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(54) **ELECTROPLATING SHIELD DEVICE**

(57) An electroplating shield device, methods of fabricating the same, and methods of electroplating with the electroplating shield device are disclosed herein. The method of electroplating includes positioning an object in an electroplating shield device. The electroplating shield device may include a conduit configured to receive the object and a plurality of openings selectively extended between inner and outer surfaces of the conduit. The openings may be positioned between first and second ends of the conduit. The method may also include forming a layer on the object by transferring fluid through the plurality of openings to at least one of a first continuous section of the object comprising a minor of the object and a second continuous section of the object comprising a major of the object. A ratio of a thickness of the major to the minor after forming the layer may range from approximately 1: 1 to approximately 1:18.

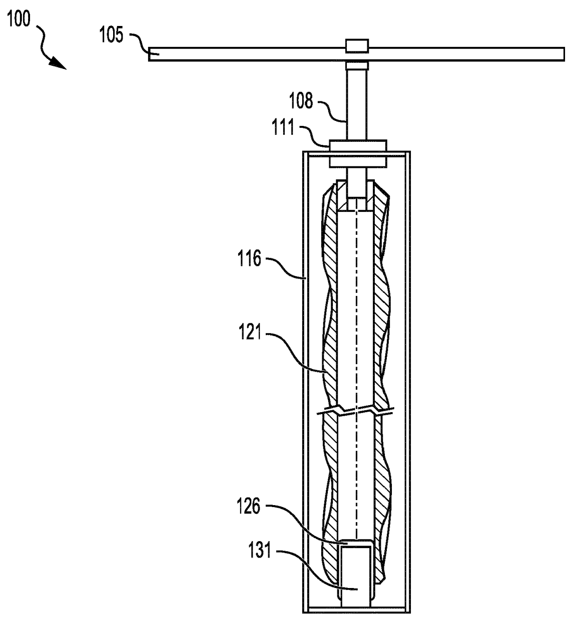

FIG. 1A

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Description

TECHNICAL FIELD

[0001] Various embodiments of the present disclosure relate generally to the field of electroplating and, more particularly, to an electroplating shield device and methods of fabricating the same.

BACKGROUND

[0002] Machinery parts are typically electroplated in electroplating solution baths or chambers. Electroplating large machinery parts requires a relatively large spacing (e.g., greater than 4 inches) between the electroplating electrode(s) and the large machinery parts. As such, high volumes of electroplating solutions are required for electroplating large machinery parts. Further, machinery parts with irregular shapes often cause variations in thickness among electroplate coating layers in various areas of the machinery parts (i.e., layers that are coated over various areas of the machinery part via electroplating). Such variations in thickness among electroplate coating layers may result in reduced wear and corrosion resistance.

[0003] Existing methods of reducing variations in thickness among electroplate coating layers include conducting multiple round plating operations (e.g., 2-3 plating operations) to increase thickness in deficient regions with a thinner coating layer. Such methods may involve the removal of excess coating and/or nodules in regions where the coating is thicker after an initial electroplating operation, followed by subsequent plating. Carrying out these methods may require the machinery parts to be removed from the electroplating bath or chamber and then added back for further processing, leading to increased production time and cost. Thus, there is a need for an efficient and cost effective solution to electroplate machinery parts in any shape and/or size with a uniform electroplate coating thickness.

[0004] The present disclosure is directed to overcoming one or more of these challenges. The background description provided herein is for the purpose of generally presenting the context of the disclosure. Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted to be prior art, or suggestions of the prior art, by inclusion in this section.

SUMMARY OF THE DISCLOSURE

[0005] According to certain aspects of the disclosure, an electroplating shield device, methods of fabricating the same for improving electroplating processes, and methods of electroplating with the electroplating shield device are provided in this disclosure.

[0006] In one embodiment, a method of electroplating a part is disclosed. The method may comprise positioning an object in an electroplating shield device. The electroplating shield device may comprise a conduit configured to receive the object and a plurality of openings selectively extended between inner and outer surfaces of the conduit. The openings may be positioned between first and second ends of the conduit. The method may also comprise forming a layer on the object by transferring fluid through the plurality of openings to at least one of a first continuous section of the object comprising a minor of the object and a second continuous section of the object comprising a major of the object. A ratio of a thickness of the major to the minor after forming the layer may range from approximately 1:1 to approximately 1:18.

[0007] In another embodiment, an electroplating shield device is disclosed. The electroplating shield device may comprise a conduit extending from a first end to a second end. The conduit may be hollow and configured to receive an object for electroplating. A plurality of openings may be selectively extended between inner and outer surfaces. The openings may be positioned between the first and second ends of the conduit. The plurality of openings may be configured to transfer fluid to at least one of a first continuous section of the object and a second continuous section of the object.

[0008] In another embodiment, a method of fabricating an electroplating shield device is disclosed. The method may comprise forming a plurality of openings on a strip and forming a conduit with the strip. The conduit may be configured to receive an object for electroplating. The plurality of openings may be configured to transfer fluid to at least one of a first continuous section of the object comprising a minor of the object and a second continuous section of the object comprising a major of the object in a major-to-minor plating ratio ranging from approximately 1:1 to approximately 1:18.

[0009] Additional objects and advantages of the disclosed embodiments will be set forth in part in the description that follows, and in part will be apparent from the description, or may be learned by practice of the disclosed embodiments. The objects and advantages of the disclosed embodiments will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims. As will be apparent from the embodiments below, an advantage to the disclosed devices, systems and methods is that machinery parts may be electroplated more efficiently while being wear and corrosion resistant with the electroplating shield device.

[0010] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the disclosed embodiments, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate various exemplary embodiments and together with the description, serve to explain the principles of the disclosed embodiments.

FIG. 1A depicts a side cross-sectional view of an example electroplating system, according to one or more aspects of the present disclosure.
FIG. 1B depicts a close-up perspective view of an exemplary cap used in the system of FIG. 1A.
FIG. 1C depicts a top plan view of the electroplating system of FIG. 1A, according to one or more aspects of the present disclosure.
FIG. 2A depicts an upper perspective view of aspects of the example electroplating system of FIG. 1A.
FIG. 2B depicts a partially exploded upper perspective view of aspects of the example electroplating system of FIG. 1A.
FIG. 3A depicts an example electroplating shield device, according to one or more aspect of the present disclosure.
FIG. 3B depicts an example electroplating shield device, according to one or more aspect of the present disclosure.
FIG. 4A depicts an example part processed using an example electroplating shield device in an example electroplating chamber of the electroplating system of FIG. 1A, according to one or more aspect of the present disclosure.
FIG. 4B depicts an exemplary top plan cross-sectional view of the part processed in the example of FIG. 4A, according to one or more aspect of the present disclosure.
FIG. 5A depicts a close-up of an upper portion of the example part shown in FIG. 4A, according to one or more aspect of the present disclosure.
FIG. 5B depicts a close-up of a middle portion of the example part shown in FIG. 4A, according to one or more aspect of the present disclosure.
FIG. 5C depicts a close-up of a lower portion of the example part shown in FIG. 4A, according to one or more aspect of the present disclosure.
FIG. 6 is a table summarizing example plating measurements, according to one or more aspect of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0012] The following embodiments describe an electroplating shield device and methods of using the electroplating shield device for improving electroplating processes, in accordance with one or more aspects of the present disclosure.

[0013] As described above, there is a need in the electroplating technology field to efficiently and uniformly electroplate, for example, machinery parts. For example, electroplating a large machinery part (e.g., a mud motor rotor) having irregular shapes may require at least 4 inches of space between a surface of the large machinery part and one or more electroplating electrodes (e.g., anode electrode(s)). That is, a relatively large electrode spacing may be required in order to produce a suitable electroplate coating layer on the large machinery part. However, such electrode spacing generally requires a large volume of electroplating solution, especially for large machinery parts (e.g., a mud motor rotor) that could extend beyond 30 feet. Minimizing the electrode spacing, in an attempt to reduce the amount of electroplating solution, may result in uneven electroplate coating layers formed on various areas of the large machinery part. Accordingly, the following embodiments describe an electroplating shield device that facilitates application of uniform electroplate coating layers on objects, such as machinery parts of any shape and/or size.

[0014] According to certain aspects of the present disclosure, the electroplating shield device may include a plurality of openings on a sidewall of the electroplating shield device. The plurality of openings may be arranged to align with particular areas of a machinery part. For example, the plurality of openings may be aligned with the minor regions (e.g., concave surfaces of a mud motor rotor) of the machinery part and/or the major regions (e.g., convex surfaces of a mud motor rotor) of the machinery part. The size and/or shape (e.g., rectangular though other shapes such as triangular, circular, elliptical, or any other polygon, etc.) of the openings may vary and/or be the same throughout. For example and without limitation, the openings may have a diameter of less than about 2 inch, e.g., less than about 1 inch, less than about 0.75 inch, or less than about 0.5 inch. The electric field applied between the machinery part and the electroplating electrode may vary based on the size of each of the plurality of openings. Additionally, the rate of flow of the electroplating solution through the plurality of openings may also vary. Thus, the amount and/or thickness of electroplate coating layers on the major regions and the minor regions of the machinery part may be controlled and/or be applied as desired. Accordingly, a uniform electroplate coating layer may be achieved on machinery parts with any shape and/or size by utilizing the electroplating shield device of the present disclosure.

[0015] The subject matter of the present description will now be described more fully hereinafter with reference to the accompanying drawings, which form a part thereof, and which show, by way of illustration, specific exemplary embodiments. An embodiment or implementation described herein as "exemplary" is not to be construed as preferred or advantageous, for example, over other embodiments or implementations; rather, it is intended to reflect or indicate that the embodiment(s) is/are "example" embodiment(s). Subject matter can be embodied in a variety of different forms and, therefore, covered or claimed subject matter is intended to be construed as not being limited to any exemplary embodiments set forth herein; exemplary embodiments are provided merely to be illustrative. Likewise, a reasonably broad scope for claimed or covered subject matter is intended. Among other things, for example, subject matter may be embodied as methods, devices, components, or systems. Accordingly, embodiments may, for example, take the form of hardware, software, firmware, or any combination thereof (other than software per se). The following detailed description is, therefore, not intended to be taken in a limiting sense.

[0016] Throughout the specification and claims, terms may have nuanced meanings suggested or implied in context beyond an explicitly stated meaning. Likewise, the phrase "in one embodiment" as used herein does not necessarily refer to the same embodiment and the phrase "in another embodiment" as used herein does not necessarily refer to a different embodiment. It is intended, for example, that claimed subject matter include combinations of exemplary embodiments in whole or in part.

[0017] The terminology used below may be interpreted in its broadest reasonable manner, even though it is being used in conjunction with a detailed description of certain specific examples of the present disclosure. Indeed, certain terms may even be emphasized below; however, any terminology intended to be interpreted in any restricted manner will be overtly and specifically defined as such in this Detailed Description section. Both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the features, as claimed.

[0018] In this disclosure, the term "based on" means "based at least in part on." The singular forms "a," "an," and "the" include plural referents unless the context dictates otherwise. The term "exemplary" is used in the sense of "example" rather than "ideal." The term "or" is meant to be inclusive and means either, any, several, or all of the listed items. The terms "comprises," "comprising," "includes," "including," or other variations thereof, are intended to cover a non-exclusive inclusion such that a process, method, or product that comprises a list of elements does not necessarily include only those elements, but may include other elements not expressly listed or inherent to such a process, method, article, or apparatus. Relative terms, such as, "substantially" and "generally," are used to indicate a possible variation of $\pm 10\%$ of a stated or understood value.

[0019] Referring now to the appended drawings, FIG. 1A depicts a side cross-sectional view of an example electroplating system 100 including a fixture 105 from which a resilient member 108 (e.g., a spring) can extend and mechanically attach a compressible disk 111 via one or more fastening mechanisms, as discussed more particularly below in Figs. 2A to 2B. FIG. 1B depicts a close-up perspective view of an exemplary cap 126 used to secure a distal end 131 of an electroplating shield device 116 with system 100 of FIG. 1A. Cap 126 can be formed of silicon with a hemispherical dome section 126a and a cylindrical section 126b proximal thereof. Portions 126a and 126b can be continuous (e.g., integrally formed) with each other or be two separate attached portions. FIG. 1C depicts a top plan cross-sectional view of aspects of system 100 while FIG. 2A depicts an upper perspective view of system 100 and FIG. 2B depicts a partially exploded upper perspective view of system 100.

[0020] As shown in FIG. 1C, system 100 may include an electroplating chamber 158 which can be an open electroplating chamber (or bath) or an enclosed electroplating chamber that is configured to receive and store device 116 and one or more parts 121 (e.g., a shaft, rod, beam, cylinder, bar, etc.). Chamber 158 can contain one or more electroplating solutions to be positioned around device 116 and part 121. System 100 can include, one or more anode electrodes 162. While system 100 in Fig. 1C depicts only one or more anode electrodes 162, it is contemplated that one or more cathode electrodes can also be incorporated by system 100 as needed or required. One or more anode electrodes 162 can apply electric current and electric fields in chamber 158 to facilitate the application of electroplating coating layers on part 121.

[0021] Chamber 158 can be configured to receive and store part 121 and device 116. A length of chamber 158 can be greater than part 121 and device 116. The electroplating chamber 158 may be greater than 20 feet, for example, to receive and store large machinery parts (e.g., a rotor of positive-displacement motors, progressive cavity pumps, etc.). Chamber 158 can also be any length suitable for various other applications. Chamber 158 may be configured to receive the one or more electroplating solutions S (e.g., from a reservoir system via one or more conduits not shown in the figures) to facilitate the electroplating process.

[0022] Additionally, the electroplating chamber 158 may be connected a controller system, which can automatically or manually facilitate the electroplating processes by providing the electroplating solutions S and electric current to the electroplating chamber 158 via pumps, actuators, electrodes, and/or valves that are coupled to the electroplating chamber 158 and the reservoir system.

[0023] Part 121 can be greater than 30 feet, for example, and as shown in Fig. 1C, can include major regions E and minor regions F. Major regions E may include one or more protruding, spiral-shaped lobes (or convex surface) that vertically extend from one end to the opposite end of part 121. Minor regions F may include spiral-shaped depressions (or concave surface) that vertically extend from one end to the opposite end of part 121. Minor regions F may be arranged adjacent to and in between major regions E. In other words, the continuous, spiral-shaped depressions of minor regions F may be arranged adjacent to and alternately in between the continuous, spiral-shaped lobes of major regions E.

[0024] In one embodiment, part 121 may be placed into the electroplating chamber 158, and device 116 may be placed in between the part 121 and the anode electrode 162. In this embodiment, the length of device 116 may be equal to or greater than the length of the part 121, so as to arrange or place the entire piece of part 121 within device 116. Device 116 can be arranged or placed relative to the part 121, so as to align one or more portions (e.g., upper portion, middle portion, lower portion, etc) of device 116 with minor regions F and/or major regions E of part 121. During an electroplating process, electroplating solutions S can flow through openings (e.g., 143 of FIGs. 3A and 3B). Further, the same and/or varying electric field may be applied to minor regions F and major regions E (e.g., greater at minor regions F than major regions E, or vice versa). Accordingly, despite minor regions F of the part 121 being located at a greater distance from anode electrode 162 than major regions E, an electroplate coating layer may be deposited on both minor regions F and major regions E with a post-plating thickness that is larger in minor regions F than in major regions E, as explained more particularly in the example of FIG. 6.

[0025] The size of each, and the density the openings of device 116 can vary depending on the shape, size, and/or dimensions of the part 121. Further, the size of each, and the density of the openings, can vary based on the distance between the anode electrode 162 and the surfaces of different regions (e.g., major regions E and minor regions F) of the part 121. In one embodiment, the electrode spacing between the anode electrode 162 and the part 121 may be 1 inch or less.

[0026] As shown in FIGs. 2A and 2B, resilient member 108 can be mechanically connected to disk 111 via one or more fastening mechanisms. For example, a proximal end of part 121 can include one or more threaded surfaces to threadingly engage with a corresponding fastener (e.g., a nut), which can couple disk 111 thereto. Any number of mechanical fastening approaches are contemplated and the example depicted in FIGs. 2A and 2B are but one example implementation of securing electroplating shield device 116 and part 121 with an electroplating system. Electroplating shield device 116 can include an inner ring 116c having an opening 116d configured to receive disk 111 (e.g., in a friction fit). One or more spokes 116a can extend outwardly from ring 116c to outer surface 116b of electroplating shield device 116. In some aspects, spokes 116a can be thicker than surface 116b. Electroplating solution can flow through areas between spokes 116a and surface 116b.

[0027] FIG. 3A depicts a side plan view of device 116 while FIG. 3B depicts a side plan view of device 116 after an example plating process where material 153 has collected or otherwise build-up about portions 147 and openings 143. In one embodiment, device 116 may include a cylindrical tube and/or a conduit that can be hollow and substantially elongated. Device 116 can extend vertically from a proximal end 216 to a distal end 214. Device 116 may also include a plurality of openings 143 (e.g., apertures, holes, slots, slits, ovals, perforations, etc.) that penetrate through the sidewall of device 116. The openings 143 may have a diameter of less than about 2 inch, e.g., less than about 1 inch, less than about 0.75 inch, or less than about 0.5 inch. Openings 143 may be selectively extended and/or arranged on the sidewall in a continuous, spiral-shaped (or helical) surface that extends vertically between ends 216 and 214. In one embodiment, the size of each of openings 143 may be equal. However, the shape and size of each of openings 143, individually or in groups, may vary based on the shape and dimensions of one or more parts or work pieces (e.g., a shaft, rod, beam, cylinder, bar, etc.) being electroplated.

[0028] In certain examples, where part 121 is a rotor, the size of each opening may depend on the rotor diameter and the number of lobes on the rotor. For example, openings 143 in the shield may be sized at 0.5 inch for 2 inch and 4 inch diameter rotors with 5 lobes. The diameter of the opening(s) may be increased for a rotor with a larger diameter. As such, openings 143 in the shield may be sized between 1 and 2 inches for an 8 inch diameter rotor with 5 lobes. In some examples, the size of the openings 143 may vary based on the distance between the shield and part 121 (e.g., rotor).

[0029] Ends 216 and 214 may be "zones" that include a continuous, cylindrical surface between the respective end and beginning of openings 143 (e.g., a non-perforated zone). In some embodiments, proximal and distal ends 216 and 214 of the part 121 may experience a higher electroplating rate compared to the rest of the part 121. For example, a predetermined vertical length at each end of the part 121 may gain a thicker growth of electroplate coating layer compared to the rest of the part 121. Further, device 116 may be arranged or placed within an electroplating chamber (e.g., the electroplating chamber 158) in the manner to cover at least about ends 214 and 216 of the part 121. Accordingly, a uniform electroplate coating layer may be formed on the part 121 by utilizing the electroplating shield device 116, in accordance with one or more aspects of the present disclosure.

[0030] In one embodiment, portions 147 of device 116 that form its sidewall around openings 143 can be made from a material including, for example, nickel-chromium alloys (e.g., ICONEL alloys, a registered trademark of Special Metals Corporation, mp 1390° C to 1425° C) or any other suitable stainless steels, high strength steels with high nickel content, and/or any other metal substrates with high nickel content having a melting point in excess of about 800°C materials that have a linear coefficient of thermal expansion (CTE) value substantially similar to ICONEL alloys. In at least one embodiment, the material used to form the sidewall around openings 143 may include iron alloys (e.g., iron-cobalt alloys, iron-nickel alloys, iron-tungsten alloys, and iron-chromium alloys etc.) and cobalt alloys (e.g., cobalt-chromium alloys). In some aspects, device 116 may or may not be conformal to part 121 and may or may not have though holes for targeted plating. Once the shape of part 121 has been determined, device 116 can receive a chemical resistant coating for longevity and to prevent buildup.

[0031] Such a thin and lightweight construction for device 116, as shown specifically with surface 116b of FIGs. 2A to 2B, improves mobility and efficiency during electroplating processes, especially for electroplating large machinery parts (e.g., length greater than 20 feet) such as mud motor rotors. Further, the thin sidewall of device 116 may displace less electroplating solution, promote efficient electroplating solution movement, and may allow tighter electrode spacing, for example, in relatively smaller, enclosed electroplating chambers, especially when compared to prior chrome plating approaches which often require many start and stop cycles to ensure coating growth is even. By use of the inductive shielding of device 116, plating can be targeted to specific slow growth areas without added rectifier cost. At the same time in some aspects, device 116 acts like a shield to prevent excessive distribution for areas of high growth on part 121. In one embodiment, one or more coatings may be applied to an outer surface of device 116 to improve corrosion resistance. Such coatings may include, for example, PVC, epoxy, and fluoropolymers (e.g., polytetrafluoroethylene (PTFE), ethylene tetrafluoroethylene (ETFE), fluorinated ethylene propylene (FEP), perfluoroalkoxy alkane (PFA), etc.).

[0032] FIG. 4A depicts an example part 121 processed using device 116 in an example electroplating chamber (e.g., chamber 158) of the electroplating system of FIG. 1A. FIG. 4B depicts an exemplary top plan cross-sectional view of part 121 taken at a middle portion of part 121 illustrating example minor regions F and major regions E. FIG. 5A depicts a close-up of an upper portion 121A of part 121 as shown in FIG. 4A. FIG. 5B depicts a close-up of a middle portion 121B of part 121 as shown in FIG. 4A. FIG. 5C depicts a close-up of a lower portion 121C of part 121 as shown in FIG. 4A. Each of FIGs. 5A to 5C illustrate example post-plating aspects of major regions E and minor regions F of part 121.

[0033] FIG. 6 is a data plot diagram showing example measurements of part 121 processed and described in Figs. 3A to 5C. Conventionally, achieving a uniform electroplate coating layer thickness on large machinery parts (e.g., mud motor rotors) with irregular shapes has been difficult. That is, a mud motor rotor, for example, may include major regions (e.g., high/convex regions such as major regions E) that may be coated with electroplating deposits many times thicker than those of minor regions (e.g., low/concave regions such as minor regions F). Since the ratio of electroplating deposit thickness difference between the major regions and the minor regions can vary, the difference in the electroplating deposit thicknesses may leave the minor regions with a thinner-than-desired electroplate deposit thickness, which may result in reduced wear and corrosion resistance.

[0034] Accordingly, the example data shown in FIG. 6 related to the machined part 121 and associated device 116 is merely for illustrative purposes. It is understood that the shape and size of each of openings 143 of device 116 may be varied based on the desired thickness of electroplating deposits on various regions of one or more parts or work pieces. Further, the density of openings 143 may also be varied based on the desired thickness of electroplating deposits on various regions of one or more parts or work pieces. With that, using the shield 116, 116' of FIGs. 3A to 3B, a pre-plating major diameter E of part 121 measured approximately 4.101 in, the post-plating major diameter E measured approximately 4.105 in, and the related post-plating major diameter E thickness measured approximately .004 in. The pre-plating minor diameter F of part 121 measured approximately 2.903 in, the post-plating minor diameter F measured approximately 2.976 in, and the related post-plating minor diameter F thickness measured approximately .073 in. The major-to-minor ratio of plating with the example shield 116, 116' of FIGs. 3A to 3B was approximately 1:18 (major: minor or .073 in / .004 in) in contrast to plating without the herein disclosed inductive shield 116, which measured approximately 47:1 (major: minor).

[0035] The advantageous improvement of the herein disclosed inductive shield therefore improves current throw into minor diameter F of part 121 thereby reducing additional plating processing which otherwise would be necessary and therefore saving production time and reduction of touch time. Advantageously, the heretofore describes use of both anode electrodes 162 and device 116 to produce a better distributed deposit on part 121, including through its major and minor regions, through use of inductive and/or bipolar current.

[0036] In some aspects of the present disclosure, the shape, size, and configuration of each of openings of the inductive shield device may be varied to achieve a major-to-minor plating ratio of approximately 1:1. In examples wherein the inductive shield device of the present disclosure has been configured to achieve a major-to-minor plating ratio of approximately 1:1, such that a ratio of thickness of the major region to the minor region is approximately 1:1, the electroplating operation may be performed in a single step.

[0037] A method of fabricating an electroplating shield device of the present disclosure may include forming a plurality of openings on a strip and forming a conduit with the strip. Each of the openings may be varied to achieve a desired to major-to-minor plating ratio. For example, the openings may be designed to transfer fluid to at least one of a first continuous section of an object (e.g., machinery part) comprising a minor of the object and a second continuous section of the object comprising a major of the object in a major-to-minor plating ratio. The major-to-minor plating ratio, corresponding to a ratio of thickness achieved, may range from approximately 1:1 to approximately 1:18.

[0038] It should be appreciated that in the above description of exemplary embodiments, various features are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed embodiment requires more features than are expressly recited in each claim. Thus, the claims following the Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment of this disclosure.

[0039] Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the disclosure, and form different embodiments, as would be understood by those skilled in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination.

[0040] Thus, while certain embodiments have been described, those skilled in the art will recognize that other and further modifications may be made thereto without departing from the spirit of the disclosure, and it is intended to claim all such changes and modifications as falling within the scope of the disclosure. For example, functionality may be added or deleted from the block diagrams and operations may be interchanged among functional blocks. Steps may be added or deleted to methods described within the scope of the present disclosure.

[0041] The above disclosed subject matter is to be considered illustrative, and not restrictive, and the appended claims are intended to cover all such modifications, enhancements, and other implementations, which fall within the true spirit and scope of the present disclosure. Thus, to the maximum extent allowed by law, the scope of the present disclosure is to be determined by the broadest permissible interpretation of the following claims and their equivalents, and shall not be restricted or limited by the foregoing detailed description. While various implementations of the disclosure have been described, it will be apparent to those of ordinary skill in the art that many more implementations and implementations are possible within the scope of the disclosure. Accordingly, the disclosure is not to be restricted.

Claims

1. A method of electroplating a part, comprising:

   positioning an object in an electroplating shield device, the electroplating shield device comprising a conduit configured to receive the object and a plurality of openings selectively extended between inner and outer surfaces of the conduit, the openings being positioned between first and second ends of the conduit; and
   forming a layer on the object by transferring fluid through the plurality of openings to at least one of a first continuous section of the object comprising a minor of the object and a second continuous section of the object comprising a major of the object;
   wherein a ratio of a thickness of the major to the minor after forming the layer ranges from approximately 1:1 to approximately 1: 18.

2. The method of claim 1, wherein the plurality of openings are selectively extended in helical shape, and wherein the conduit is formed of a metal alloy.

3. The method of claim 2, wherein the metal alloy is selected from one or more nickel-chromium alloys, one or more cobalt alloys, and one or more iron alloys.

4. The method of claim 1, wherein the conduit is formed of one or more nickel-chromium alloys.

5. The method of claim 1, wherein the conduit is formed of material comprising a melting point of approximately 1390° C to 1425° C.

6. The method of claim 1, wherein the conduit is formed of material comprising a melting point in excess of about 800°C.

7. The method of claim 1, wherein the layer is formed in an electroplating chamber.

8. The method of claim 1, wherein the object is electroplated prior to positioning in the electroplating shield device and forming the layer.

9. The method of claim 8, wherein the ratio of the thickness of the major to the minor after forming the layer is approximately 1:18.

10. The method of claim 1, wherein the layer is formed substantially on the first continuous section of the object comprising the minor of the object.

11. The method of claim 1, wherein the layer is formed by transferring fluid through the plurality of openings to the first continuous section of the object comprising the minor of the object and the second continuous section of the object comprising the major of the object.

12. The method of claim 11, wherein the ratio of the thickness of the major to the minor after forming the layer is approximately 1:1.

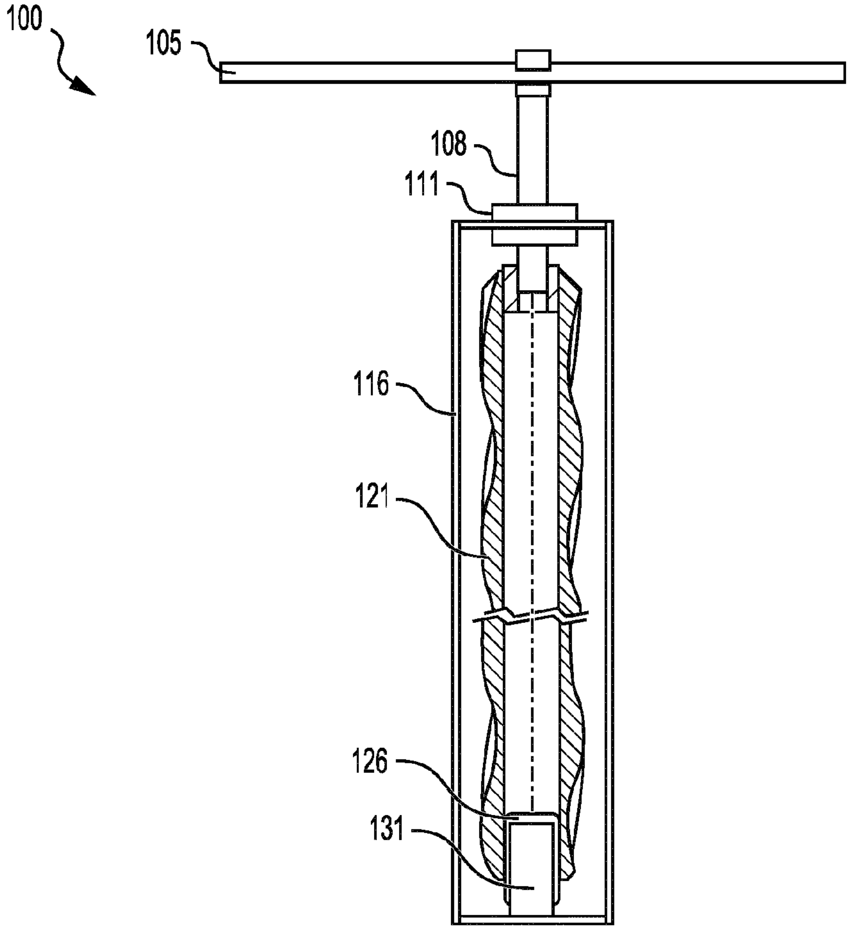

FIG. 1A

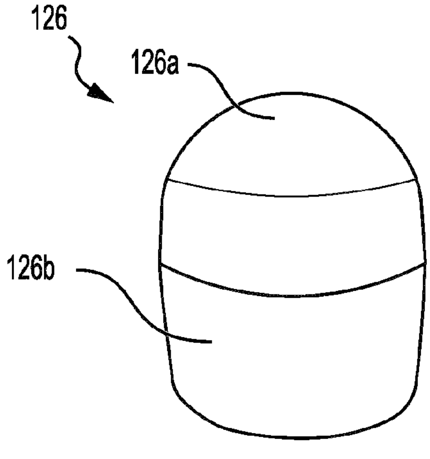

FIG. 1B

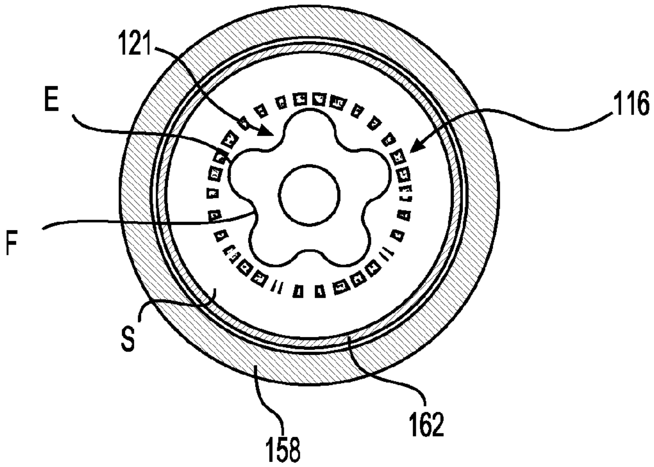

FIG. 1C

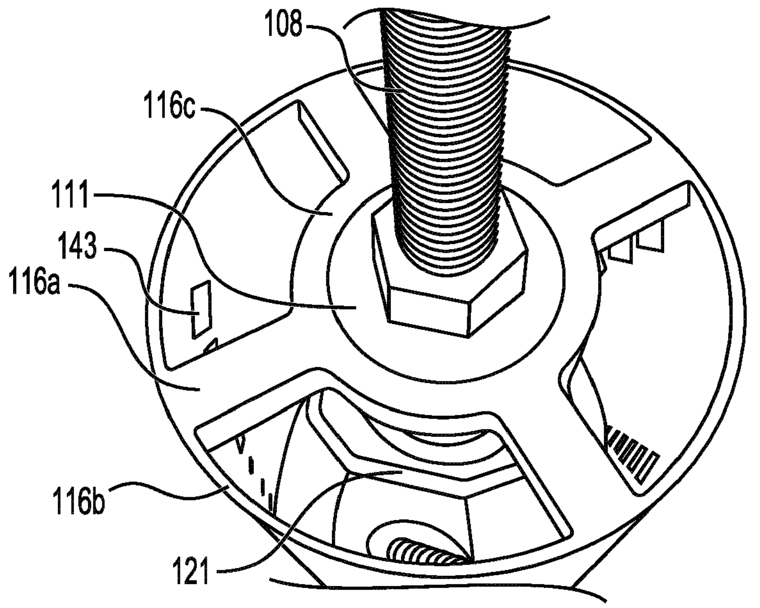
108
116c
111
143
116a
116b
121

FIG. 2A

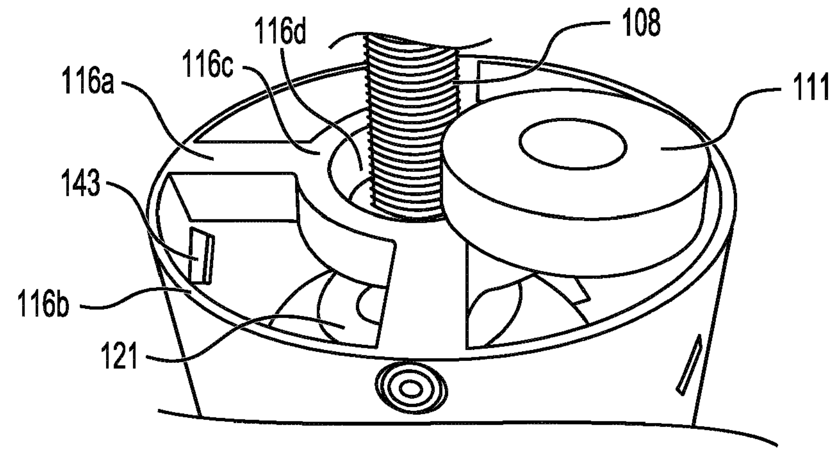
116d
108
116a
116c
111
143
116b
121

FIG. 2B

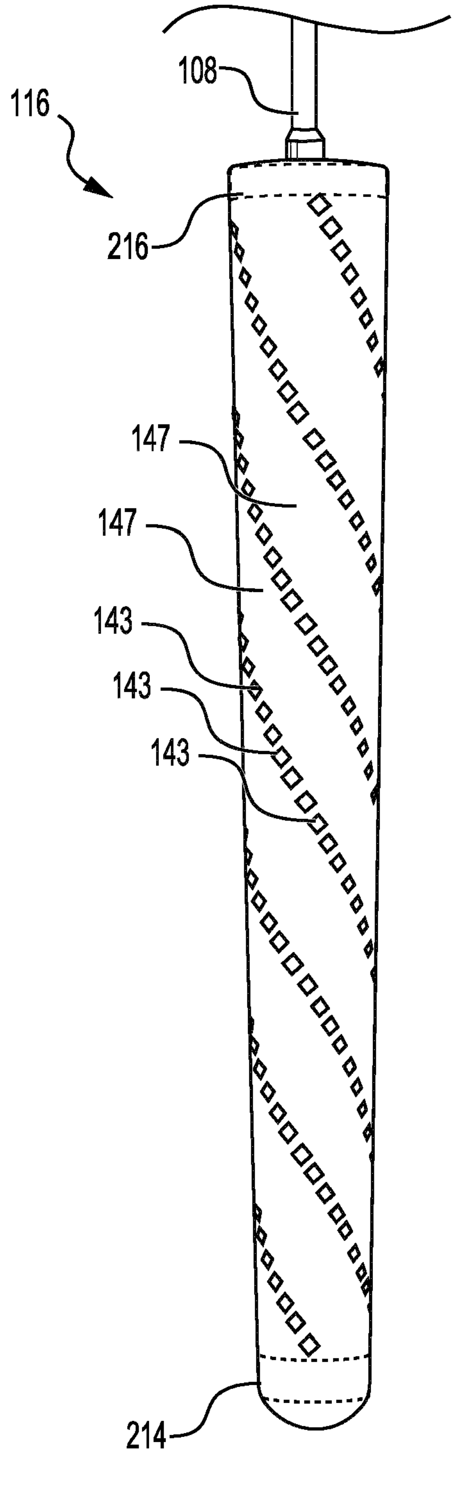

FIG. 3A

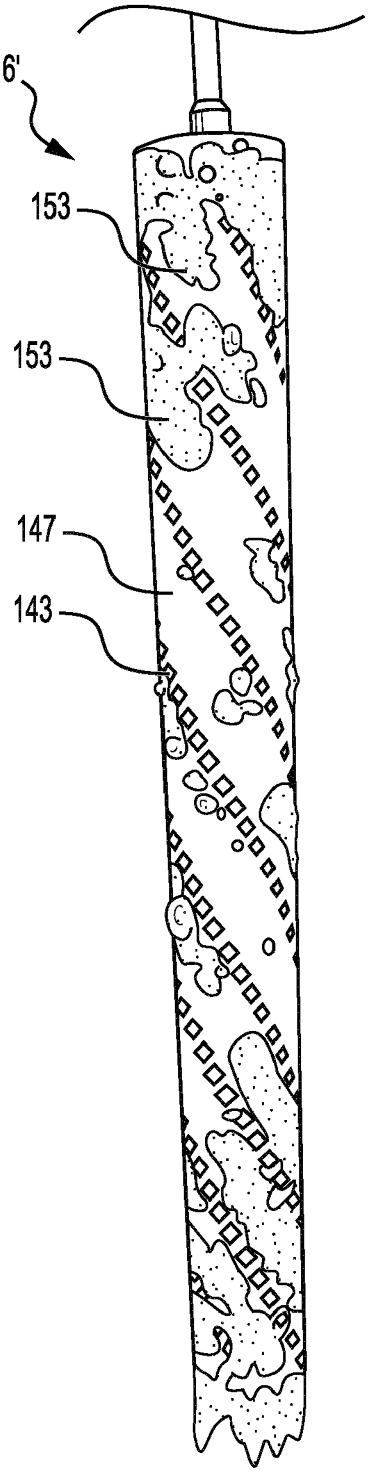

FIG. 3B

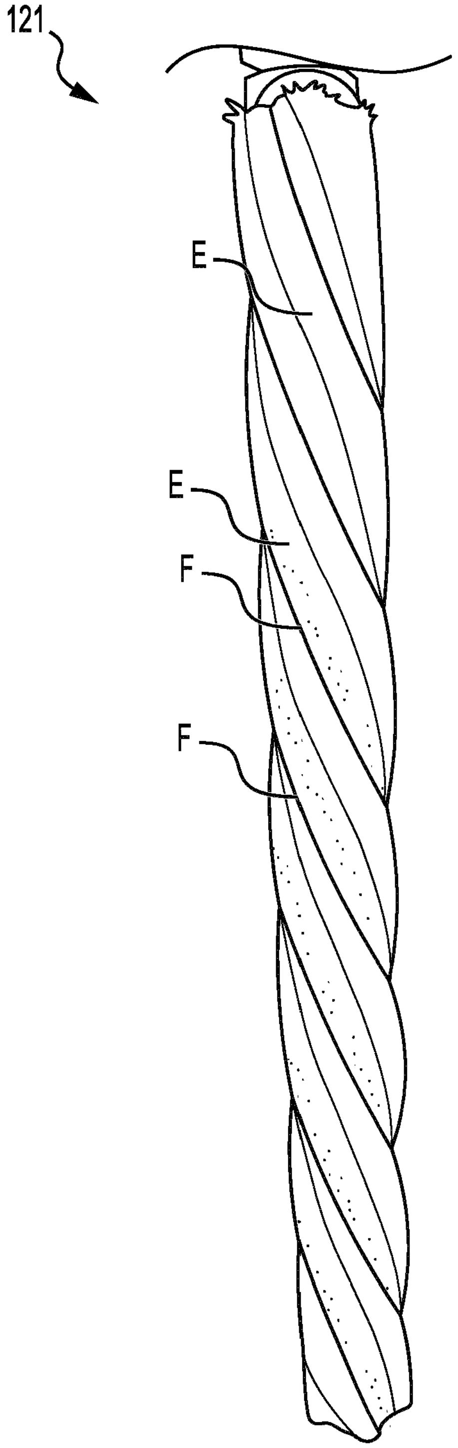

FIG. 4A

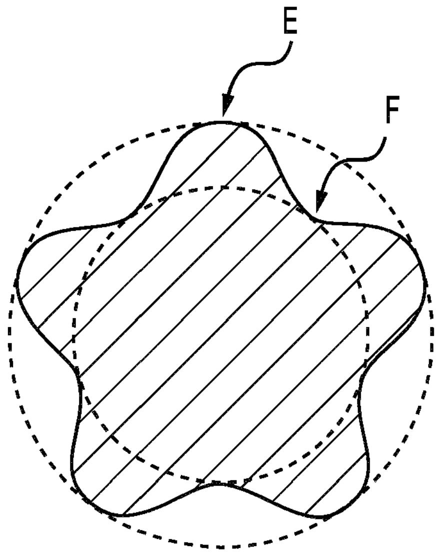

FIG. 4B

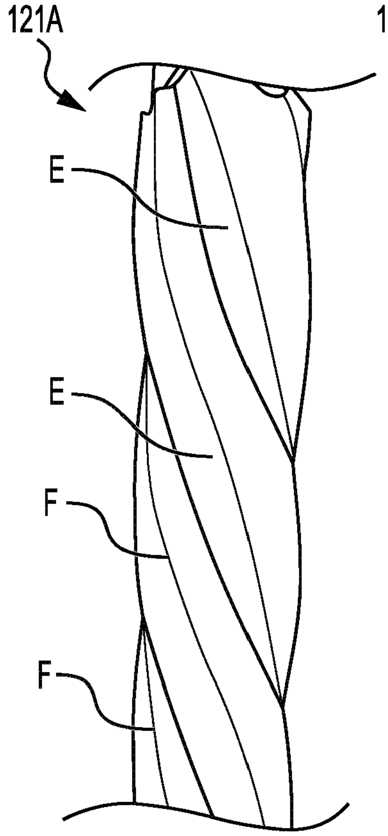

FIG. 5A

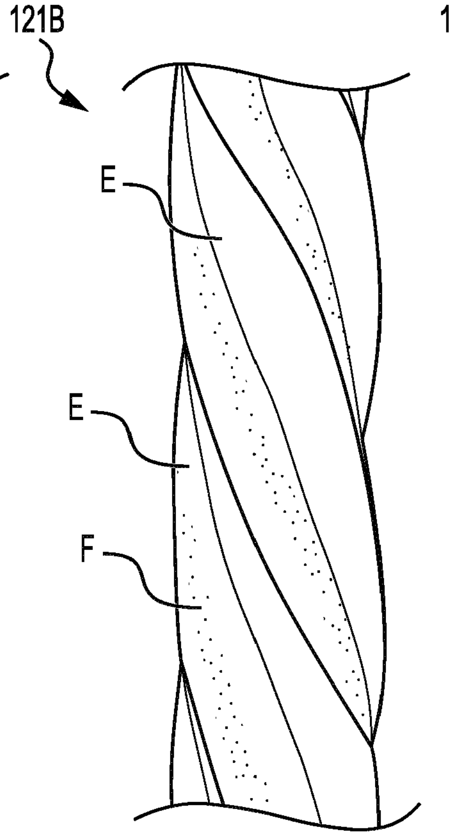

FIG. 5B

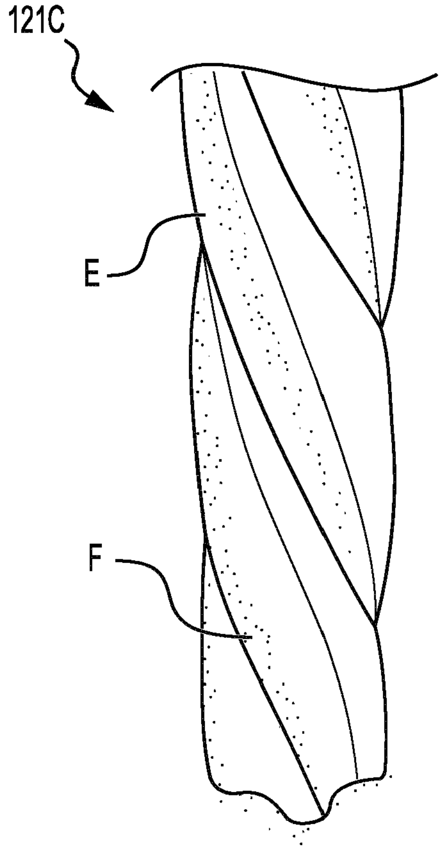

FIG. 5C

DESCRIPTION	PRE-PLATING MEASUREMENTS	POST-PLATING MEASUREMENTS	POST PLATING THICKNESS
MAJOR	4.101	4.105	0.004
MINOR	2.903	2.976	0.073

FIG. 6