

Description

FIELD OF THE INVENTION

[0001] The present invention relates generally to the art of electrolytic formation of coatings on metallic parts. More specifically, it relates to electrolytic formation of a coating on a metallic substrate by cathodic deposition of dissolved metallic ions in the reaction medium (electrolyte) onto the metallic substrate (cathode), or anodic conversion of the metallic substrate (anode) into an adherent ceramic coating (oxide film).

BACKGROUND OF THE INVENTION

[0002] It is well known that many metallic components or parts need a final surface treatment. Such a surface treatment increases functionality and the lifetime of the part by improving one or more properties of the part, such as heat resistance, corrosion protection, wear resistance, hardness, electrical conductivity, lubricity or by simply increasing the cosmetic value.

[0003] One example of a part that is typically surface treated is the head of aluminum pistons used in combustion engines. (As used herein an aluminum component is a component at least partially comprising aluminum, including aluminum alloys.) Such piston heads are in contact with the combustion zone, and thus exposed to relatively hot gases. The aluminum is subjected to high internal stresses, which may result in deformation or changes in the metallurgical structure, and may negatively influence the functionality and lifetime of the parts. It is well known that formation of an anodic oxide coating (anodizing) reduces the risk of aluminum pistons performing unsatisfactorily. Thus, many aluminum piston heads are anodized.

[0004] There is a drawback to anodizing piston heads. Conventional anodizing with direct current or voltage, increases the surface roughness of the initial aluminum surface by applying an anodic coating. The amount of VOC (Volatile Organic Compounds) in the exhaust of a combustion engine is correlated with the surface finish of the anodized aluminum piston: higher surface roughness reduces the efficiency of the combustion, because a greater proportion of organic compounds can be trapped in micro cavities more easily. Therefore, a smooth surface is required, which may not always be provided by anodization.

[0005] Conventional anodizing includes subjecting the aluminum to an acid electrolyte, typically composed of sulfuric acid or electrolyte mixed with sulfuric and oxalic acid. Higher concentrations and temperature usually decrease the formation rate significantly. Also, the formation voltage decreases with higher temperature, which adversely affects the compactness and the technical properties of the oxide film.

[0006] Performing anodizing processes at a (relatively) low temperature and fairly high current density in-

creases the compactness and technical quality of the coating performance (high hardness and wear resistance). The anodization produces a significant amount of heat. Heat is the result of the exothermic nature of the anodizing of aluminum, and the resistance of the aluminum toward anodizing.

[0007] The electrolyte is acidic, and thus chemically dissolves the aluminum oxide. Thus, the net formation of the coating (aluminum oxide) depends on the balance between electrolytic conversion of aluminum into aluminum oxide and chemical dissolution of the formed aluminum oxide. The rate of chemical dissolution increases with heat. Thus, the total production of heat influences this balance and the final quality of the anodic coating. Heat should be dispersed from areas of production toward the bulk solution at a rate that prevents excess heating of the electrolytic near the aluminum part. If the balance between formation and dissolution is not properly struck, and dissolution is favored, the oxide layer may develop holes, exposing the alloy to the electrolyte.

[0008] Heat produced at the aluminum surface is dispersed by air agitation or mechanically stirring of the electrolyte in which the oxidation of aluminum is taking place, in the prior art, to help reach the desired balance. Another way of dispersing the heat is by spraying the electrolyte toward the aluminum surface (US Patent 5,534,126 and US Patent 5,032,244). The electrolyte is sprayed toward the aluminum surface at an angle of 90 degrees, moving heat toward the areas of production, and then symmetrically dispersed away from the aluminum surface. Another way to disperse heat is to pump the electrolyte over the aluminum substrate (US Patent 5,173,161). The electrolyte is moved parallel to the aluminum surface, moving heat from the lower part of the aluminum substrate over the entire surface before it is finally dispersed away from the aluminum surface.

[0009] US Patent 6126808, hereby incorporated by reference, is a significant advance over the prior art and teaches to spray the reaction medium toward the metallic substrate (component) through holes in the counter electrode (cathode) at a horizontal angle of between 15 and 90 degrees, and preferably between 60 and 70 degrees. Horizontal angle, as used herein, includes the angle, in a horizontal plane, relative to the shortest horizontal distance to a component, and a zero horizontal angle is along the horizontal line that is the shortest distance to the component.

[0010] The system provides for flow of the reaction medium from a bulk solution below the container through the reaction chamber and back into the reservoir. Because the reaction medium moves toward the working electrode at a horizontal angle, heat and reaction products may be dissipated away from the working electrode. The electrolyte is stored and chilled to an appropriate process temperature ranging from -10 degrees C to +40 degrees C. This system was a substantial improvement over the prior art. However, dissolved metals from the process can plate the holes in the counter electrode

(cathode), which can lead to clogging unless cleaning is performed.

[0011] An anodizing method and apparatus that further reduce processing time with high formation potentials and minimal handling to obtain coatings of desirable quality and consistency is desirable. The process and apparatus will preferably lessen production costs and have a closed loop process design that reduces the impact of the electrolyte on internal and external environments. The process will preferably further remove heat from near the component being anodized, and avoid clogging of nozzles through which the reaction fluid flows.

SUMMARY OF THE PRESENT INVENTION

[0012] According to a first aspect of the invention an apparatus for electrolytically treating a surface of a component includes a reaction chamber, a transport chamber and a fluid return path. The reaction chamber is adapted for placing at least a portion of the component therein, and holds a reaction fluid. The transport chamber is in fluid communication with the reaction chamber. Fluid enters the reaction chamber from the transport chamber through a plurality of inlets directed toward the component. Each of the inlets is disposed to direct the fluid toward the component at at least one non-zero vertical angle. The fluid returns from the reaction chamber to the transport chamber via the fluid return path.

[0013] According to a second aspect of the invention a fixture for anodizing a component includes a reaction chamber with a plurality of inlets. Each of the inlets directs the electrolyte toward the component at at least one non-zero vertical angle.

[0014] According to a third aspect of the invention a method for electrolytically treating a component includes directing a reaction fluid toward the component along a plurality of paths. Each path is at one of at least one non-zero vertical angle.

[0015] The at least one non-zero vertical angle is at least two non-zero vertical angles, greater than and/or less than zero in various alternatives.

[0016] The plurality of inlets direct the fluid toward the component at at least one non-zero horizontal angle, or at at least two non-zero horizontal angles, greater than and/or less than zero in other alternatives.

[0017] The reaction chamber is a fixture having a cover with an underside shaped to direct the fluid to the surface of the component, such as by having a plurality of slopes in other embodiments.

[0018] The plurality of inlets and the cover underside cooperate to refresh the fluid at the surface, and/or cause the fluid to remove heat from the surface of the component in other alternatives.

[0019] The inlets are through a material that is electrically non-conductive, such as ceramic, plastic, PVC, and fiber reinforced plastic, and/or the fixture further includes a titanium cathode ring that can be vertically adjacent the non-conductive material in various alternatives.

[0020] According to a fourth aspect of the invention there is provided an apparatus for electrolytically treating a surface of a component comprising a reaction chamber, adapted for placing at least a portion of the component therein, and for holding a reaction fluid, a transport chamber in fluid communication with the reaction chamber, wherein the fluid enters the reaction chamber from the transport chamber through a plurality of inlets directed toward the component, wherein each of the plurality of inlets is disposed to direct the fluid toward the component at at least one non-zero vertical angle, and a fluid return path, wherein the fluid returns from the reaction chamber to the transport chamber.

[0021] The at least one non-zero vertical angles may be at least two non-zero vertical angles.

[0022] At least a first of the at least two non-zero vertical angles may be greater than zero and at least a second of the at least two non-zero vertical angles is less than zero.

[0023] Each of the plurality of inlets may be further disposed to direct the fluid toward the component at at least one non-zero horizontal angle.

[0024] The at least one non-zero horizontal angle may be at least two non-zero horizontal angles.

[0025] Each of the plurality of inlets may be further disposed to direct the fluid toward the component at at least one non-zero horizontal angle.

[0026] The reaction chamber may be a fixture having a cover over the reaction chamber, and the cover may have an underside shaped to direct the fluid entering the reaction chamber through the plurality of inlets to the surface of the component.

[0027] The cover underside may have a plurality of slopes.

[0028] The plurality of inlets and the cover underside may cooperate to refresh the fluid at the surface.

[0029] The plurality of inlets and the cover underside may cooperate to cause the fluid to remove heat from the surface of the component.

[0030] The plurality of inlets may be through a first material that is electrically non-conductive.

[0031] The first material may be comprised of at least one of ceramic, plastic, PVC, and fiber reinforced plastic.

[0032] The plurality of inlets may be in the fixture, and the fixture may further include a titanium cathode ring.

[0033] The titanium cathode ring may be vertically adjacent the first material.

[0034] The plurality of inlets may be through a first material that is electrically non-conductive. The reaction chamber may be a fixture and the plurality of inlets may be through the fixture, and the fixture may further include a titanium cathode ring.

[0035] The titanium cathode ring may be vertically adjacent the first material.

[0036] According to a fifth aspect of the invention there is provided a fixture for anodizing a component, comprising, a reaction chamber with a plurality of inlets, wherein each of the plurality of inlets is disposed to direct an elec-

trolyte toward the component at at least one non-zero vertical angle.

[0037] The at least one non-zero vertical angles may be at least two non-zero vertical angles.

[0038] At least a first of the at least two non-zero vertical angles may be greater than zero and at least a second of the at least two non-zero vertical angles may be less than zero.

[0039] Each of the plurality of inlets may be further disposed to direct the fluid toward the component at at least one non-zero horizontal angle.

[0040] The at least one non-zero horizontal angle may be at least two non-zero horizontal angles.

[0041] The fixture may include a cover over the reaction chamber, and the cover may have an underside disposed to direct the electrolyte to a reaction surface of the component

[0042] The plurality of inlets and the cover underside may cooperate to refresh the electrolyte at the reaction surface.

[0043] The plurality of inlets and the cover underside may cooperate to cause the electrolyte to remove heat from the reaction surface.

[0044] The cover underside may have a plurality of slopes.

[0045] The plurality of inlets may be through a first material that is electrically non-conductive.

[0046] The first material may be comprised of at least one of ceramic, plastic, PVC, and fiber reinforced plastic, and wherein the fixture may further include a titanium cathode ring.

[0047] The titanium cathode ring may be vertically adjacent the first material.

[0048] According to a sixth aspect of the invention there is provided a method for electrolytically treating a component comprising, directing a reaction fluid toward the component along a plurality of paths, wherein each of the plurality of paths is at one of at least one non-zero vertical angle.

[0049] Directing a reaction fluid toward the component along a plurality of paths at one of at least one non-zero vertical angle, may include directing a reaction fluid toward the component along a plurality of paths, wherein each of the plurality of paths is at one of at least two non-zero vertical angles.

[0050] At least a first of the at least two non-zero vertical angles may be greater than zero and at least a second of the at least two non-zero vertical angles may be less than zero.

[0051] Each of the plurality of paths may be at at least one non-zero horizontal angle.

[0052] The at least one non-zero horizontal angle may be at least two non-zero horizontal angles.

[0053] The method may further comprise refreshing the fluid at the surface.

[0054] The method may further comprise removing heat from the surface of the component

[0055] Directing the reaction fluid toward the compo-

nent along a plurality of paths may include directing the reaction fluid through a first material that is electrically non-conductive.

[0056] Directing the reaction fluid toward the component along a plurality of paths may include directing the reaction fluid through a first material that is electrically non-conductive and vertically adjacent a cathode ring.

[0057] Directing the reaction fluid toward the component along a plurality of paths may include directing the reaction fluid through a first material that is electrically non-conductive and vertically adjacent a titanium cathode ring.

[0058] Other principal features and advantages of the invention will become apparent to those skilled in the art upon review of the following drawings, the detailed description and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0059] Figure 1 is a block diagram of a general method implementing the present invention;

[0060] Figure 2 is a schematic sectional view of process container implementing the present invention;

[0061] Figure 3 is an angle sectional view of a counter electrode in accordance with the preferred embodiment;

[0062] Figure 4 is a perspective view of a counter electrode in accordance with the preferred embodiment;

[0063] Figure 5 is vertical cross section of a working electrode mounted in a mounting fixture, in accordance with the preferred embodiment;

[0064] Before explaining at least one embodiment of the invention in detail it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting. Like reference numerals are used to indicate like components.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0065] While the present invention will be illustrated with reference to a particular system and method for anodizing an aluminum part with a particular fixture, it should be understood at the outset that the invention can also be implemented with other systems and methods and used to anodize other parts comprising other materials held in other fixtures.

[0066] The process and apparatus described herein is generally consistent with that of prior art US Patent 6126808, but with changes that are described below. The general process and system are shown by the block diagram of Figure 1. Anodizing occurs in a process container 100 (described in more detail later). A working elec-

trode 102 (i.e., the part to be anodized) is placed in a reaction container 104, which is part of container 100. After anodizing component or part 102 is moved to a rinsing tank 110, where the working electrode is rinsed with water pumped from a rinse reservoir 112 by a pump 114 into a rinse chamber 116, through a set of spray nozzles 11 B. The rinse water leaves the rinse chamber 116 through a rinse outlet 119 and returns to the rinse reservoir 112. Working electrode or part 102 is mechanically held in position during the rinse. After rinsing, working electrode 102 is transferred to a drying container 120, where it is dried with hot air from a heater 122, which is pumped into the drying container 120 through several drying inlets 124. Component, as used herein, includes the device or object which is being treated or anodized.

[0067] Alternatives include performing multiple steps (such as anodizing and rinsing) in a single container or providing a station (following drying container 120, e.g.) that scan the component as a quality control measure. The scanning may be automatically performed using known techniques such as neural network analysis.

[0068] Referring now to Figure 2, a schematic of a section of process container 100 and related components is shown, including an outer circular transport chamber 201 and inner reaction container 104. The reaction medium (electrolytic solution) is transported from a medium reservoir 202, located below process container 100 and in fluid communication therewith, by a pressure pump 203 into transportation chamber 201 through several inlet channels 205. Alternatives include other shaped chambers, as well as the inlets and outlets being in different locations. Fluid communication, as used herein, includes a path or connection through which fluid can flow from one location or container to another. Reaction chamber, as used herein, includes the container in which the component is placed to be treated or anodized. Transport chamber, as used herein, includes the container and pipes, etc. that store and move an electrolyte or fluid to a reaction chamber.

[0069] Transportation channel 201 and reaction container 104 are separated by an inner wall consisting of a lower portion 206, made of an inert material, and an upper portion 207, part of which is the counter electrode, and part of which is (unlike the prior art) a non-conductive injection ring and includes a set of reaction inlets or nozzles 210. Alternatively, the entire wall may be the electrode. The reaction medium enters reaction container 104 through reaction inlets or nozzles 210 through portion 207. The reaction medium enters reaction container 104 at a non-zero horizontal angle and (unlike the prior art) at a non-zero vertical angle relative to the surface of the component, part, aluminum substrate, or working electrode 102. The horizontal angle to the part is within the range of 15 to 90 (or 15 to -90) degrees, preferably 60 to 70 (or -60 to -70) degrees. The vertical angle to the component within the range of 15 to 85 degrees, preferably 20 to 40 degrees. Vertical angle, as used herein, includes the angle relative to horizontal, and a vertical

angle upward is greater than zero, and a vertical angle downward is less than zero.

[0070] The reaction medium leaves reaction container 104 through a reaction outlet 212 and returns to medium reservoir 202. The inner wall (comprised of portions 206 and 207), and an outer wall 213 are fixed to a bottom wall 214. Walls 206, 213 and 214 are comprised of an inert material, such as polypropylene. Reaction container 104 is closed by a moveable top lid made of an inert material such as polypropylene, which includes a cover lid 219 and a mounting fixture 220, and in which working electrode 102 is placed. Mounting fixture 220 is exchangeable and specially designed for the particular parts or working electrode 102 which is being anodized. Fixture, as used herein, includes the reaction chamber and the walls, inlets, cover, cathode, connections, etc. Cover (of a reaction chamber or fixture), as used herein, includes the surface over the reaction chamber of the chamber and can be partially open, and/or have the component extending therethrough.

[0071] The upper portion of working electrode 102 is exposed to air, enhancing the dispersion of heat accumulated in working electrode 102 during processing. Selective formation of coatings on working electrode 102 can be obtained in manner consistent with the prior art, particularly US Patent 6126808, Figures 3 and 4, such as using a top mask etc. The mounting and masking device allows selective formation of coatings on the metallic substrate at high speed as set forth in US Patent 6126808.

[0072] The reaction medium is sprayed toward the metallic substrate through holes in the counter electrode in a manner that reaction products (heat) are carried away from the metallic substrate (working electrode). Figure 3 shows a sectional view, at an angle relative to horizontal, of an injection ring 301. A plurality of inlets 1001 are shown, and are horizontally angled between 60 and 70 degrees. They are also at a non-zero vertical angle, as discussed in more detail below.

[0073] As set forth in USP 6126808 the reaction medium may be a solution of sulfuric acid and/or suitable organic acids. The electrolyte is preferably stored and chilled to an appropriate process temperature and pumped up into the reaction chamber at an appropriate flow rate. The flow of direction of electrolyte is toward the aluminum surface so heat is transported away from the areas of heat production. The electrolyte is transported to the reaction site in an outer circular inlet chamber and through the counter electrode toward the component, such as an aluminum piston. The counter electrode contains from one to 50, but preferably from 10 to 30 transport inlets to the reaction chamber. The counter electrode is connected to the rectifier and acts as cathode (negative). A pulse current pattern such as that set forth in US Patent 6126808 is preferably used.

[0074] Referring again to Figure 3, a sectional view of an injection ring of portion 207 of the inner wall is shown. Injection ring 301 includes inlets 1001, and the section

is at an angle equal to the vertical angle of inlets 1001. If the sectional view was at a horizontal angle, the inlets would appear to be ovals. Inlets 1001 are horizontally angled between 60 and 70 degrees, and thus direct the fluid to the component at a non-zero horizontal angle. Directed toward the component, as used herein, includes toward the component either directly or obliquely, such that the shortest distance to the component decreases.

[0075] Inlets 1001 are through an electrically non-conductive material in the preferred embodiment. Examples of such electrically non-conductive materials include ceramic, plastic, PVC, fiber reinforced plastic, etc. The preferred embodiment provides that the entire injection ring 301 is electrically non-conductive. Other embodiments provide that portions between inlets 1001 are electrically conductive. Electrically non-conductive, as used herein, includes a material that can electrically insulate at the voltages being used in the treatment.

[0076] A perspective view of portion 207 is shown in Figure 4, and includes injections ring 301 and a cathode (or counter electrode) 401. Cathode 401 is preferably comprised of titanium and is vertically adjacent and directly below injection ring 301 (unlike the prior art). Other embodiments provide for cathode 401 to be directly above (still vertically adjacent) injection ring 301, or adjacent and disposed between inlets 1001. Vertically adjacent, as used herein, includes being contiguous with, in contact with, or near, in the vertical direction.

[0077]] Because the inlets are not through the cathode there is less likelihood of the inlets being clogged by plating of dissolved metals that enter the anodizing solution during processing of alloyed materials. Rather, using this invention will limit unwanted plating primarily in non-critical areas, such as on ring 401, or on the surface of ring 301.

[0078] The inlets are at a non-zero vertical angle, and thus direct the fluid toward the component at a non-zero vertical angle. Figure 5 shows a vertical cross section of a component 102 in a fixture 220 in accordance with the preferred embodiment. An inlet 1001 is shown, and is at a vertical angle of preferably between 20-40 degrees. Inlet 1001 appears to be an oval because the section is at a zero horizontal angle, and inlet 1001 is at a non-zero horizontal angle. Alternative embodiments provide for negative vertical angles, and/or two or more non-zero vertical angles, and/or two or more non-zero horizontal angles for inlets 1001. For example, every alternating inlet could be at +30 and -30 degree vertical angles.

[0079] Component 102 is a piston, and supported in position by a spacer S01 1 on fixture 220. The reaction fluid enters through inlet 1001, as indicated by an arrow 503. Inlet 1001 is through non-conductive ring 301. Non-conductive ring 301 is disposed vertically adjacent cathode 401. Cover 219 is placed over fixture 220, and fluid passes between cover 504 and fixture 220. Unlike the prior art, the underside of cover 505 is shaped to direct the fluid to piston 102 by having an upward slope. More specifically, the underside of cover 505 includes a first

sloped region 507 and a second sloped region 508. They combine to produce an non-zero average slope. Alternatives provide for a single slope, a plurality of slopes with abrupt changes joining the slopes or a continuously changing slope. Shaped to direct the fluid, as used herein, includes a profile that has a non-zero average slope, and can be a single slope, a plurality of slopes, or a changing slope. Underside of the cover, as used herein, is the surface of the cover closest to the reaction fluid.

[0080] Fluid is directed by the underside of cover 505 and by inlets 503 to piston 102, as shown by arrow 510. Fluid returns to a storage chamber along a path shown by arrows 511 and 512. The shape of the underside of cover 505 and the direction of inlets 503 help create a laminar flow where arrows 510 and 511 are shown.

[0081] Thus, the invention provides for inlets or nozzles in the fixture at non-zero vertical and horizontal angles, as well as through material that is electrically non-conductive. The non-zero angles, in cooperation with the sloped underside of the cover, allows the electrolyte to roll into the ring groove on the piston and refresh the electrolyte solution at the interface of the anodizing area. This circulation of the electrolyte flow, shown by arrows 510 and 511, allows the electrolyte to remove heat effectively and refresh the fluid (electrolyte) at the surface of the aluminum to create a dense oxide structure. Moreover, this cooperation helps even out the electrolyte replenishing at the anodizing interface reducing any potential hot spots in between the electrolyte injection nozzles. Refresh the fluid at a surface, as used herein, includes directing new fluid to the reaction surface. Various alternatives include having non-zero vertical angles with zero horizontal angles, with or without the sloped underside of the cover and with or without the non-conductive inlet ring. Other alternatives include having a non-conductive inlet ring with or without non-zero vertical angles, non-zero horizontal angle and the sloped (i.e., non-zero average slope) under side of the cover. Additional alternatives include having an underside of the cover that directs fluid to the component (such as a sloped underside), with or without a non-conductive inlet ring, non-zero vertical angles, and nonzero horizontal angles.

[0082] Numerous modifications may be made to the present invention which still fall within the intended scope hereof. Thus, it should be apparent that there has been provided in accordance with the present invention a method and apparatus for a system and method for electroplating that fully satisfies the objectives and advantages set forth above. Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

Claims

1. An apparatus for electrolytically treating a surface of a component comprising:

a reaction chamber, adapted for placing at least a portion of the component therein, and for holding a reaction fluid;
 a transport chamber in fluid communication with the reaction chamber, wherein the fluid enters the reaction chamber from the transport chamber through a plurality of inlets directed toward the component, wherein each of the plurality of inlets is disposed to direct the fluid toward the component at at least one non-zero vertical angle; and
 a fluid return path, wherein the fluid returns from the reaction chamber to the transport chamber.

2. The apparatus of claim 1, wherein the at least one non-zero vertical angles is at least two non-zero vertical angles.

3. The apparatus of claim 2, wherein at least a first of the at least two non-zero vertical angles is greater than zero and at least a second of the at least two non-zero vertical angles is less than zero.

4. The apparatus of any preceding claim, wherein each of the plurality of inlets is further disposed to direct the fluid toward the component at at least one non-zero horizontal angle.

5. The apparatus of any preceding claim, wherein the reaction chamber is a fixture having a cover over the reaction chamber, and the cover has an underside shaped to direct the fluid entering the reaction chamber through the plurality of inlets to the surface of the component.

6. The apparatus of claim 5, wherein the plurality of inlets and the cover underside cooperate to refresh the fluid at the surface.

7. The apparatus of claim 5, wherein the plurality of inlets are through a first material that is electrically non-conductive.

8. The apparatus of claim 7, wherein the plurality of inlets are in the fixture, and the fixture further includes a titanium cathode ring.

9. The apparatus of claim 8, wherein the titanium cathode ring is vertically adjacent the first material.

10. The apparatus of any of claims 1 to 4, wherein the plurality of inlets are through a first material that is electrically non-conductive and wherein the reaction

chamber is a fixture and the plurality of inlets are through the fixture, and the fixture further includes a titanium cathode ring.

11. A fixture for anodizing a component, comprising, a reaction chamber with a plurality of inlets, wherein each of the plurality of inlets is disposed to direct an electrolyte toward the component at at least one non-zero vertical angle.

12. A method for electrolytically treating a component comprising, directing a reaction fluid toward the component along a plurality of paths, wherein each of the plurality of paths is at one of at least one non-zero vertical angle.

13. The method of claim 12, wherein directing a reaction fluid toward the component along a plurality of paths at one of at least one non-zero vertical angle, includes directing a reaction fluid toward the component along a plurality of paths, wherein each of the plurality of paths is at one of at least two non-zero vertical angles.

14. The method of claim 13, wherein at least a first of the at least two non-zero vertical angles is greater than zero and at least a second of the at least two non-zero vertical angles is less than zero.

15. The method of claim 13, wherein each of the plurality of paths is at at least one non-zero horizontal angle.

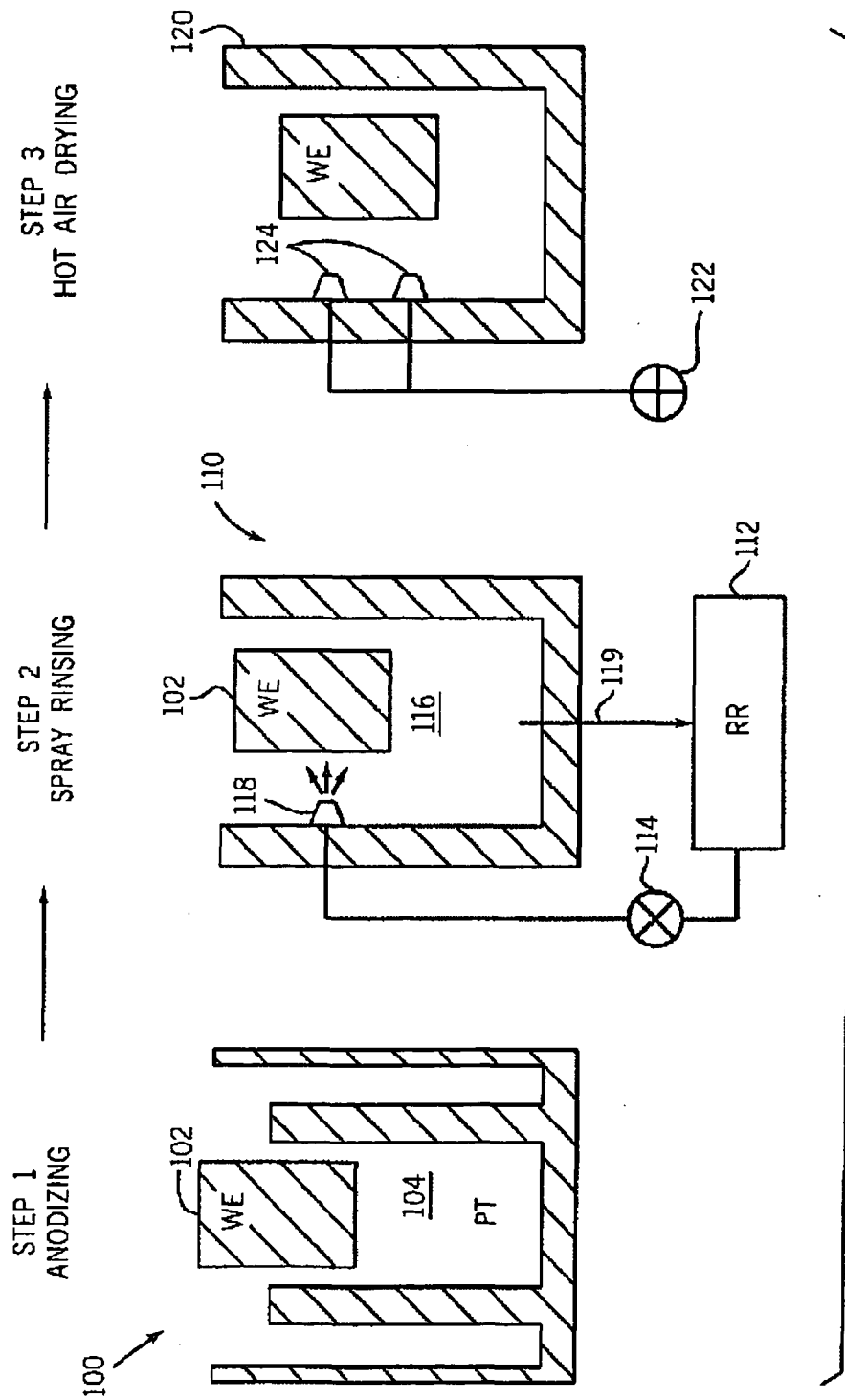
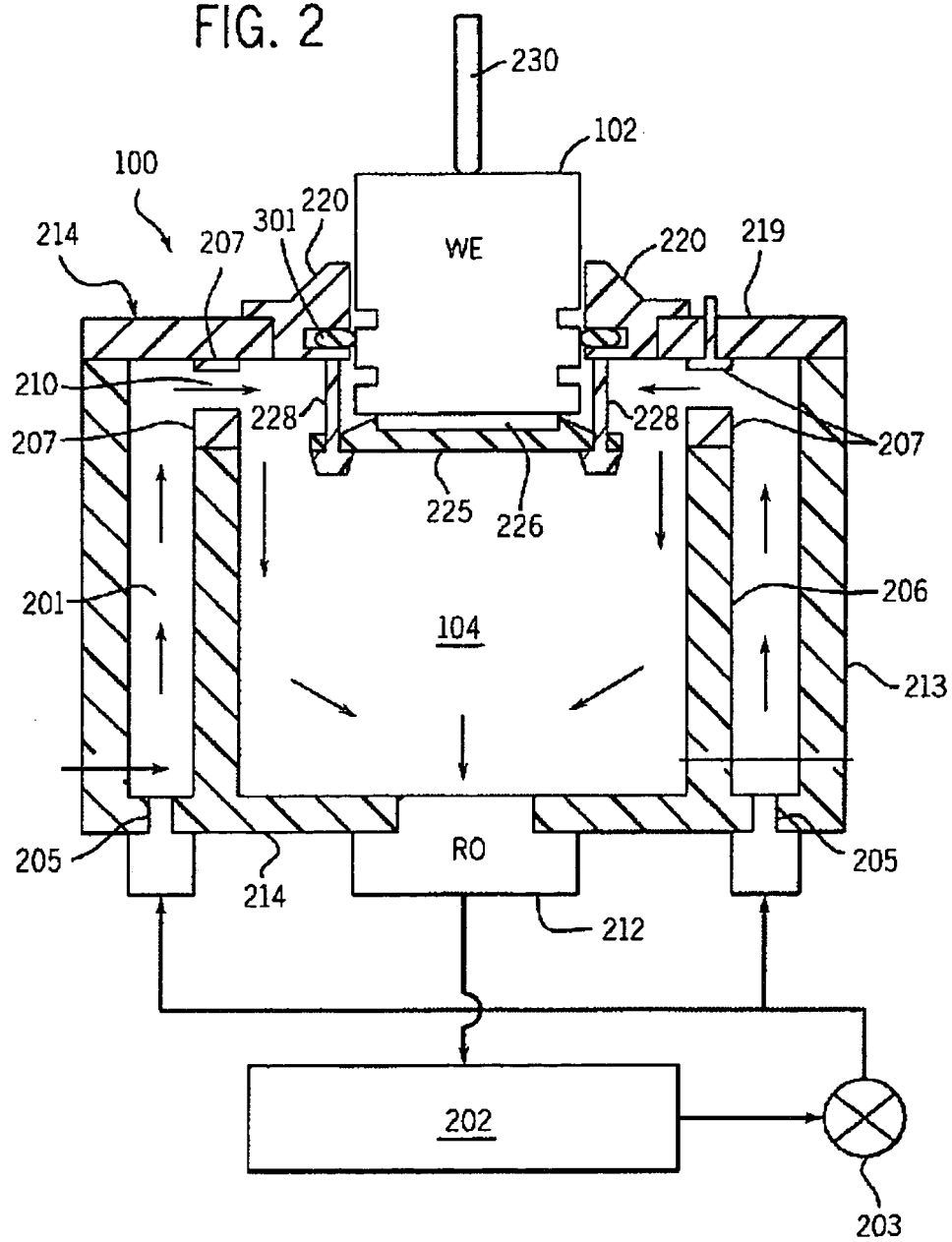


FIG. 1

FIG. 2



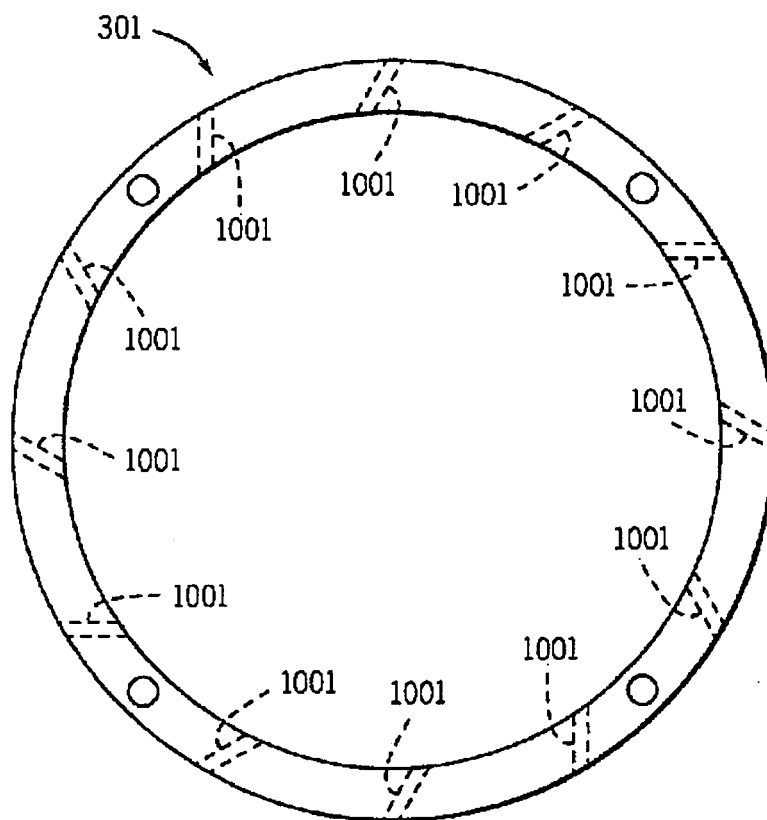


FIG. 3

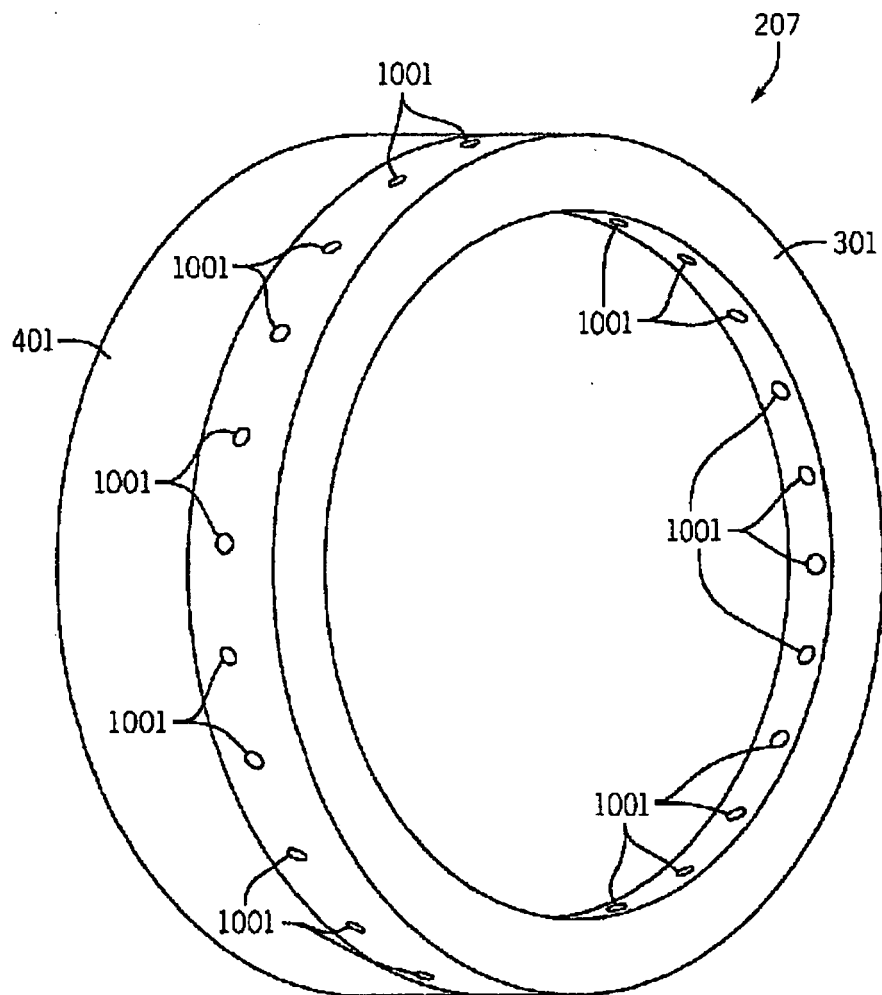


FIG. 4

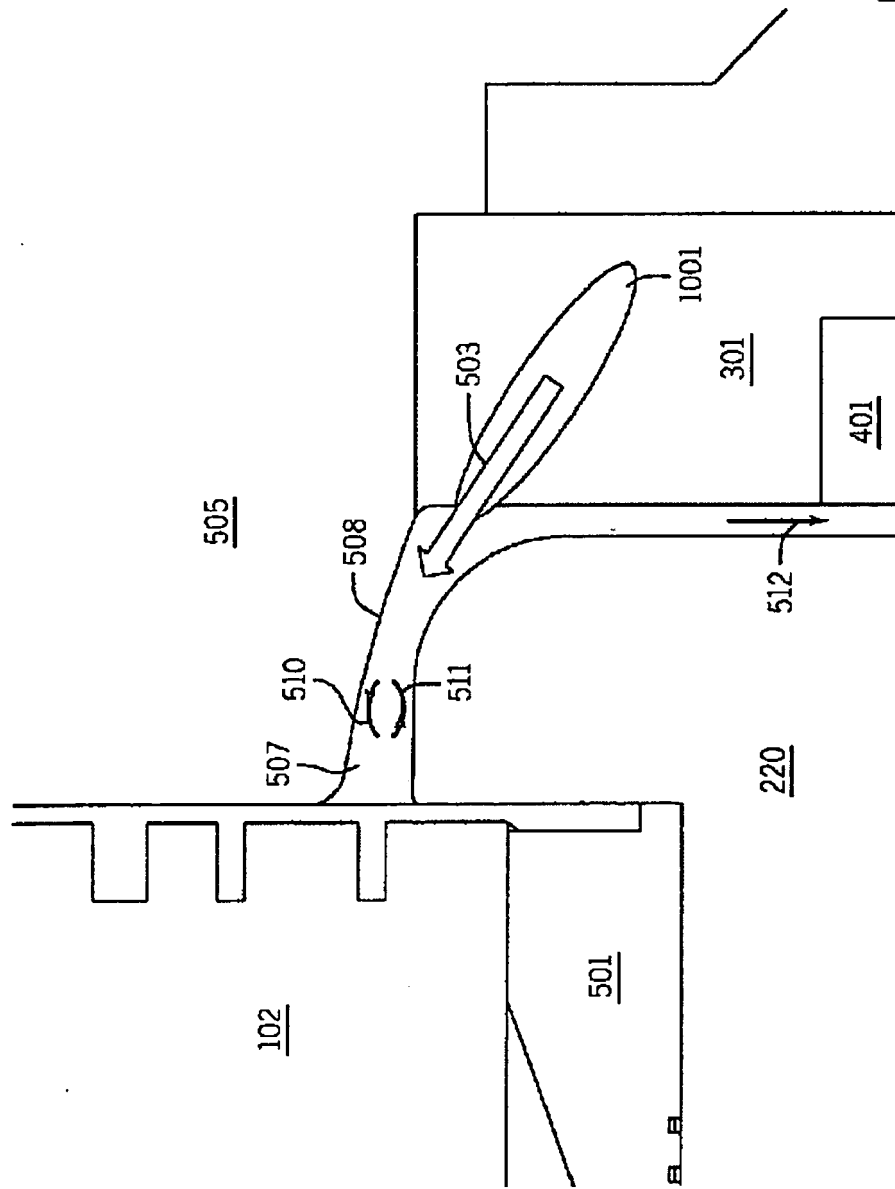


FIG. 5

**PARTIAL EUROPEAN SEARCH REPORT**

Application Number

under Rule 62a and/or 63 of the European Patent Convention.
This report shall be considered, for the purposes of
subsequent proceedings, as the European search report

EP 11 25 0536

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 1 225 254 A1 (UNISIA JECS CORP [JP] HITACHI LTD [JP]) 24 July 2002 (2002-07-24) * abstract * * paragraphs [0001], [0033] - [0035], [0047] - [0049], [0052], [0056], [0057], [0059], [0064] *	1-7, 11-15	INV. C25D5/08 C25D11/02 C25D17/02
X	& US 2003/085134 A1 (SASAKI MASATO [JP] ET AL) 8 May 2003 (2003-05-08) * paragraphs [0030] - [0033] * ----- -/--	7-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			C25D
INCOMPLETE SEARCH			
The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC so that only a partial search (R.62a, 63) has been carried out. Claims searched completely : Claims searched incompletely : Claims not searched : Reason for the limitation of the search: see sheet C			
Place of search Munich		Date of completion of the search 14 September 2011	Examiner Haering, Christian
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

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EPO FORM 1503 03.82 (P04E07)



PARTIAL EUROPEAN SEARCH REPORT

Application Number

EP 11 25 0536

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (IPC)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
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**INCOMPLETE SEARCH
SHEET C**Application Number
EP 11 25 0536

Claim(s) searched incompletely:
1-15

Reason for the limitation of the search:

The initial phase of the search revealed a very large number of documents relevant to the issue of novelty. So many documents were retrieved that it is impossible to determine which parts of the claims may be said to define subject-matter for which protection might legitimately be sought (Article 84 EPC). Indeed, the apparatus of claims 1 or 12 is in fact only characterised by inlets directing the electrolyte toward the substrate at a non-zero angle. This is well known in the state of the art, the whole class C25D5/08 should have been checked (more than 1500 documents). For these reasons, a meaningful search of the whole claimed subject-matter of the claims could not be carried out (Rule 63 EPC). The extent of the search was consequently limited.

The search restricted to a few relevant documents, in particular D1 and D2 referring to an apparatus and a method for anodising pistons rings.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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