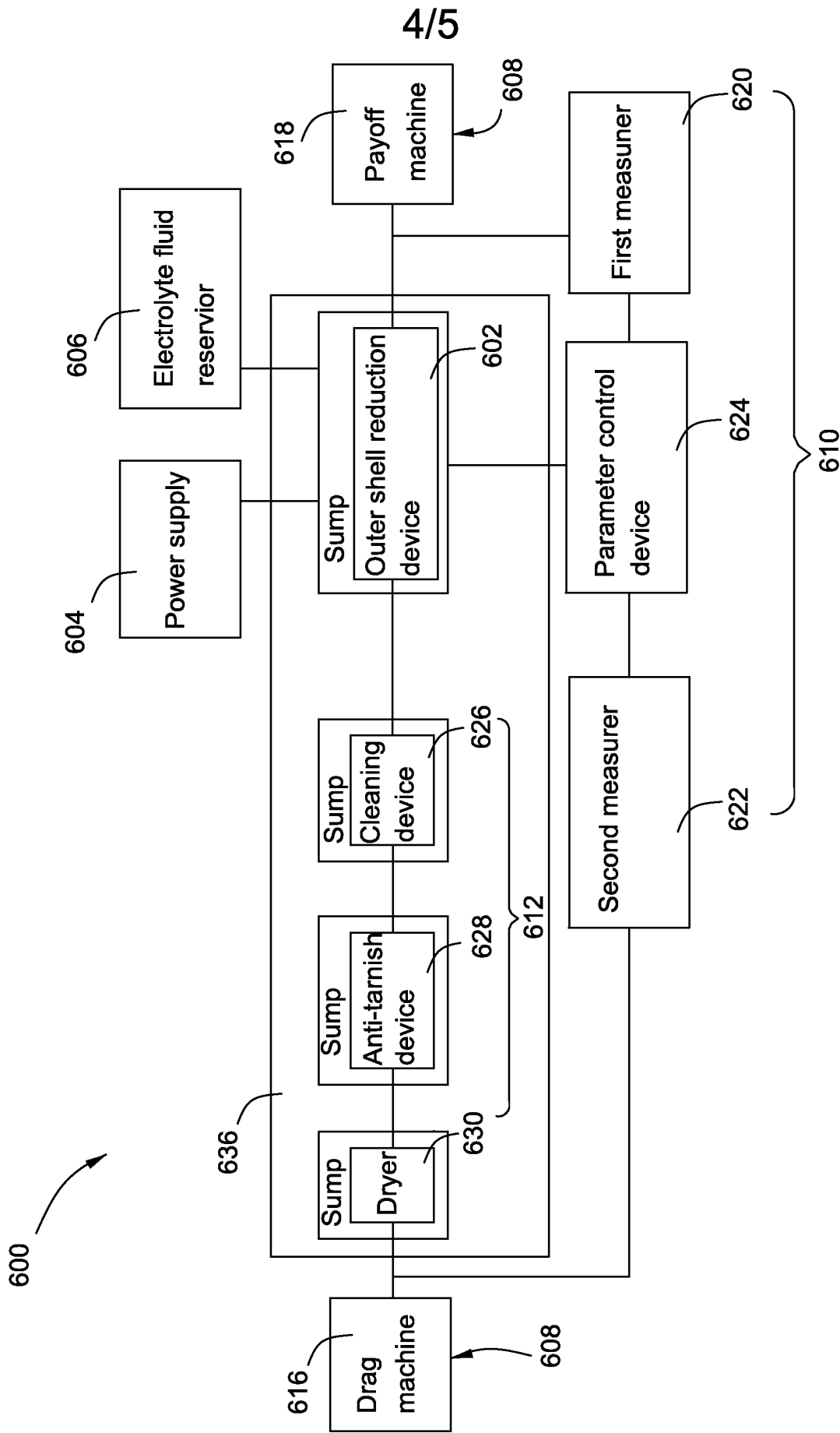


FIG. 4

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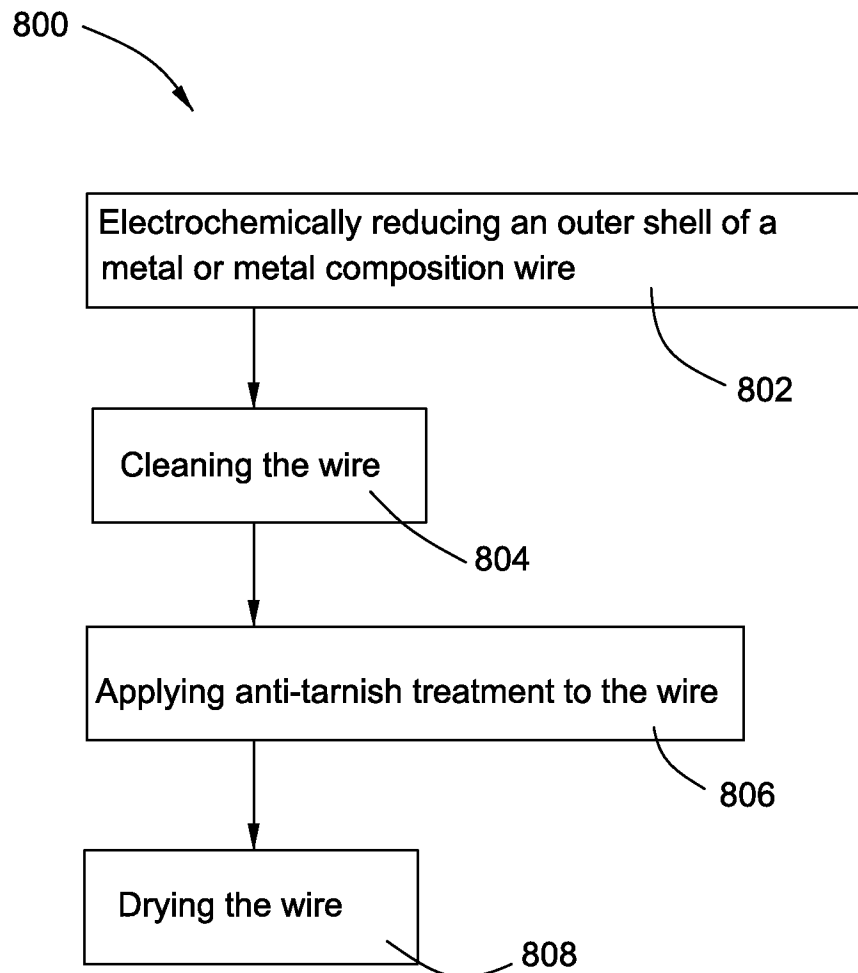


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/035537

A. CLASSIFICATION OF SUBJECT MATTER

INV. B23H9/00 C25F7/00 B23H3/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B23H C25F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 6 007 694 A (WALSH DAVE [US] ET AL) 28 December 1999 (1999-12-28) figure 1	1,2,4-9, 13-16,20
X	US 5 176 803 A (BARBUTO ANTHONY [US] ET AL) 5 January 1993 (1993-01-05) abstract	1,13
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

17 July 2012

Date of mailing of the international search report

25/07/2012

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2012/035537

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	EP 0 520 073 A1 (FURUKAWA ELECTRIC CO LTD [JP]) 30 December 1992 (1992-12-30) page 3, lines 18-24; figure 6 page 5, line 53 claims 6,7 -----	1,13
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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