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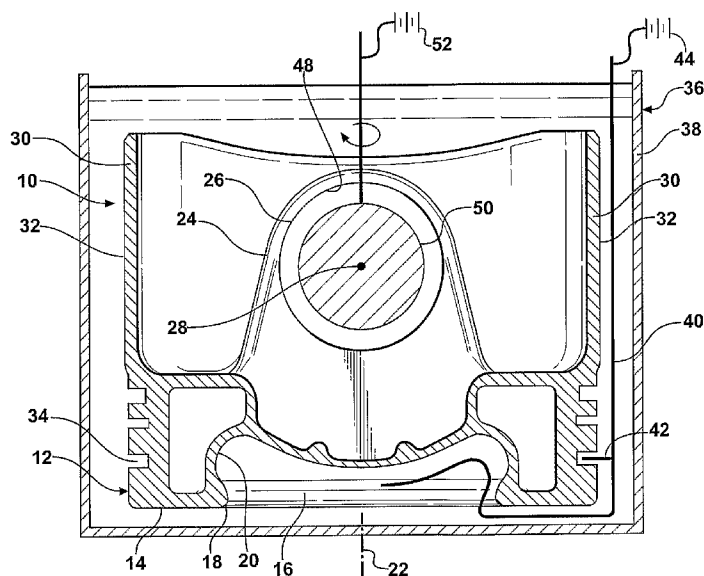
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(54) Title: PROCESS AND APPARATUS FOR PLATING ARTICLES



(57) Abstract: A process and apparatus utilizing at least one conformable anode (40) in a plating process to apply a plating to an article (10). A wire or other material suitable for an anode is shaped to conform to the approximate shape of a region of the article to be coated. The anode is powered by an electrical power source (44), and the article serves as the cathode. The anode and article are both immersed in a plating bath (38). The article and anode are rotated relative to one another about a central axis (22) of the article. The relative movement between the anode and the article causes a uniform plating (46) to be applied to selected regions of the article that pass the anode. Another anode (50) can be arranged in fixed relation with the article to cause plating to a separate selected region of the article concurrently with the other anode.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

PROCESS AND APPARATUS FOR PLATING ARTICLES

[0001] This application claims the benefit of U.S. Provisional Application Serial No. 60/702,483, filed July 26, 2005, which is incorporated herein in its entirety.

BACKGROUND OF THE INVENTION

1. Technical Field

[0002] This invention relates generally to processes and apparatus for plating articles, such as, but not limited to, pistons for combustion engines.

2. Related Art

[0003] It is known to plate articles by immersing an article in a plating bath and establishing an anode/cathode arrangement whereby one or more surfaces of the article are plated with material from the bath solution. For example, some articles are plated with chrome using this general technique.

[0004] One of the challenges presented in plating articles having contoured surfaces and/or sharp corners is that the shape of the article can interfere with the uniform development of the coating, with some areas getting more coating than is otherwise desired and others getting less than what is otherwise desired.

SUMMARY OF THE INVENTION

[0005] The present invention provides an apparatus and process for plating articles with a coating from a plating bath, such as, for example, application of a chrome-based coating to surfaces of a piston. The apparatus includes a shaped anode which is contoured to at least some of the outer contoured features of the article. The article itself is made the cathode, and the cathode and anode are moved relative to one another during plating to control application of the plating to the article.

[0006] According to a particular embodiment, the shaped anode is held stationary and the piston is rotated in the plating bath relative to the shaped anode. This relative movement, and particularly the relative rotational movement enables better control of the application of the coating to desired areas of the piston in need of the coating. In this regard, the invention is particularly well suited to articles having rotational symmetry such that the shape of the anode can be fixed and the article rotated relative

to the anode to maintain a constant spacing between the article and contours of the anode during plating. In this regard, pistons are particularly well suited in that many of the features, including the outer surface of the piston, the ring grooves, the top surface, and often the combustion bowl, have symmetry relative to a central longitudinal axis of the piston body, or at least approximate symmetry.

[0007] In regard to coating a piston, not only is there is an advantage to coating the outer surface, but also coating the surface of the upper ring groove, the top face, as well as the combustion bowl. In some piston configurations, the combustion bowl has a reentrant bowl configuration such that the combustion bowl undercuts a circumferential upper lip of the bowl, thus, making it particularly difficult to plate these areas using a conventional plating bath arrangement. The present invention can accommodate such difficult contours, by extending, in the case of the upper ring groove, a portion of the anode into the ring groove and shaping the anode across the top surface and into the combustion bowl and to include, if necessary, the reentrant feature of the combustion bowl. As such, the desired amount of coating is applied, as desired, to the surfaces during the plating process as the piston rotates relative to the anode about the longitudinal axis of the piston in order to enable a uniform deposition of the plating material in the desired areas associated with the shaped anode.

[0008] According to a further particular feature of the invention, the apparatus and process may optionally include at least a second anode that is stationary relative to the article being plated and moveable relative to the first anode. In one preferred arrangement, this second anode is designed to rotate with the article relative to the first anode for simultaneously plating other areas of the article which may not be accessible or convenient for access by the first fixed anode. For example, the article may have internal features or passages that are not accessible from outside the article (for example, passages or bores or non-circular features). In the case of a piston, it may, for example, be desirable to plate the pin bores from the plating bath. A pin-shaped anode may be positioned in the pin bores and supported for rotation with the piston about the longitudinal axis of the piston and coupled to an associated rectifier to impart controlled plating to the surfaces of the pin bores. This may be done at the same time that the outer surface of the piston is being plated as it rotates relative to

the rotationally fixed first anode. With this apparatus and method, it makes it possible to coat the piston skirt, top ring groove and combustion bowl of the piston via the first anode while also plating the pin bores via the second anode in the same plating bath and at the same time so as to achieve the desired consistency and uniformity of plating on all the desired surfaces in a single step process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] These and other features and advantages of the present invention will become more readily appreciated when considered in connection with the following detailed description of presently preferred embodiments and best mode, appended claims and accompanying drawings, wherein:

[0010] Figure 1 is a perspective view of an article plated by the process;

[0011] Figure 2 is a schematic cross-sectional view of the article shown in association with the plating apparatus; and

[0012] Figure 3 is a view similar to Figure 2 rotated 90 degrees about a central axis of the article.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0013] The invention provides a process and apparatus that utilizes conformable anodes in a plating process to apply a plating material to an article. A wire or other material suitable for an anode is shaped to conform to the approximate shape of a region of the article to be coated. The anode is powered by an electrical power source, such as a rectifier, and the article serves as the cathode, wherein the anode and article are both immersed in a plating bath. While immersed, there is relative movement imparted between the anode and the article. In one presently preferred embodiment, the article is rotated relative to the anode about a central axis of the article, wherein the anode can be fixed so as to not rotate about the central axis. As a result of the relative movement between the anode and the article, a uniform plating is applied to the regions of the article that pass by the anode, thereby achieving, if desired, a 360 degree plating of the article.

[0014] The method and apparatus may also include one or more additional anodes that may be positionally fixed relative to the article (and thus relatively moveable relative to the other shaped anode to plate other areas of the article that are inaccessible or less conventionally coated by the other shaped anode). For example, if the article has a bore that is arranged transverse to the rotation axis of the article, the apparatus and method contemplates inserting a correspondingly shaped anode into the bore that can rotate with the article such that the surfaces of the bore can be plated in the same bath and at the same time as the other surfaces being plated in connection with the shaped anode.

[0015] Turning now to the drawings, in which, by way of example and without limitation, Figures 1-3 show a piston article 10, referred to hereafter as piston, as the article to be plated. The piston 10 includes a piston head 12 having an upper surface 14 extending substantially perpendicular to the central axis 22 in which a combustion bowl 16 is formed. The combustion bowl 16 may have an edge or lip 18 and an undercut region 20 extending radially outwardly from the lip 18. The piston 10 has a central longitudinal axis 22 which various outer surfaces of the piston extend at least partially symmetrically about, and also includes a pair of laterally spaced pin bosses 24 in which aligned pin bores 26 are formed having a common pin bore axis 28. The pin bore axis 28 extends transversely to the central axis 22, and may be perpendicular to the central axis 22. The piston 10 may further include a pair of opposed piston skirt portions 30 that are formed as one piece with the pin bosses 24 having an outer surface 32. The piston head 12 is formed with a plurality of ring grooves, including an upper ring groove 34 that is closest to the upper surface 14 of the piston article 10.

[0016] Figures 2 and 3 illustrate the piston 10 in conjunction with a plating apparatus 36. The apparatus 36 preferably includes a plating bath 38 of a selective plating solution (such as, for example, one which will produce a chromium-based coating) in which the piston 10 may be immersed. The apparatus 36 includes a first shaped anode 40 that may be in the form of a wire or other suitable material that can serve as an anode. The anode 40 is arranged along the outside of the piston 10 and has an area less than the total area of the outer surface of the piston 10. The anode 40 is formed to have a shape corresponding to the general shape of the outer surface of

the piston in relation to the longitudinal cross section of the piston presented to the anode 40 for the surfaces that are to be plated. As such, even over areas having a geometrically discontinuous shape in axial cross section, such as a surface transforming from a linear surface to a nonlinear and/or curvilinear surface, the anode 40 is able to be conformed to follow the contour of the surface. This is particularly important in being able to apply a uniform coating across the various ring grooves, as well as the undercut region 20.

[0017] For example, in connection with the example of the piston 10 shown in Figures 1-3, the shaped anode 40 is configured relative to the shape of the piston 10 in order to develop a plating on the outer surface 32 of the skirt portions 30, the upper ring groove 34 and preferably the entire surface of the combustion bowl 16. For this purpose, the shaped anode 40 extends at least partially in the longitudinal direction generally parallel to the central axis 22 and along the outer surface of the piston 10 adjacent the outer surface 32 of the skirt portions 30, along the head of the piston 12. The anode 40 is represented as having a portion 42 extending into the upper ring groove 34 generally perpendicular to the central axis 22, and also has a portion that wraps around the upper surface 14 of the piston 10 and then down into the combustion bowl 16. The portion of the anode 40 in the combustion bowl follows the contour of the undercut region 20 where it may terminate at the central longitudinal axis 22. As such, the undercut region 20 is able to be plated with a uniform thickness of coating material, as desired. Desirably, the distance in which the anode 40 is spaced from the adjacent surfaces can be controlled with a high degree of precision. As such, it will be appreciated that if the piston article 10 were rotated relative to the anode 40 (or vice versa) that the relative movement would cause the entire outer surface of the regions of the piston 10 that are desired to be coated to be exposed to the shaped anode. In other words, with each revolution, the outer surfaces would pass by the fixed shaped anode 40.

[0018] In the plating process, the shaped anode 40 is coupled to a corresponding electrical power source, such as rectifier 44 and the piston 10 is electrically coupled to make it a cathode in relation to the anode 40. The piston 10, immersed in the plating bath 38 along with the shaped anode 40, is rotated relative to the shaped anode 40 to

develop a controlled thickness of plating 46 on the targeted areas of the piston 10 as mentioned. Of course, other areas may be coated as well, but the shaped anode makes certain that these targeted areas are carefully controlled.

[0019] It may be further desirable to coat an inner diameter surface 48 of the pin bores 26 with the plating material from the bath 38. This can be achieved at the same time that the outer surface is coated by positioning another anode, referred to hereafter as a pin bore anode 50, within the pin bore 26 and supporting the pin bore anode 50 in relative fixed relation to the piston 10, while enabling the pin bore anode 50 to rotate concurrently with the piston 10 about the longitudinal central axis 22, and thus, relative to the shaped anode 40 during the plating process. The pin bore anode 50 is coupled to an associated rectifier 52 which results in deposition of the plating material to the pin bore surface 48. Coupling the pin bore anode 50 to its own rectifier 52 separate from the other rectifier 44 enables independent control of the pin bore anode 50 and the corresponding plating of the pin bore surface 48 from that of the shaped anode 40 and the corresponding plating of the other surfaces, including the upper surface 14, the combustion bowl 16, the skirt portions 30, one or more of the ring grooves, if desired.

[0020] Accordingly, one aspect of this invention provides the use of anodes which are conformable to varying geometric shapes of surfaces being plated in a plating process, such as a plating process used to coat a heavy duty (HD) steel piston. A wire, such as shown at 40, or other preformed anode member conforming to the approximate shape of surfaces being plated on the piston (skirt area 30 to ring area above the skirt area to top bowl area 14) is utilized to allow deposition of the coating to the areas of interest. This is powered by the plating electrical power source, such as the rectifier 44. The entire piston assembly is rotated within the plating bath 38 such that it revolves past the conformable anode 40 resulting in deposition of the coating over the intended areas. Additionally, the second anode 50 is utilized, with the common cathode connection being the same steel piston 10, whereby this second conformable anode 50 is placed within the pin bores 26 resulting in deposition of the coating on the ID surface 48 of the pin bores 26. This is powered by the rectifier 52 which, as mentioned, is separate from the rectifier 44.

[0021] The use of conformable anodes 40, 50 for plating surfaces of the piston 10 allows the deposition of the coating in those areas where the coating is desired at the desired thicknesses. Spinning the piston 10 allows for uniform deposition around the entire circumference of the piston 10. The use of two separate rectifiers 44, 52 and anodes 40, 50 (with a common cathode designated here as the piston 10) allows for deposition of the coating into areas separate from one another that could not be coated in a single rectifier/anode configuration and allows the desired thicknesses of the plating material to be applied where needed.

[0022] The piston 10 will be fitted into a holder or otherwise supported by a member that makes the common cathode connection to the piston 10 as well as to serve as the mechanism for rotating the piston 10 about its central axis 22 so that it can be rotated past the conformable anode 40 that results in deposition of the coating on the piston skirt 30, ring groove area and the upper surface 14, including the combustion bowl 16. The pin bores 26 are plated by means of the cylindrical anode 50 placed within the pin bore area, which as described, is powered by the second rectifier 52. This allows for application of the appropriate plating density and thickness for each of the two separate regions being plated. As such, in a single plating process, the piston areas plated by the separate anodes 40, 50 can have differing plating densities and thicknesses.

[0023] Obviously, in light of the above teachings, many modifications and variations of the present invention are possible. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A process for plating a surface of an article acting as a cathode in a plating bath, the surface extending at least in part symmetrically about a central axis of the article, the surface including a portion having a geometrically discontinuous shape in axial cross section, comprising:

providing at least one anode having a shape substantially conforming to said geometrically discontinuous shape of said portion;

placing said anode at a predetermined distance from said article such that said anode substantially follows said portion of said surface;

disposing the article and said anode in said plating bath; and

rotating said article and said anode relative to one another and energizing said anode in said plating bath to apply a predetermined thickness of the plating to said portion.

2. The process of claim 1 further including forming said anode so that one portion of said anode extends substantially perpendicular to said axis and another portion of said anode extends substantially perpendicular to said axis.

3. The process of claim 1 including providing the article as a piston having an annular ring groove extending circumferentially about the axis, and further including forming a portion of said anode so that it extends into said ring groove so that the ring groove is plated during the rotating step.

4. The process of claim 3 wherein the piston has a combustion bowl extending generally perpendicular to the axis, and further including forming a portion of said anode so that it follows the contour of the combustion bowl so that the combustion bowl is plated during the rotating step.

5. The process of claim 3 further including providing the piston as a steel piston.
6. The process of claim 1 including providing the article as a piston having a combustion bowl extending generally perpendicular to the axis, the combustion bowl having an annular undercut region extending circumferentially about the axis, and further including forming a portion of said anode so that it follows the contour of the undercut region so that the undercut region is plated during the rotating step.
7. The process of claim 1 further including providing another anode and plating a portion of the article separate from said one anode during said rotating step.
8. The process of claim 7 further including providing the article as a piston having a combustion bowl and a pair of pin bosses defining pin bores and plating the combustion bowl with said one anode and plating the pin bores with said another anode during the rotating step.
9. The process of claim 8 further including moving said one anode relative to said another anode during the rotating step.
10. The process of claim 8 further including providing the piston with an annular ring groove extending circumferentially about the axis and plating the ring groove with said one anode during the rotating step.
11. The process of claim 10 further including extending at least a portion of said one anode into said ring groove to facilitate applying a uniform plating to the ring groove.
12. An apparatus for plating a surface of an article acting as a cathode, the surface extending at least in part symmetrically about a central axis of the article and including a portion having a geometrically discontinuous shape in axial cross section, comprising:

a plating bath having a plating material therein;

an electrical power source; and

at least one anode in electrical communication with said power source, said anode having a shape substantially conforming to the geometrically discontinuous shape of the portion of the article.

13. The apparatus of claim 12 further comprising another anode for plating a portion of the article separate from the portion being plated by said one anode.

14. The apparatus of claim 13 wherein said one anode and said another anode move simultaneously relative to one another.

15. The apparatus of claim 13 wherein said one anode remains stationary relative to said plating bath while plating one of the portions and said another anode rotates relative to the plating bath about the central axis of the article while plating the other portion of the article.

16. The apparatus of claim 13 wherein said at least one anode is arranged to plate a combustion bowl of a piston and said another anode is arranged to plate a pair of pin bores of the piston simultaneously.

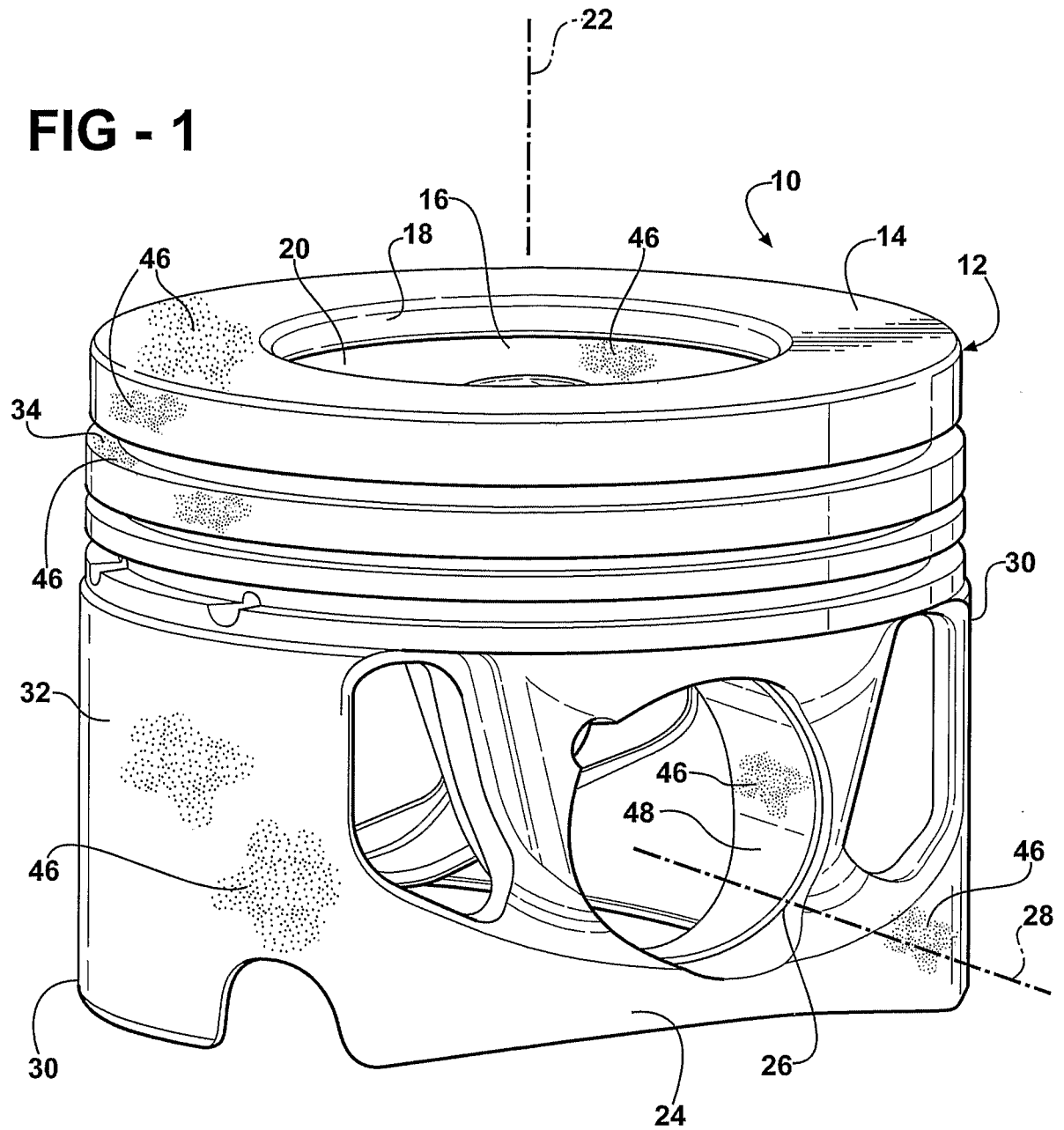
17. The apparatus of claim 13 wherein said at least one anode extends in part generally parallel to the central axis and said another anode extends generally perpendicular to the central axis.

18. The apparatus of claim 17 wherein at least a portion of said one anode extends generally perpendicular to said axis.

19. The apparatus of claim 12 wherein said at least one anode is a wire.

20. The apparatus of claim 13 further comprising another power source in electrical communication with said another anode separate from said at least one anode.

FIG - 1



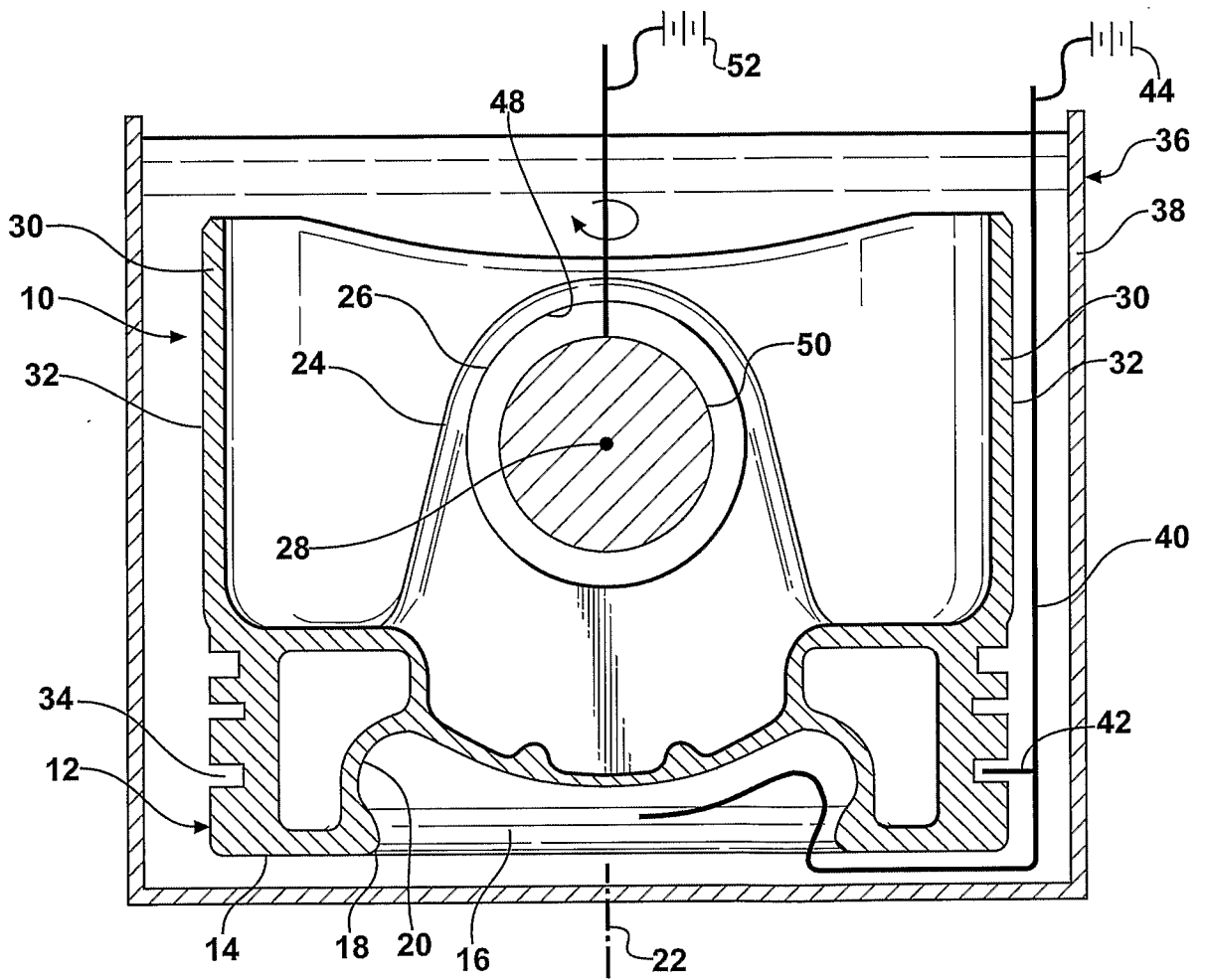
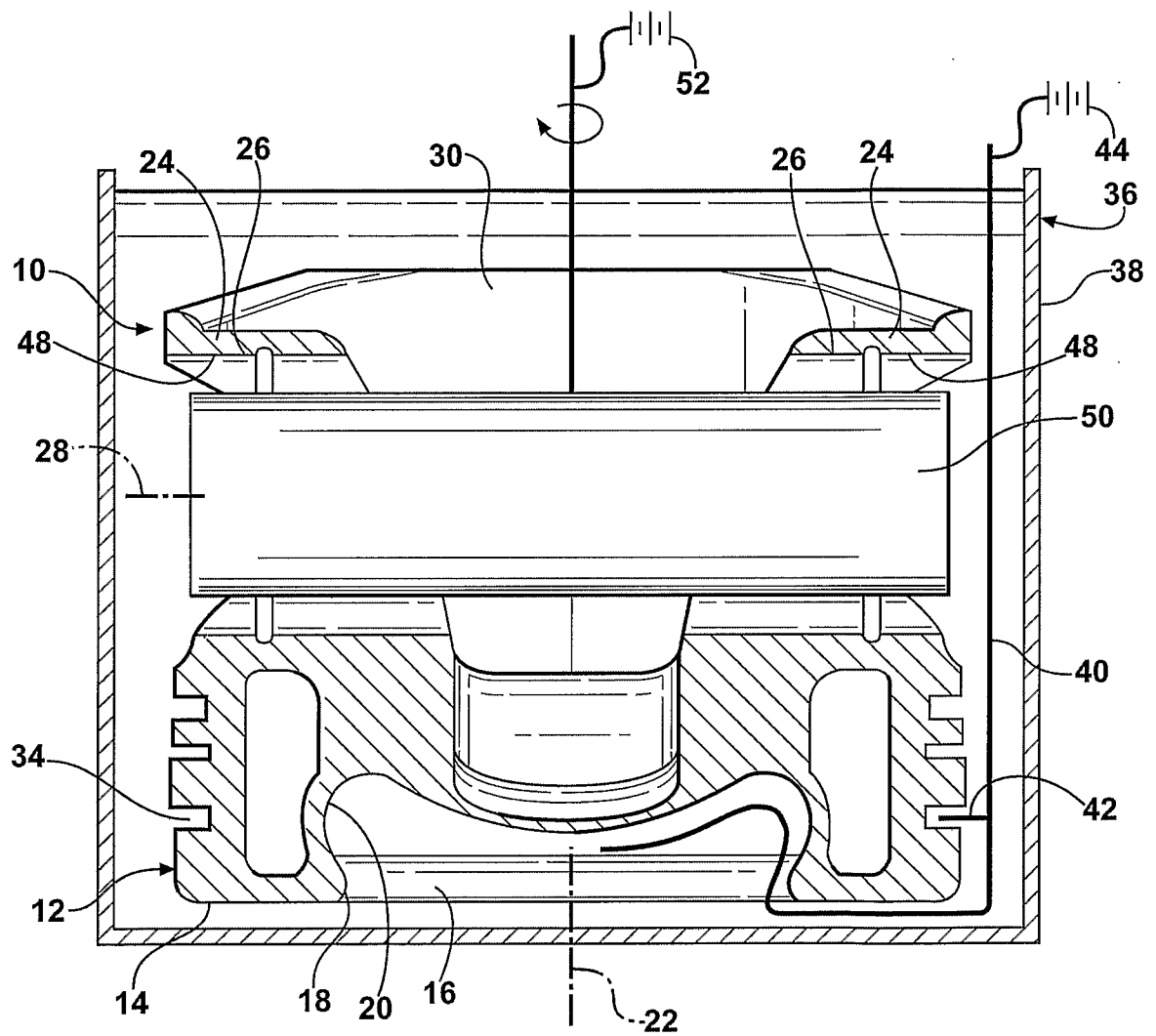


FIG - 2

**FIG - 3**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US06/29072

A. CLASSIFICATION OF SUBJECT MATTER

IPC: C25D 17/00(2007.01),5/00(2007.01),7/00(2007.01),7/04(2007.01);C25B 9/00(2007.01),11/00(2007.01)

USPC: 204/212,242,280,289;205/143,149,151

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)

U.S. : 204/212,242,280,289;205/143,149,151

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)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 3636532 A1 (GALVANO WERNIGERODE VEB) 27 May 1987 (27.05.87), abstracts.	1-20

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A"	document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search

05 December 2006 (05.12.2006)

Date of mailing of the international search report

11 JAN 2007

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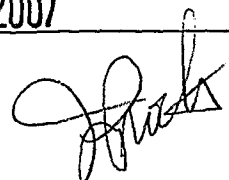
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US06/29072

Continuation of B. FIELDS SEARCHED Item 3:

EAST

search terms: anode, shape, conform, contour, rotate, spin, revolve, electroplating, electrodepositing, piston, chromium