



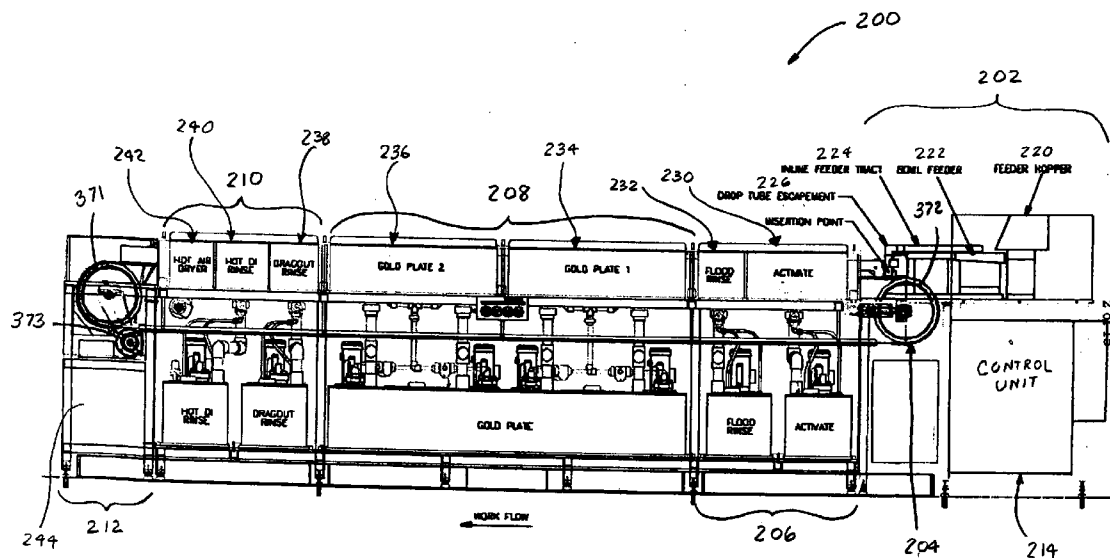
US 20060219563A1

(19) **United States**(12) **Patent Application Publication****Sepp et al.**(10) **Pub. No.: US 2006/0219563 A1**(43) **Pub. Date: Oct. 5, 2006**(54) **SYSTEM AND METHOD OF CONTROLLING THE DEMARCATION LINE FORMED ON PARTIALLY ELECTROPLATED ARTICLES**(52) **U.S. Cl. 205/80; 204/196.08; 205/198**(76) **Inventors: William F. Sepp**, Mission Viejo, CA (US); **Jeffrey P. Ramirez**, Yorba Linda, CA (US); **Fred C. Hayward JR.**, Seal Beach, CA (US); **Daniel James Gramarossa**, Las Vegas, NV (US)

Correspondence Address:

CROWELL & MORING LLP
INTELLECTUAL PROPERTY GROUP
P.O. BOX 14300
WASHINGTON, DC 20044-4300 (US)(21) **Appl. No.: 11/097,787**(22) **Filed: Apr. 1, 2005****Publication Classification**(51) **Int. Cl.****C25D 5/00** (2006.01)**C23F 13/00** (2006.01)**C23C 28/00** (2006.01)(57) **ABSTRACT**

A processing system, electroplating cell, and method of reducing the ration (i.e., demarcation line) that often forms on articles undergoing a partial plating process. The processing system may include a loading station, pre-processing station, electroplating station, post-processing station, unloading station, and a transport system that transports the articles to the various stations. The electroplating cell comprises a container to support a plating fluid bath, an anode electrode, a support structure, which may be part of the transport system, to support the articles such that only a portion thereof is immersed in the plating fluid bath and an air flow system adapted to cause air flow proximate the interface of the articles to the plating fluid bath. The air flow near the articles prevents or reduces plating fluid vapors from impinging the articles, thereby reducing the discoloration that would otherwise form on the articles.



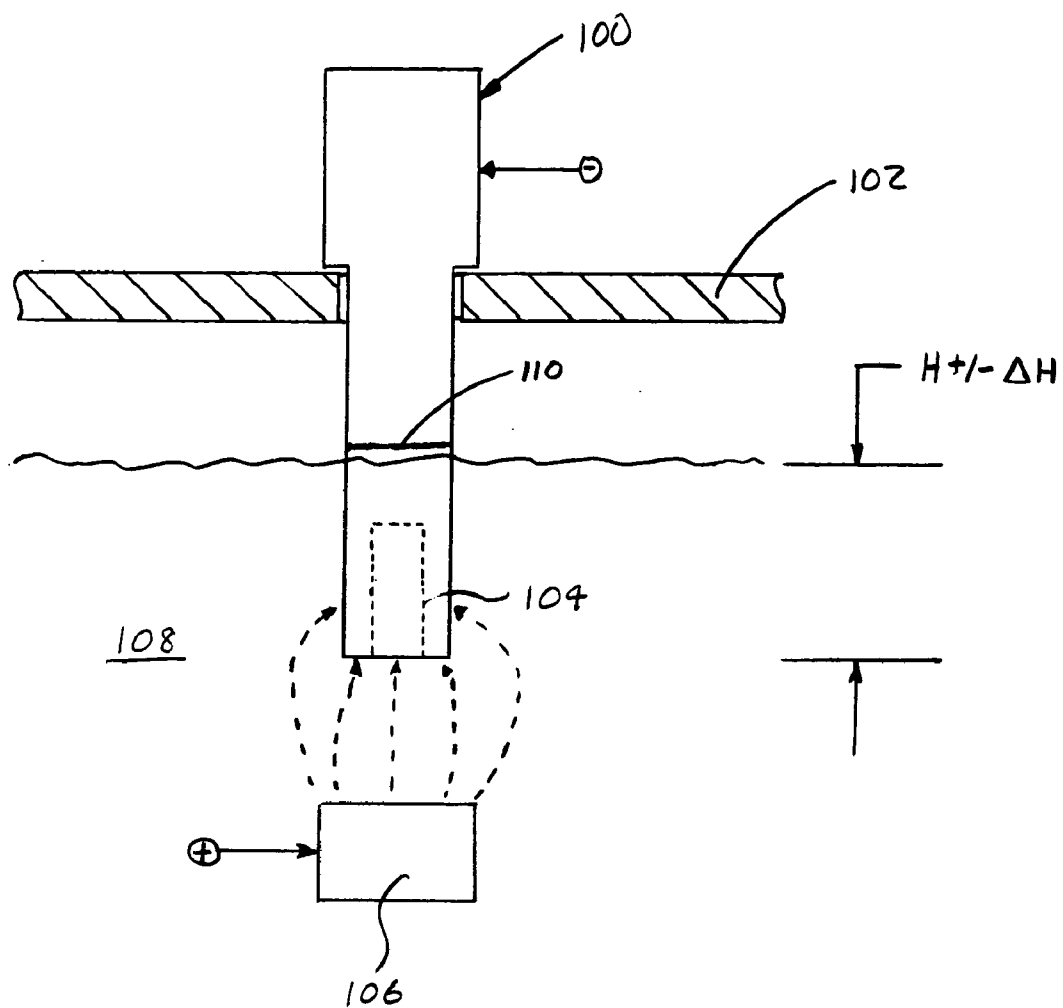


FIGURE 1

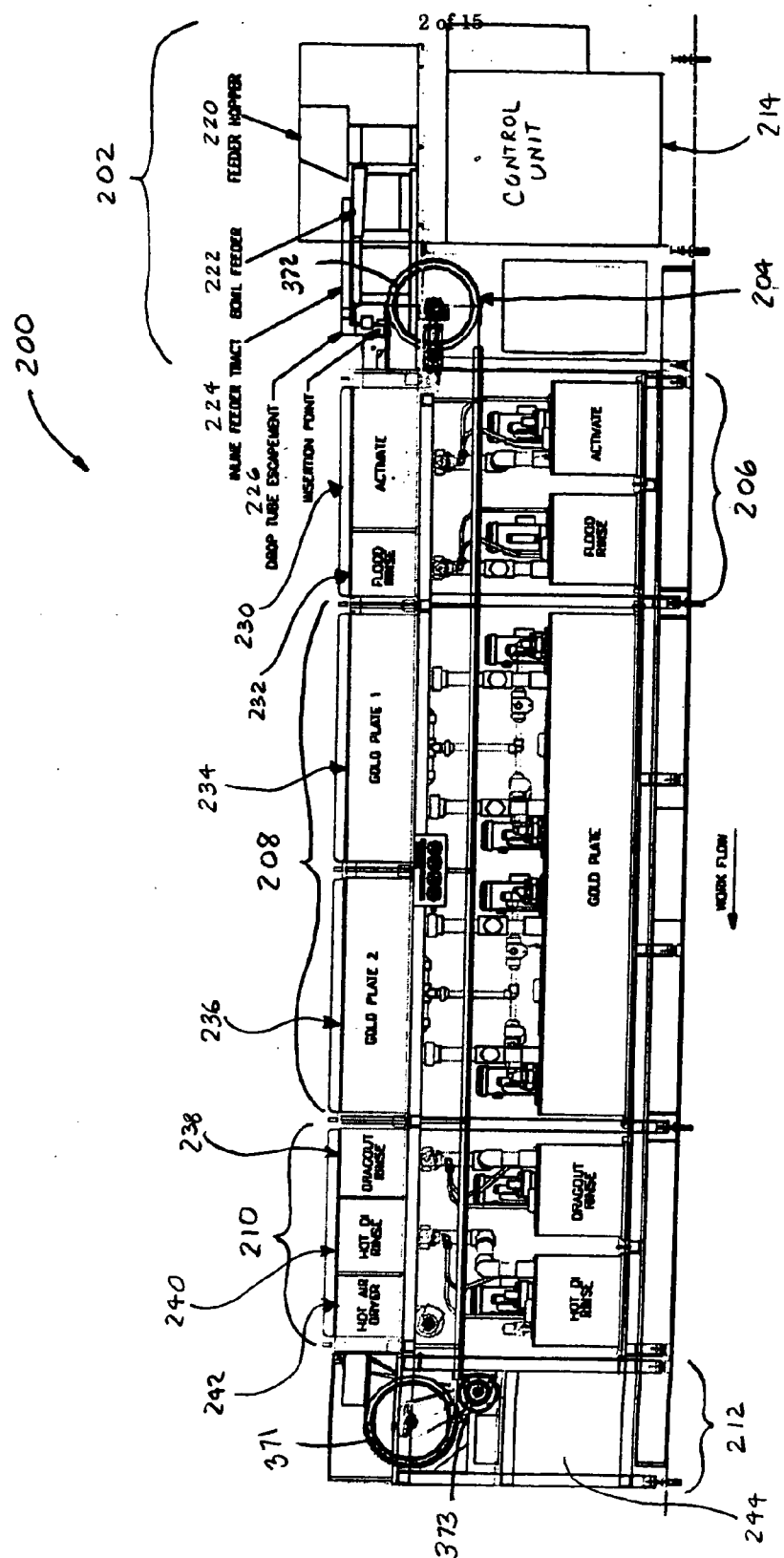
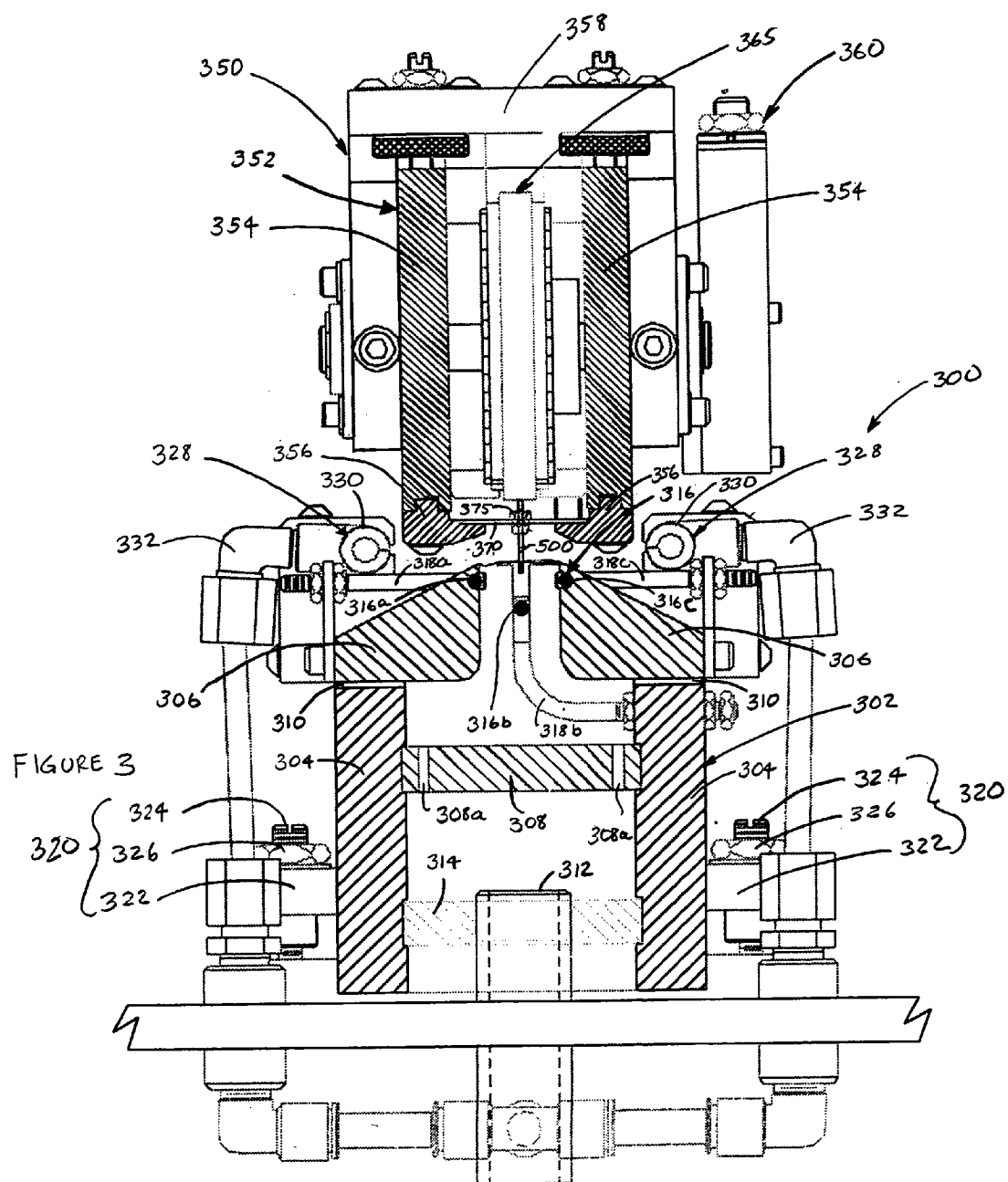


FIGURE 2



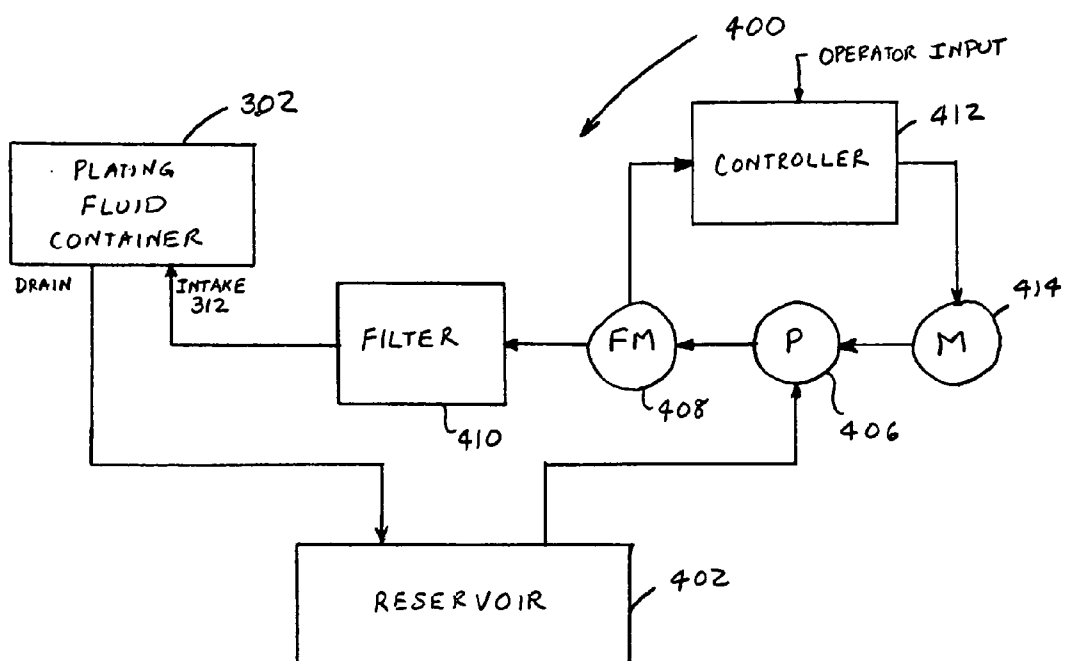


FIGURE 4

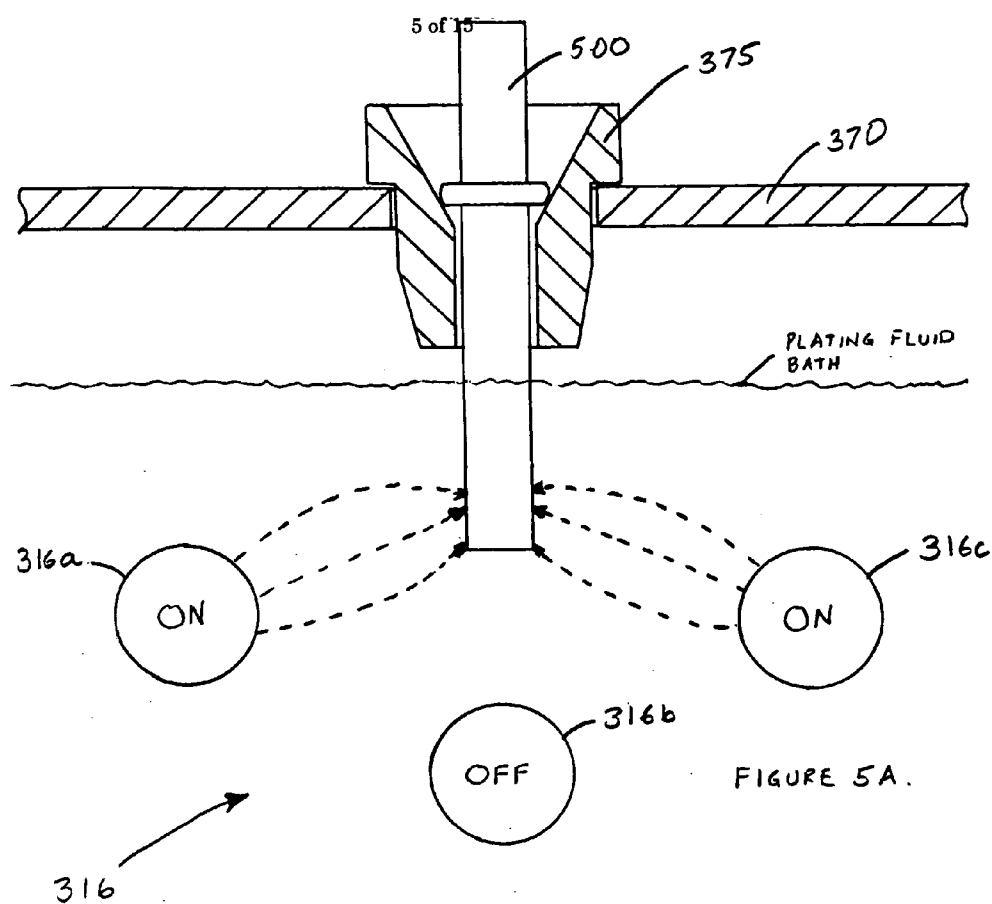


FIGURE 5A.

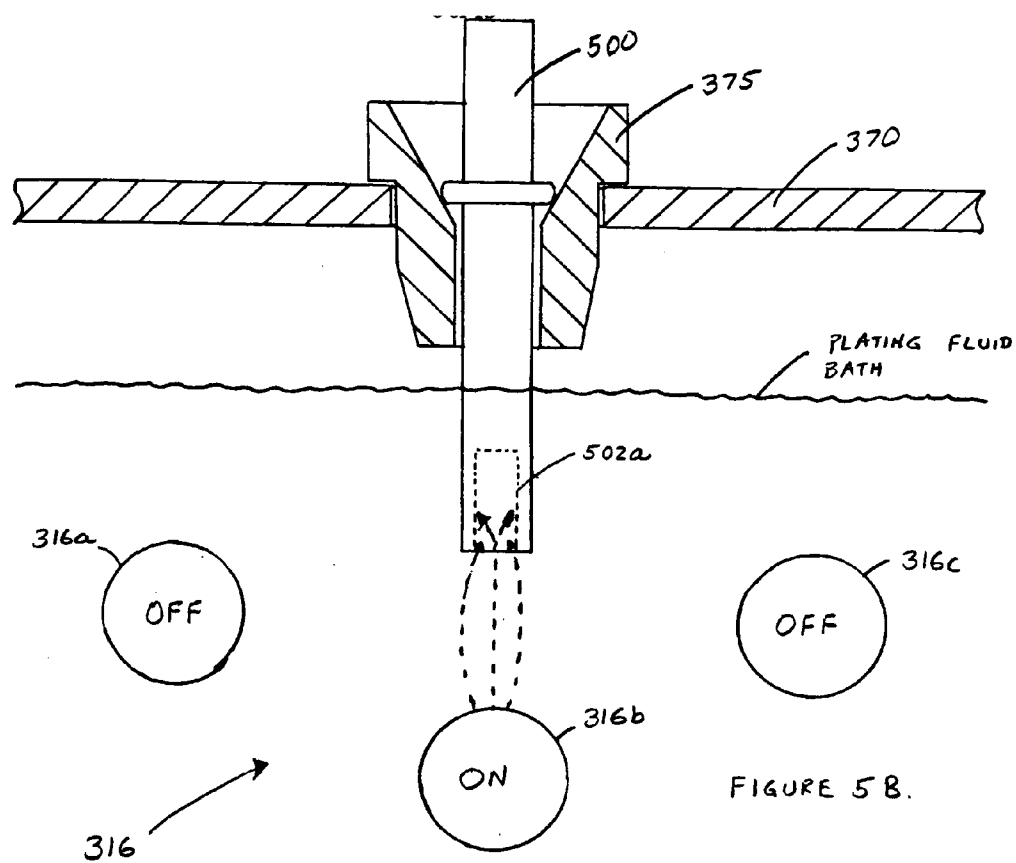


FIGURE 5B.

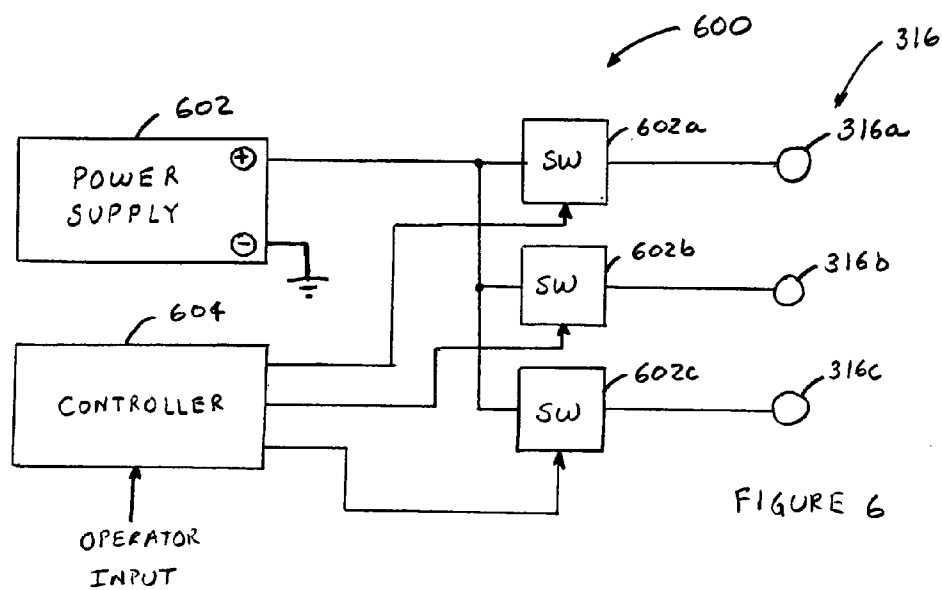
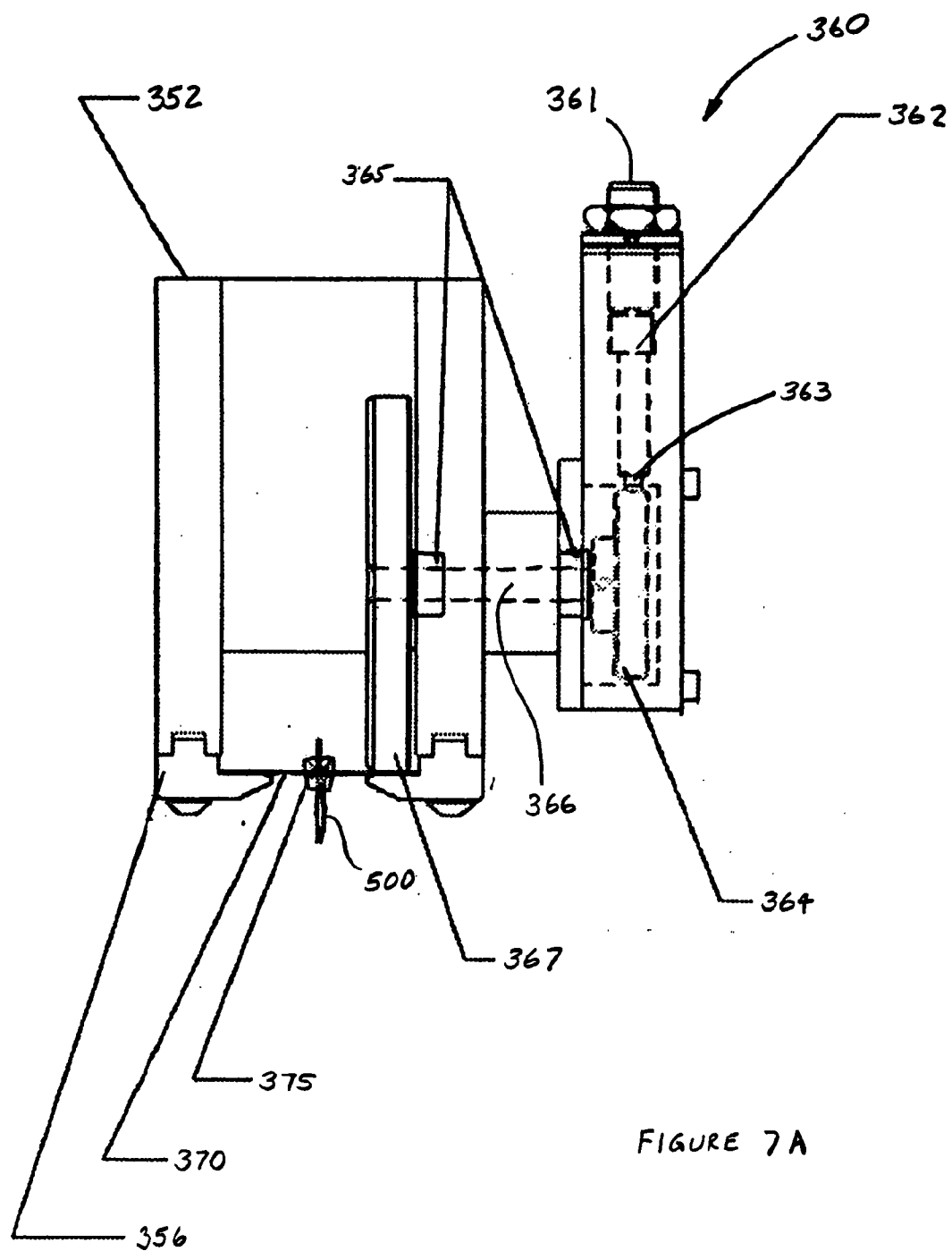


FIGURE 6



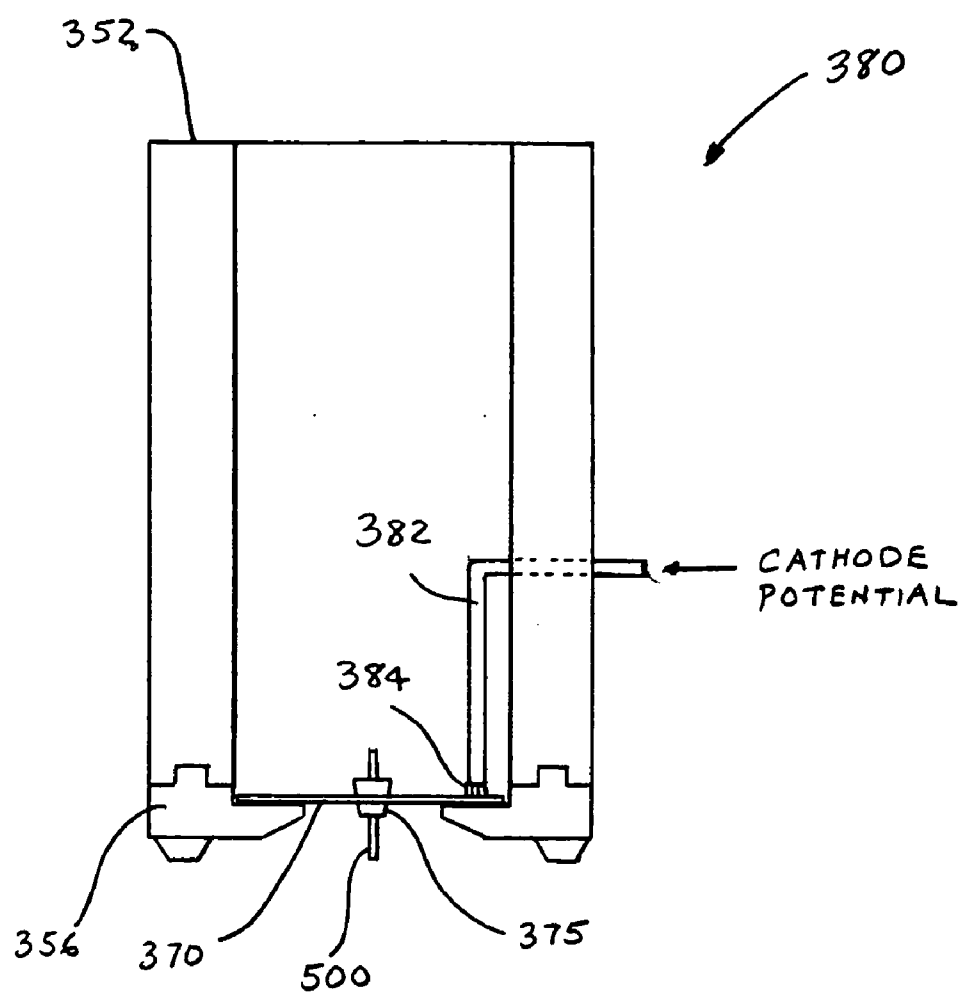


FIGURE 7B

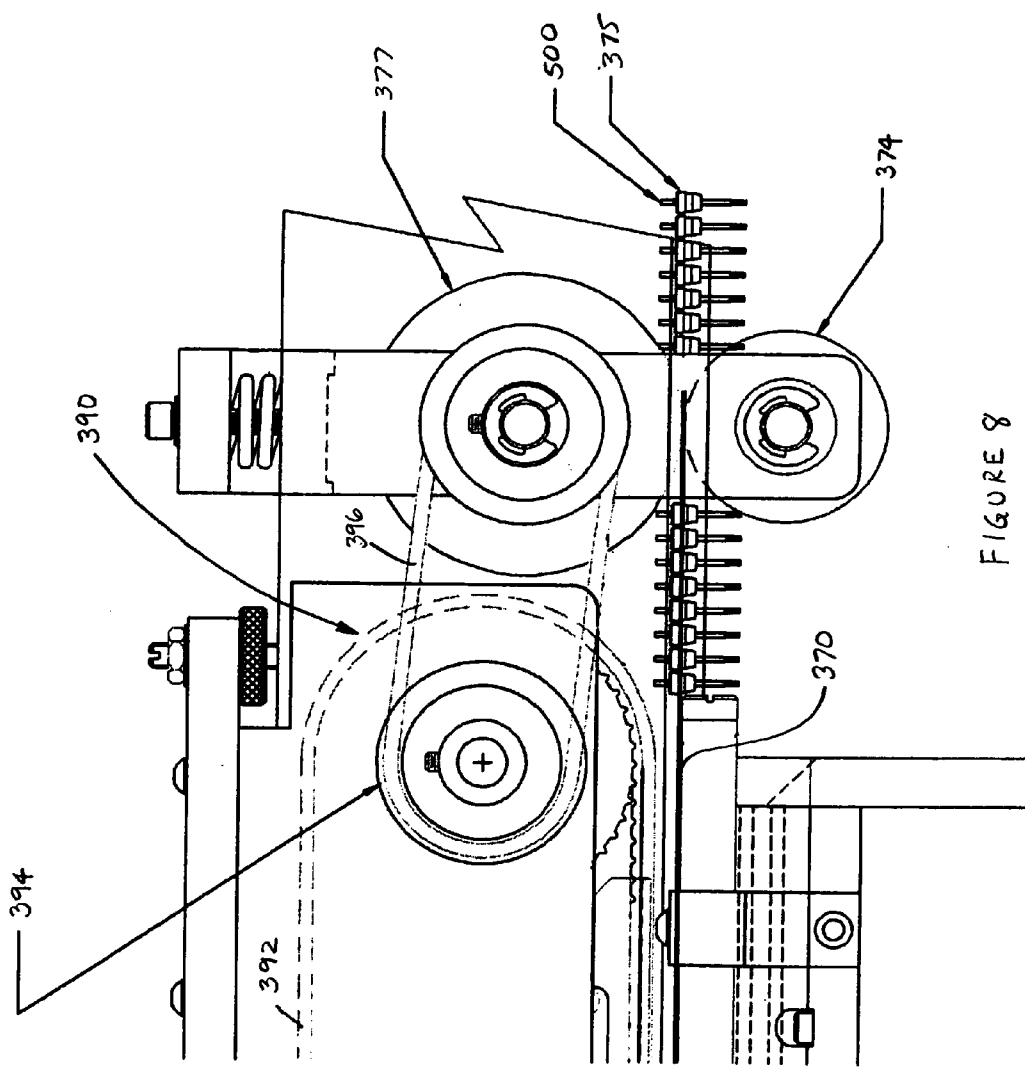


FIGURE 8

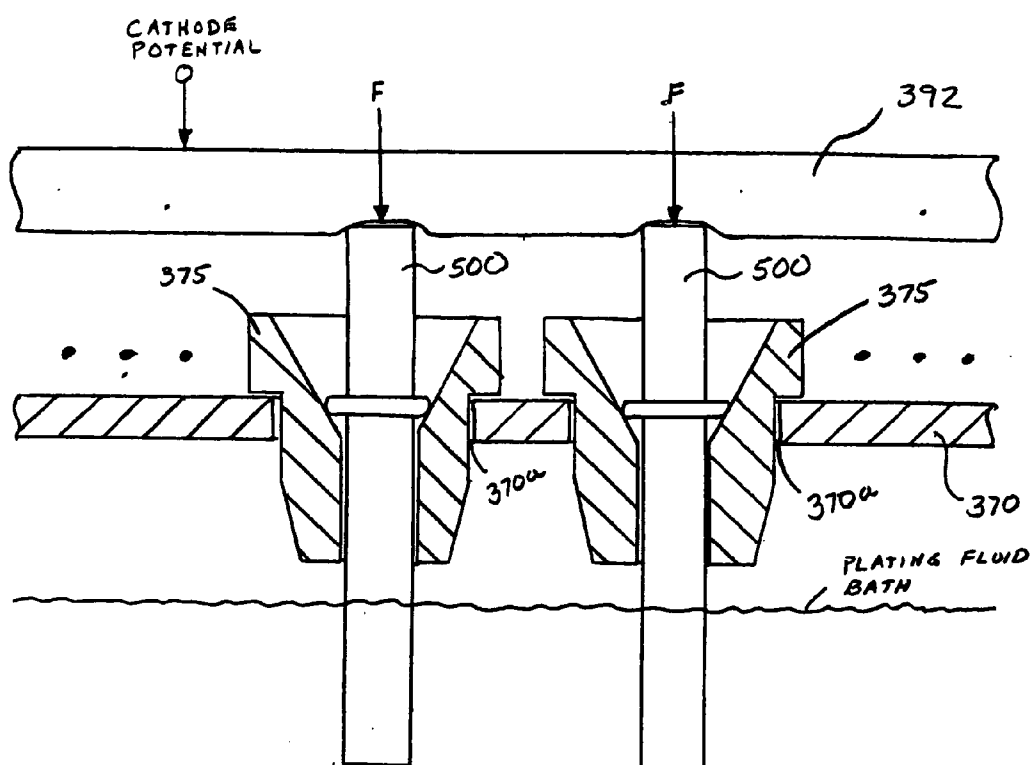


FIGURE 9A

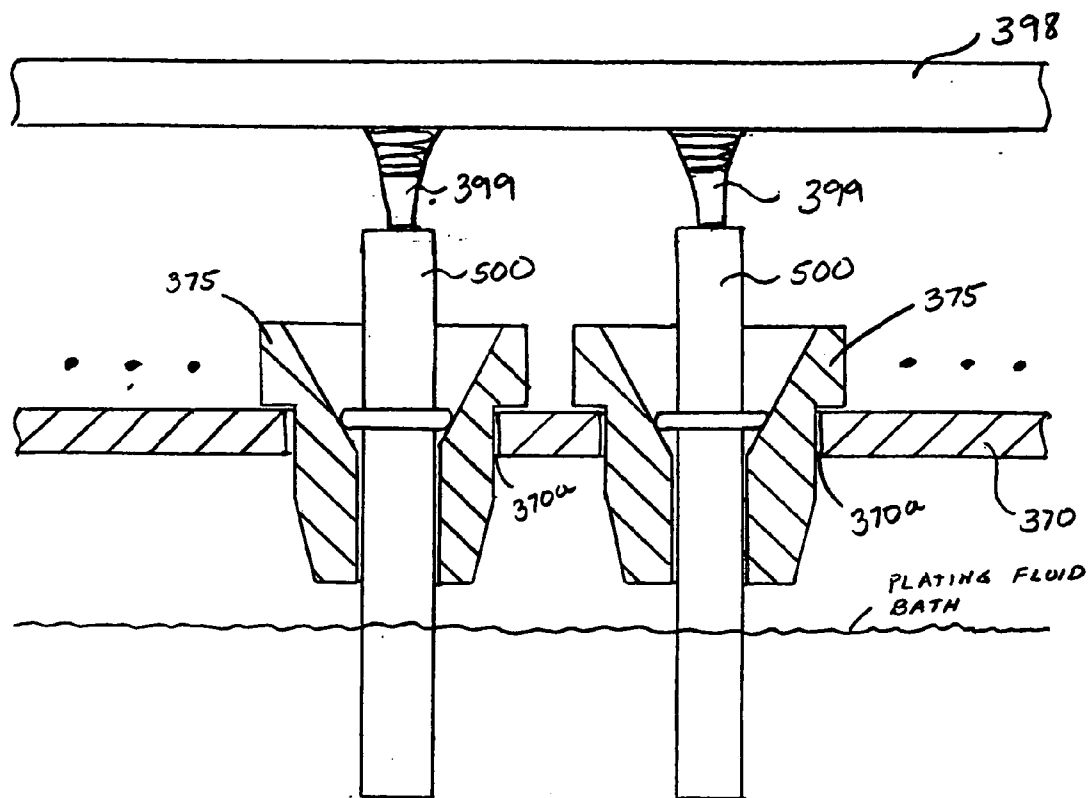


FIGURE 9B

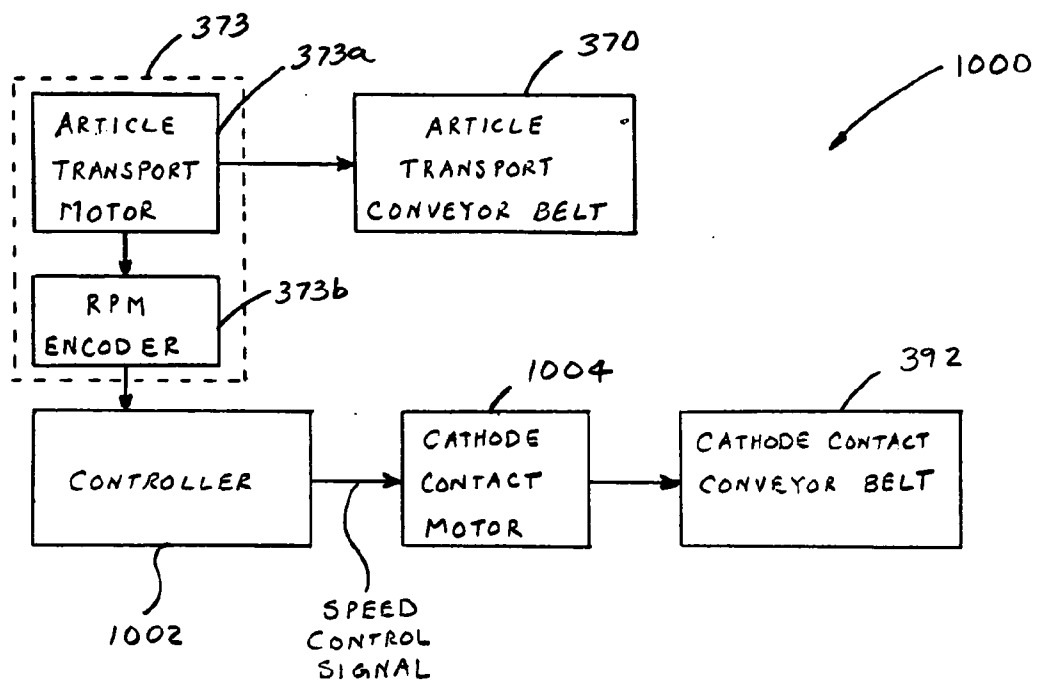


FIGURE 10

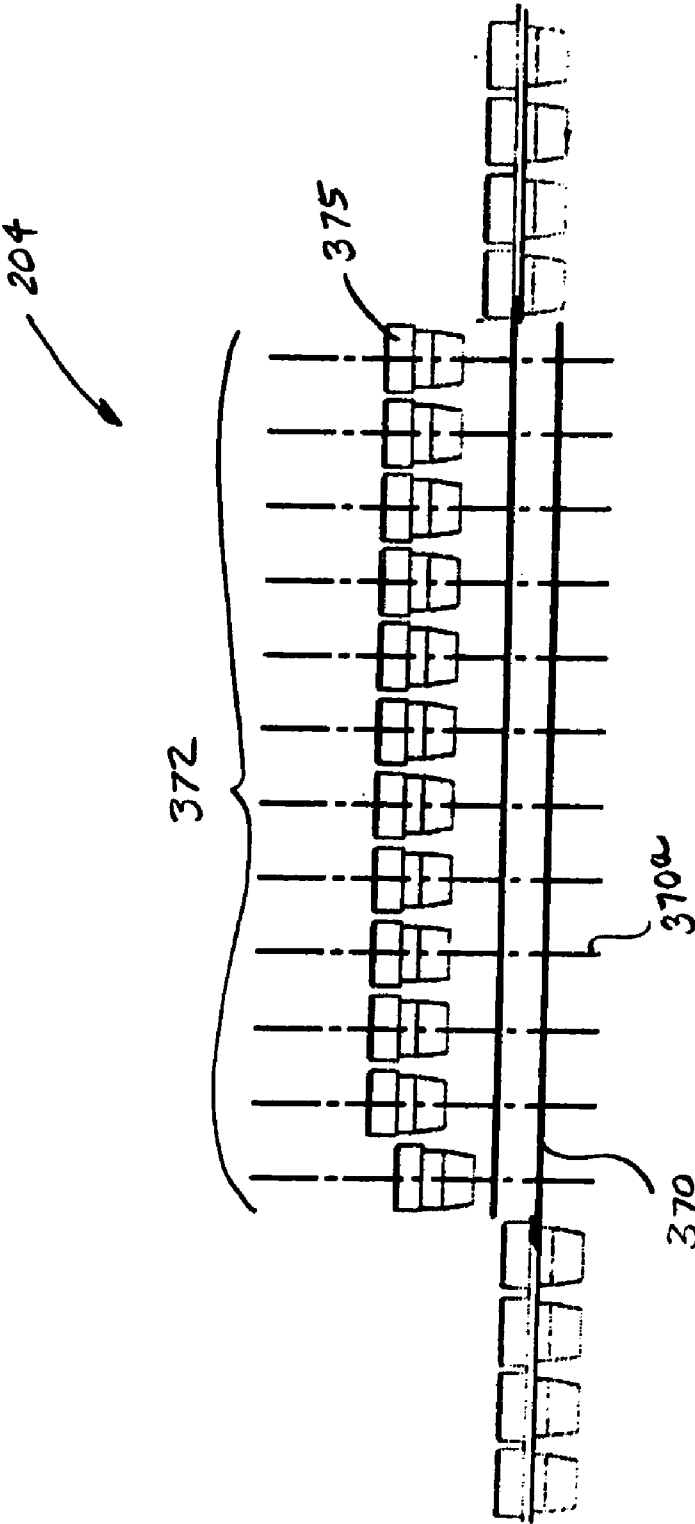


FIGURE 11

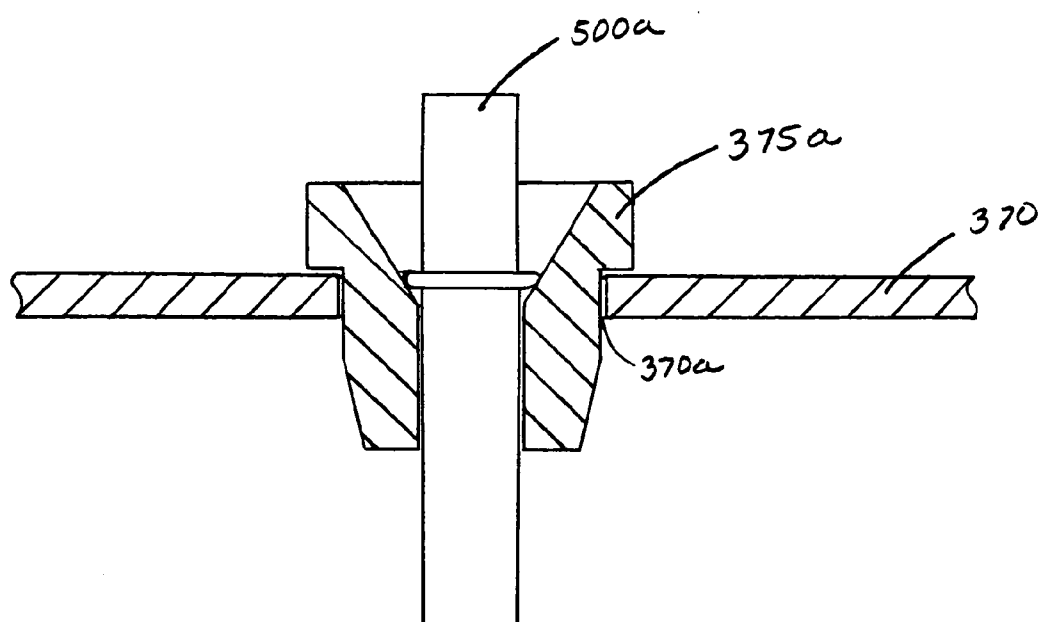


FIGURE 12A

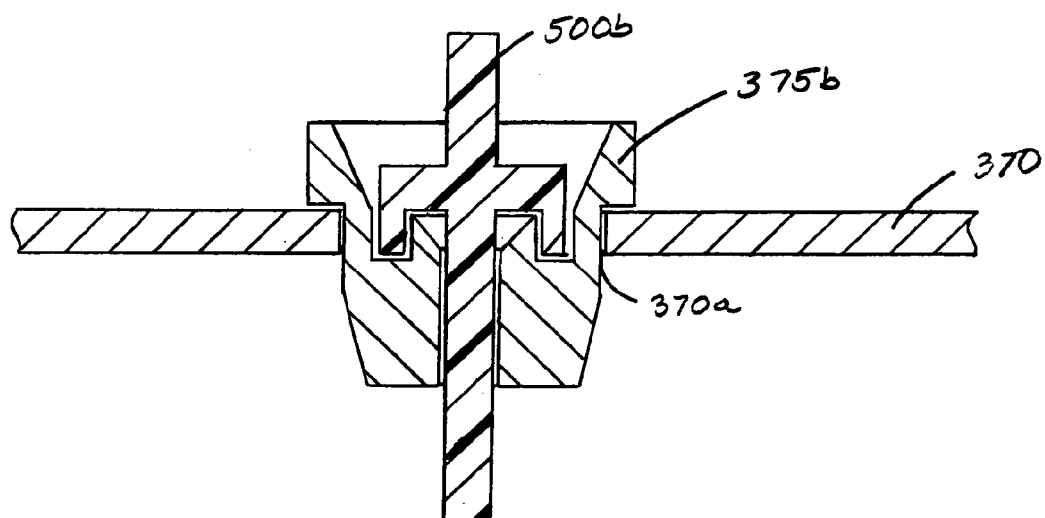


FIGURE 12B

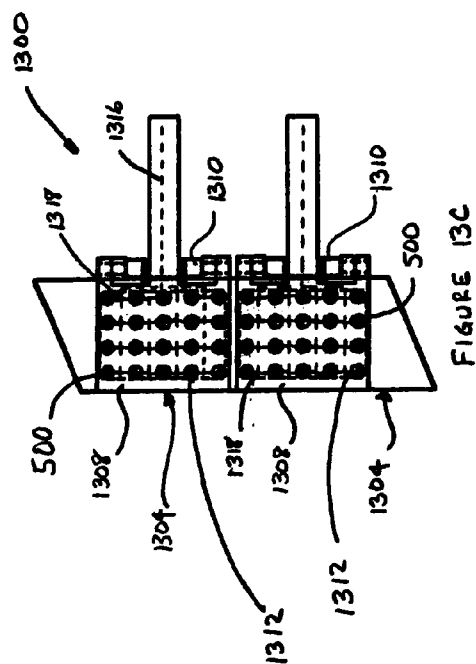


FIGURE 13C

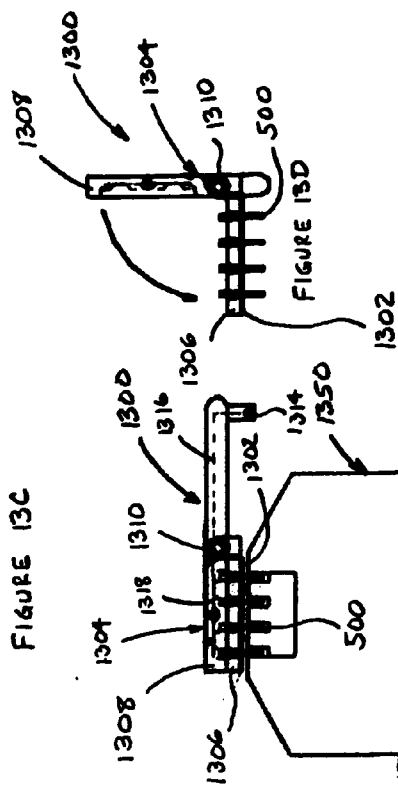


FIGURE 13D

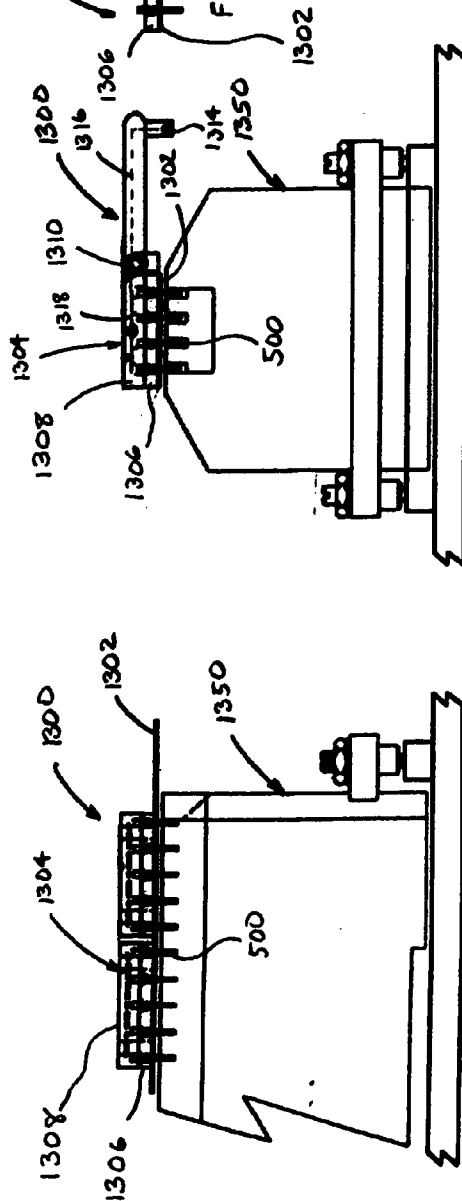


FIGURE 13A

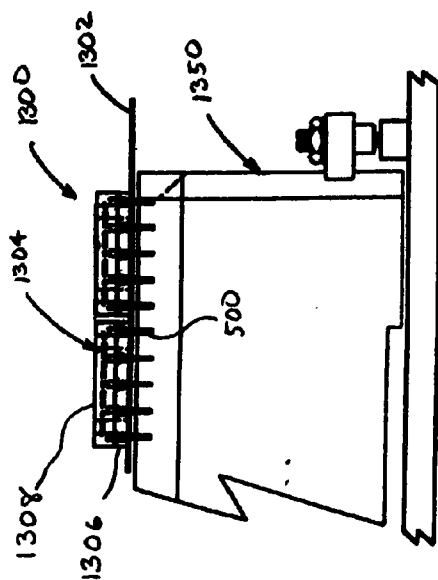


FIGURE 13B

SYSTEM AND METHOD OF CONTROLLING THE DEMARCATION LINE FORMED ON PARTIALLY ELECTROPLATED ARTICLES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of the filing date of Provisional Patent Application Ser. No. _____, filed on Mar. 30, 2005, and entitled "System and Method of Electroplating Relatively Small Articles," which is incorporated herein by reference. This application is also related to Patent Application, Ser. No. _____, filed on _____, and entitled "System and Method of Transporting and Providing a Cathode Contact to Articles in an Electroplating System," which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] This invention relates generally to electroplating systems, and in particular, to a system and method of controlling the demarcation line formed on a partially electroplated article.

BACKGROUND OF THE INVENTION

[0003] The electroplating of relatively small articles, such as connector pins and sockets, presents many challenges. These challenges include providing a relatively uniform metallic coating on the articles, efficiently using the amount of plating solution to plate the articles, and configuring the plating process and equipment to electroplate large quantities of relatively small articles, while maintaining plating uniformity and consistency.

[0004] There are presently many techniques for electroplating small articles. One such technique is referred to in the relevant field as "barrel plating." In barrel plating, small articles are placed into a barrel containing plating solution and an internal lose wire, typically referred to as a "dangler", to act as an anode. The barrel is typically positioned on its side and continuously rotated while a plating current is formed through the plating solution. A drawback of the barrel plating technique is that the entire surface of each of the articles is plated. If the entire surface need not be plated, the barrel plating technique results in a substantial excess of plating, which can be very expensive over many runs and time.

[0005] In the case where the entire surface of an article need not be plated, only the particular surface of the article that requires plating is immersed in the plating solution while undergoing an electroplating process. Such partial plating technique requires many considerations, including consistency in the amount of surface plated from article-to-article, consistency in the uniformity of the plating formed on the partial surface of the articles, and control of the demarcation lines typically formed on the articles. These considerations are further explained with reference to the following example.

[0006] FIG. 1 illustrates a side view of a relatively small article 100 undergoing an electroplating process wherein only a portion of its entire surface is being plated. In this example, the article 100 may be a contact pin or socket. The article 100 is supported in a vertical orientation by a belt 102. In particular, the article 100 includes a wider head

portion that rests on the belt 102, and a narrow body portion that extend below the belt 102 through an opening thereof. The lower portion of the article 100 is immersed in plating solution 108. An anode 106 is also immersed in the plating solution, and in this example, is situated directly below the article 100. The cathode makes electrical contact to the head portion of the article 100. If the article 100 is a socket, it may include a cavity 104 with an opening situated coaxially at the lower portion of the article 100.

[0007] As discussed above, the electroplating of relatively small articles requires many considerations. For instance, there is the consideration of the consistency in the amount of surface plated from article-to-article. In this example, it is desired that the lower portion of the article 100 be plated to a height of $H \pm \Delta H$, where ΔH is an acceptable error for the height H . If the electroplating process is unable to achieve the height requirement on a consistent article-to-article basis, many articles will be defective which can drive up substantially the costs of plating the articles. Thus, in order to provide consistency in the amount of surface plated from article-to-article, the height of the plating fluid and the vertical position of the article 100 should be well controlled.

[0008] Also, as discussed above, another consideration in providing desirable electroplating of relatively small articles is the uniformity of the plating formed on the partial surface of the articles. In this example, if the article 100 is a socket, it would be desirable to uniformly plate the cavity 104 of the socket because that is the region where electrical contact to the socket would normally be made. Accordingly, positioning the anode 106 directly below the article 100 optimizes the plating of the cavity 104 since the electric field (shown as arrows with dashed lines) has generally a preferred path to the cavity 104.

[0009] However, if the article is a pin, it would be more desirable to focus the plating to the outer wall of the pin; the region where electrical contact to the pin would normally be made. In this case, the positioning of the anode 106 directly below the article 100 does not optimize the plating of its outer wall since the electric field does not have a generally preferred path to the outer wall. In such a case, it would be preferable to place the anode 106 on the side of the pin. However, the positioning of the anode 106 to the side of the pin, would not be desirable for plating a socket. Thus, to provide optimal plating of different articles (e.g., sockets, pins, etc.), it would be desirable for the position of the anode relative to the article to be adjustable.

[0010] Further, as discussed above, the other consideration in providing desirable electroplating of relatively small articles is the control of the demarcation line formed on the articles. Often, during the partial plating of an article 100, a discoloration 110, often referred to as a demarcation line, forms on the article 100 near the surface of the plating solution. It has been previously theorized that the demarcation line 110 was formed by the surface of the plating solution. Through various experiments, it has been discovered by the inventors that the demarcation line 110 actually forms on the article 110 a relatively short distance above the surface of the plating solution. The inventors theorized that the demarcation line 110 is formed by ejection of the plating fluid and subsequent impingement of the plating fluid vapors onto the article. Based on this theory, the inventors have

devised a system and method of preventing or reducing the occurrence of the formation of the demarcation line 110 on articles.

[0011] Also, in an electroplating system, the articles are typically transported from a loading station through various processing stations, and then to an unloading station. When the articles are within the electroplating station, a cathode contact to the articles is needed to perform the electroplating process. Accordingly, there is a need for a transport system that not only transports the articles from the loading station to the unloading station by way of the various processing stations, but there is a further need for the transport system to provide a cathode contact to the articles.

[0012] These needs and other are met by the various exemplary embodiments of the invention described in detail below.

SUMMARY OF THE INVENTION

[0013] An aspect of the invention relates to a processing system, electroplating cell, and method of electroplating only a desired portion of respective articles. The processing system comprises a pre-processing station including one or more cells to perform one or more pre-electroplating processes on the articles, for example an activation and rinse processes; an electroplating station including one or more cells to plate the articles with one or more desired materials, for example gold; and a post-processing station including one or more cells to perform one or more post-electroplating processes, for example, a dragout rinse, hot deionized rinse, and hot air dryer processes. The processing system may further include a transport system to transport the articles from a loading station to an unloading station by way of the pre-processing, electroplating, and post-processing stations.

[0014] The electroplating cell comprises a container to support a plating fluid bath and an anode electrode situated within the container and adapted to contact the plating fluid bath. The methodology of electroplating only a desired portion of the respective articles entails several aspects such as the transport system being secured to a fixed member such that the vertical position (i.e., height) of the articles remains substantially constant as the articles are transported in and out of the electroplating cell. Also, the electroplating cell includes a vertical-adjustment mechanism to adjust the height of the container such that the desired portion of the respective articles is immersed in the plating fluid bath at a precise controlled depth. The electroplating cell further includes a flow control system to control the flow rate of plating fluid into the container such that the height of the surface of the plating fluid bath is maintained substantially constant. The container additionally includes one or more bleed holes through its walls, which assist in stabilizing the surface of the plating fluid bath.

[0015] Another aspect of the invention relates to a processing system, electroplating cell, and method of adjusting the effective position of a plurality of anode electrodes to desirably electroplate different type articles. The processing system may be similar to the one described above, including a loading station, pre-processing station, electroplating station, post-processing station, unloading station, and a transport system that transports the articles to the various stations. The electroplating cell comprises a container to support a plating fluid bath, a plurality of spaced-apart anode elec-

trodes situated within the container and adapted to contact the plating fluid bath, and a power supply system adapted to energize a first subset of the anode electrodes with an anode voltage when plating one or more first type articles, and to energize a second and different subset of the anode electrodes with an anode voltage when plating one or more second and different type articles.

[0016] Another aspect of the invention relates to a processing system, electroplating cell, and method of reducing the discoloration (i.e., demarcation line) that often forms on articles undergoing a partial plating process. The processing system may be similar to the ones described above, including a loading station, pre-processing station, electroplating station, post-processing station, unloading station, and a transport system that transports the articles to the various stations. The electroplating cell comprises a container to support a plating fluid bath, an anode electrode situated within the container and adapted to contact the plating fluid bath, a support structure, which may be part of the transport system, to support the articles such that only a portion thereof is immersed in the plating fluid bath, and a gas flow system adapted to cause gas flow (e.g., air, nitrogen gas, argon gas, etc.) proximate the interface of the articles to the plating fluid bath. The gas flow near the articles prevents or reduces plating fluid vapors from impinging the articles, thereby reducing the discoloration that would otherwise form on the articles.

[0017] Another aspect of the invention relates to a processing system, transport subsystem, cathode contact subsystem and method of providing a cathode contact to the articles being transported within an electroplating cell. The processing system may be similar to the ones described above, including a loading station, pre-processing station, electroplating station, post-processing station, unloading station, and a transport system that transports the articles to the various stations. The transport system comprises an electrically conductive, movable support structure to support the articles; and the cathode contact system is adapted to provide a cathode potential to the one or more articles by way of the electrically conductive, movable support structure.

[0018] Another aspect of the invention relates to a processing system, electroplating cell, transport system, cathode contact subsystem and method of providing a cathode contact to the articles being transported within an electroplating cell. The processing system may be similar to the ones described above, including a loading station, pre-processing station, electroplating station, post-processing station, unloading station, and a transport system that transports the articles to the various stations. The electroplating cell comprises a container to support a plating fluid bath, and an anode electrode situated within the container and adapted to contact the plating fluid bath. The transport system is adapted to transport the articles to and from the various stations. The cathode contact system comprises an electrically-conductive moving structure adapted to make cathode contact to said articles and move substantially in synchronous with the articles.

[0019] Another aspect of the invention relates to a processing system, electroplating cell, transport system, cathode contact subsystem and method of providing a cathode contact to the articles being transported within an electro-

plating cell. The processing system may be similar to the ones described above, including a loading station, pre-processing station, electroplating station, post-processing station, unloading station, and a transport system that transports the articles to the various stations. The transport system comprises a plurality of carriers supported by a conveyor structure. Each of the carriers are adapted to support at least one article, but may be able to support a plurality of articles configured into various patterns, such as a single row, or a plurality of rows (i.e., an array). Further, the carriers are adapted to provide a cathode contact to the articles.

[0020] Other aspects, features, and techniques of the invention will be apparent to one skilled in the relevant art in view of the following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] **FIG. 1** illustrates a side view of a relatively small article undergoing an electroplating process where only a portion of its entire surface is being plated;

[0022] **FIG. 2** illustrates a side view of an exemplary electroplating system in accordance with an embodiment of the invention;

[0023] **FIG. 3** illustrates a side cross-sectional view of an exemplary electroplating cell in accordance with another embodiment of the invention;

[0024] **FIG. 4** illustrates a block diagram of an exemplary system for controlling the plating fluid flow into the electroplating cell in accordance with another embodiment of the invention;

[0025] **FIG. 5A** illustrates a side view of an exemplary anode electrode configuration operated in a first manner in accordance with another embodiment of the invention;

[0026] **FIG. 5B** illustrates a side view of the exemplary anode electrode configuration operated in a second manner in accordance with another embodiment of the invention;

[0027] **FIG. 6** illustrates a block diagram of an exemplary anode power system in accordance with another embodiment of the invention;

[0028] **FIG. 7A** illustrates a side view of an exemplary cathode contact system in accordance with another embodiment of the invention;

[0029] **FIG. 7B** illustrates a side view of another exemplary cathode contact system in accordance with another embodiment of the invention;

[0030] **FIG. 8** illustrates a side view of an exemplary cathode contact preload system in accordance with another embodiment of the invention;

[0031] **FIG. 9A** illustrates a side view of the exemplary cathode contact preload system in contact with a pair of articles in accordance with another embodiment of the invention;

[0032] **FIG. 9B** illustrates a side view of another exemplary cathode contact preload system in contact with a pair of articles in accordance with another embodiment of the invention;

[0033] **FIG. 10** illustrates a block diagram of an exemplary synchronization system to synchronize the speed of the article transport conveyor belt with the cathode contact conveyor belt in accordance with another embodiment of the invention;

[0034] **FIG. 11** illustrates a side view of a portion of the exemplary article transport system in accordance with another embodiment of the invention;

[0035] **FIG. 12A** illustrates a side view of an exemplary carrier in accordance with another embodiment of the invention;

[0036] **FIG. 12B** illustrates a side view of another exemplary carrier in accordance with another embodiment of the invention; and

[0037] **FIGS. 13A-D** illustrate front, side, top and open views of another exemplary article transport system in accordance with another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

I. Overall Electroplating System

[0038] **FIG. 2** illustrates a side view of an exemplary electroplating system **200** in accordance with an embodiment of the invention. The electroplating system **200** comprises a loading station **202**, a transport system **204**, a pre-processing station **206**, an electroplating station **208**, a post-processing station **210**, an unloading station **212**, and a control unit **214**. The loading station **202** automatically loads articles onto the transport system **204**. The transport system **204** transports the articles from the unloading station **202** through the various processing stations **206**, **208**, and **210**, and finally to the unloading station **212**.

[0039] In this example, the pre-processing station **206** performs an activation (e.g., cleaning) and rinsing of the articles. The electroplating station **208** performs one or more electroplating processes to form a desired plating of the articles. The post-processing station **210** performs a dragout rinse, a hot de-ionized (DI) water rinse, and a hot air drying of the articles. The unloading station **212** unloads the articles from the transport system **204** into an output bin **244**. The control unit **214** controls the operations of the electroplating system **200**.

[0040] More specifically, the loading station **202** comprises a feeder hopper **220**, a bowl feeder **222**, an inline feeder tract **224**, and a drop tube escapement **226**. The feeder hopper **220** receives articles to undergo the processes provided by the electroplating system **200**. In this example, the feeder hopper **220** holds approximately $\frac{1}{2}$ cubic feet of articles to be processed, and dispenses articles to the bowl feeder **222** based on a signal it receives therefrom. For example, the feed hopper **220** is disabled unless it receives a low-level condition signal from the bowl feeder **222**.

[0041] The bowl feeder **222** orients the articles appropriately (e.g., in a substantial vertical fashion with the portion thereof to be plated situated at the lower end of the articles), and serially provides the oriented articles to the inline feeder tract **224**. The inline feeder tract **224** transports the articles in a linear fashion to the drop tube escapement **226**. The drop tube escapement **226**, using a pressurized air nozzle, releases single articles downward to respective carriers periodically

spaced on a conveyor belt as part of the transport system **204**. The drop tube escapement **226** releases articles on the basis of a position encoder which tracks the position of the carriers as the conveyor belt moves and sends signals to the drop tube escapement **226** at the proper times to cause the articles to be inserted into respective carriers.

[0042] As is discussed in more detail below, the transport system **204** includes a horizontally-oriented endless conveyor belt rotationally supported by vertically-oriented **371** and **372**. As discussed above, the belt is tooled with removable carriers situated into periodic spaced-apart openings through the belt. In this example, the transport system **204** may include two independent conveyor belts each with their own loading and unloading stations **202** and **212**. The belts are, however, attached to a common drive motor **373** with closed loop speed control. Each conveyor belt has an independent tensioning and disengaging device to allow the running of one conveyor belt while the other is available for servicing. It shall be understood that the belt may be replaced with other types of conveyable structures, such as a chain or cable.

[0043] As discussed above, the pre-processing station **226**, in this example, includes an activate cell **230** and a flood rinse cell **232**. The process performed in the activate cell **230** serves to remove contaminants, such as light surface soils and metal oxides, from the articles prior to plating. In this example, the articles may be immersed in a bath of alkaline solution. Alternatively, or in addition to, the articles may undergo an anode and/or cathode cleaning process to generate oxygen (reverse) or hydrogen (direct) on the surface of the articles. In such a case, electrodes are also immersed in the solution to generate the current needed to perform the anode and/or cathode cleaning process. There are many other processes that may be employed in the activate cell **230** in order to prepare the articles for the electroplating process.

[0044] In the flood rinse cell **232**, the articles undergo a process to remove and contain residual activation chemistry (also known as "dragout") that may be present on the surface of the articles due to the prior activation process. This prevents the activation chemistry from contaminating the electroplating cell **234**. In this example, the articles may be immersed in de-ionized water reservoir and/or sprayed also with de-ionized water. The de-ionized water may be recirculated to and from a rinse reservoir. In such a case, the de-ionized water may be replaced with clean water on a time basis. Accordingly, a programmed timer may be provided to operate a valve to open a fresh DI water supply line in order to replenish the rinse reservoir.

[0045] As discussed above, the electroplating station **208** may include one or more plating cells. In this example, two gold electroplating cells **234** and **236** are shown. It shall be understood that the electroplating need not be limited to gold. Other materials may be used to plate the articles. As discussed in more detail in Section II entitled the Electroplating Station, each of the electroplating cells **234** and **236** are configured to control the amount of partial plating of the articles; adjust the effective position of the anode to improve the plating of selected regions of the articles; reduce or eliminate the demarcation line that would otherwise form on the articles; provide a cathode connection to the articles that reduces contamination of the electroplating cell.

[0046] As discussed above, the post-processing station **210**, in this example, includes a dragout rinse cell **238**, a hot DI rinse cell **240**, and a hot air dryer cell **242**. In the dragout rinse cell **238**, a process may be employed to remove residual chemistry remaining on the articles due to the prior electroplating process or processes. The process may be similar to the one performed in the flood rinse cell **232** previously described. Additionally, the process may include a gold recovery chamber to collect any gold metal removed from the articles during the rinse process. In particular, the gold recovery chamber may include ion exchange resin beads, which attract the gold metal as the recirculated water passes through the chamber. After a determined time period, the resin beads are removed from the chamber, and the gold metal is recovered from the resin material.

[0047] In the hot rinse cell **240**, a process may be employed to remove any remaining residues from the articles due to the prior dragout rinse process. In this example, the articles are subjected to a rinse (e.g., bath and/or spray) using hot deionized water, which may also be recirculated. The hot rinse cell **240** may be equipped with a heater to raise the temperature of the water to a desired level.

[0048] In the hot air dryer cell **242**, a process may be employed to substantially dry the articles. In this example, the hot air dryer cell **242** includes a metal chamber that encloses that portion of the conveyor belt and articles thereon. A thermostatically controlled hot air blower may be located at the bottom of the metal chamber. The chamber may be designed to direct a flow of temperature-controlled hot air around the articles as the conveyor belt passes through the cell **242** to substantially remove the residual water from the articles due to the prior hot DI rinse process.

[0049] As discussed above, the electroplating system **200** also includes a loading station **212** that removes the processed articles from the conveyor belt and into an output bin **244**. In this example, the output bin **244** is located below the drive wheel of the conveyor belt to collect the articles as they fall from the belt in the region where the belt is being inverted. The unloading station **212** may also include a compressed air nozzle or other mechanical devices configured to assist the removal of the articles from the conveyor belt into the output bin **244**. The output bin **244** may be removable by an operator when it becomes full with processed articles.

[0050] The following section entitled Electroplating Station describes in more detail an exemplary electroplating cell.

II. Electroplating Station

[0051] As discussed above, the electroplating station **208** of the exemplary electroplating system **200** may include one or more electroplating cells, such as cells **234** and **236**, to form a desired partial plating of articles. The following describes a detailed embodiment of an exemplary electroplating cell that may serve as one or more cells of the electroplating station **208** of the exemplary electroplating system **200**. This exemplary electroplating cell is characterized in having a system and method of controlling the amount of partial plating of the articles; a system and method of selectively adjusting the effective position of the anode; a system and method of eliminating or reducing the demarcation line that typically forms on articles above the

plating fluid surface; a system and method of providing a cathode connection to the articles; and a system and method of improving the cathode contact of the articles. An overview of the exemplary electroplating cell is discussed below.

[0052] A. Overview of Electroplating Cell

[0053] FIG. 3 illustrates a side cross-sectional view of an exemplary electroplating cell 300 in accordance with another embodiment of the invention. The electroplating cell 300 comprises a container 302 for supporting a plating fluid bath. The container 302 includes lower walls 304, upper walls 306, and a sparger 308, including one or more vertically-oriented thru-holes 308a. The sparger 308 is connected horizontally to the lower walls 304. In this example, the upper walls 306 are situated closer to each other to form a narrower upper container portion, whereas the lower walls 304 are situated farther apart to form a wider lower container portion. Also in this example, the sparger 308 traverses the lower container portion to form an upper-lower container portion and a lower-lower container portion. The container 302 further includes one or more bleed ports 310 situated between the upper walls 306 and the lower walls 304. The container 302 further includes a vertically-oriented inlet pipe 312 partially situated within the lower-lower container portion, and supported by a transverse member 314 connected horizontally to the lower walls 304.

[0054] The electroplating cell 300 further comprises an anode electrode configuration 316 including, in this example, a plurality of anode electrodes 316a, 316b, and 316c situated in the upper container portion between upper walls 306. The anode electrodes 316a, 316b, and 316c are respectively supported by respective members 318a, 318b, and 318c. The support members 318a, 318b, and 318c, in turn, enclose wiring that electrically connect the respective anode 316a, 316b, and 316c to the positive terminal of a power supply. In this example, the anode electrodes 316a and 316c are situated near the top of the respective upper walls 306, and the anode electrode 316b is situated approximately in the middle between the upper walls 306 and lower than the other anode electrodes 316a and 316c.

[0055] The electroplating cell 300 further includes one or more vertical-adjustment mechanisms 320 for adjusting the height of the plating fluid container 302. In this example, each vertical-adjustment mechanism 320 includes a threaded container member 322 connected to the exterior of the lower walls 304 of the plating fluid container 302. Each vertical-adjustment mechanism 320 further includes a bolt 324 threaded with the container member 322, and having a bottom lying on a substantially fixed member. Additionally, each vertical-adjustment mechanism 320 includes a lock nut 326 for preventing undesired rotation of the bolt 324. The lock nut 326 is threaded with the bolt 324, and lies on top of the container member 322.

[0056] The electroplating cell 300 further includes an gas-flow system 328 for directing gas flow toward (positive pressure) or away from (negative pressure) the articles while they undergo an electroplating process. Examples of gases that can be used include air, nitrogen gas, argon gas, etc. The gas-flow system 328 includes a pipe 332 for routing gas flow towards or away from a nozzle 330 that includes an opening configured to direct gas flow towards or away from the articles. As is discussed in more detail later, the continued direction of gas flow towards or away from the articles while

they undergo an electroplating process prevents and/or eliminates a discoloration of the articles that typically forms above the plating fluid bath surface.

[0057] Also illustrated in FIG. 3 is portion of an exemplary article transport system 350, which may be an exemplary detailed version of the transport system 204 of the electroplating system 200. The transport system 350 comprises a frame 352 for supporting and guiding the movement of a conveyor belt 370 supporting a plurality of insert-carriers 375 which, in turn, carry respective articles 500. In this example, the frame 352 comprises upper walls 354, lower walls 356, and upper cross member 358. The conveyor belt 370 is supported and guided, in particular, by the lower walls 356 of the frame 352. The frame 352 supports other elements of the electroplating system 200 including the cathode contact system 360 and the cathode contact preload system 365, which are discussed in further detail below.

[0058] B. Controlling the Amount of Partial Plating of the Articles

[0059] The electroplating cell 300 is configured to provide a desired control of the amount of partial plating of the articles. It achieves this desired control by providing a substantially stable frame 352 that supports articles at substantially a fixed height, a vertically-adjustable plating fluid container 302, a control system for controlling the flow of plating fluid into the plating fluid container, and one or more bleed ports 310 embedded in the plating fluid container to substantially stabilize the surface of the plating fluid bath.

[0060] As discussed above, the frame 352 supports and guides the movement of the conveyor belt 370 as it moves through the various processing stations of the electroplating system 200. A plurality of insert carriers 375 are securely inserted into corresponding spaced-apart openings in the conveyor belt 370. Each of the insert carriers 375 support an article 500 in a substantially vertical orientation. A portion of the article 500 below the insert carrier 375 is immersed in the plating fluid bath supported by the container 302. It is this portion of the article 500 that is being plated. In order to achieve the desired control of the amount of partial plating of the articles, the vertical position of the articles should be controlled as well as the height of the surface of the plating fluid bath.

[0061] With regard to the control of the vertical position of the articles, the frame 352 that supports the conveyor belt 370 including the insert carriers 375 that carry the articles, is connected to a substantially fixed member of the electroplating system 200. In addition, the frame 352 is made of relatively high strength material, such as stainless steel, such that the frame 352 exhibits substantially no movement in the vertical direction during the operation of the transport system 350. These characteristics of the frame 352 ensure that the articles exhibit substantially no movement in the vertical direction while being transported through the electroplating cell 300.

[0062] With regard to the control of the height of the surface of the plating fluid bath, the electroplating cell 300 includes three elements that assist in this control. First, as previously discussed, the height of the plating fluid container 302 may be adjusted by the vertical-adjustment mechanism 320. This allows the proper setting of the height of the surface of the plating fluid bath supported by the

container 302 by adjusting the bolt 324 and subsequently fixing the desired position by tightening the lock nut 326. Second, the bleed ports 310 allows plating fluid from the bath to bleed into a drain. The bleed ports 310 improve the stability of the height of the surface of the plating fluid bath. Plating fluid from the surface of the bath also continuously drains by flowing down the inclined surface of the upper walls 306 of the container 302. Third, the flow of plating fluid into the bath by way of the inlet pipe 312 is controlled with the use of a feedback control system, an example of which is discussed below.

[0063] FIG. 4 illustrates a block diagram of an exemplary system 400 for controlling the plating fluid flow into the plating fluid container 302 in accordance with another embodiment of the invention. The system 400 comprises a reservoir 402, a pump 406, a flow meter (FM) 408, a filter 410, a controller 412, and a motor 414. The reservoir 402 holds plating fluid for use in plating articles. The pump 406 causes plating fluid to flow from the reservoir 402 to the plating fluid container 302 by way of the flow meter 408, filter 410, and intake pipe 312. The flow meter 408 generates a signal indicative of the flow rate of the plating fluid into the container 302. The filter 410 removes contaminants from the plating fluid. The motor 414 drives the pump 406. The controller 412 senses the flow rate of the plating fluid by receiving the signal from the flow meter 408, and controls the motor 414 so that the desired flow rate for the plating fluid flow is established and maintained. The controlled plating fluid flow into the container 302 and the plating fluid that drains out of the container 302 from the top of the electroplating cell 300 and from the bleed ports 310 substantially stabilizes the height of the surface of the plating fluid bath.

[0064] C. Selectively Adjusting the Effective Position of the Anode

[0065] As discussed in the Background section, optimal electroplating of different articles may require different anode configurations. For instance, certain articles such as pins, where the plating of their respective side walls is most desirable, the anode electrodes should be positioned such that the electric field lines have a generally direct path to the surface that requires plating, i.e., the side walls of the pins. Other articles, such as sockets, where the plating of their respective cavities is most desirable, the anode electrodes should be positioned such that the electric field lines have a generally direct path to the surface that requires plating, i.e., the cavities of the sockets. As discussed in detail below, the exemplary anode electrode configuration 316 of the electroplating system 200 allows for the effective position of the anodes to be adjusted in order to provide the desired plating of the articles.

[0066] FIG. 5A illustrates a side view of an exemplary anode electrode configuration 316 operated in a first manner in accordance with an embodiment of the invention. In this example, the article 500 is a pin, which is being held in a substantially vertical position by the insert carrier 375 which, in turn, is supported by the conveyor belt 370. As discussed above, it is desirable to focus the plating at the lower side wall portion of the pin 500. In such a case, it is preferable that an anode voltage is applied to only anode electrodes 316a and 316c, and that no anode voltage is applied to anode electrode 316b. This is because the electric

field lines from the anode electrodes 316a and 316c to the lower side wall portion of the pin 500 follow a generally direct path. Whereas the would-be electric field lines from the anode electrode 316b to the lower side wall portion of the pin 500 do not follow a preferred path.

[0067] FIG. 5B illustrates a side view of an exemplary anode electrode configuration 316 operated in a second manner in accordance with an embodiment of the invention. In this example, the article 500 is a socket including a downward-oriented cavity 502a positioned at the lower end of the article 500. Similarly, the socket is held in a substantially vertical position by the insert carrier 375 which, in turn, is supported by the conveyor belt 370. In this case, it is desirable to focus the plating at the internal side wall of the cavity 502a of the pin 500. In such a case, it is preferable that an anode voltage is applied to only anode electrode 316b, and that no anode voltage is applied to anode electrodes 316a and 316c. This is because the electric field lines from the anode electrode 316b to the internal side wall portion of the cavity 502a of the pin 500 follow a generally direct path. Whereas the would-be electric field lines from the anode electrodes 316a and 316b to the internal side wall of the cavity 502a of the pin 500 do not follow a preferred path.

[0068] FIG. 6 illustrates a block diagram of an exemplary anode power system 600 in accordance with another embodiment of the invention. The anode power system 600 comprises a power supply 602 including a positive terminal and a grounded negative terminal. The positive terminal of the power supply 602 is electrically coupled to the respective inputs of controllable switching elements 602a, 602b, and 602c. The switching elements 602a, 602b, and 602c include respective outputs electrically coupled to the corresponding anode electrodes 316a, 316b, and 316c of the anode electrode configuration 316. The anode power system 600 further comprises a controller 604 having outputs respectively coupled to control inputs of the respective switching elements 602a, 602b, and 602c.

[0069] The controller 604 controls whether the switching elements 602a, 602b, and 602c electrically connect the respective anode electrodes 316a, 316b, and 316c to the positive terminal of the power supply 602. Based on inputs from an operator, the controller 604 can determine which of the anode electrodes 316a, 316b, and 316c receives the anode voltage, and which do not. Although, in this example, three anode electrodes 316a, 316b, and 316c are shown, it shall be understood that the anode electrode configuration 316 may include any number of electrodes. Although not shown, the anode power system 600 may include one or more voltage regulators to independently regulate (and/or in common) the anode voltages at the respective anode electrodes 316a, 316b, and 316c. Alternatively, the anode power system 600 may have independent power supplies for the respective anode electrodes 316a, 316b, and 316c.

[0070] D. Eliminating or Reducing the Demarcation Line on Articles

[0071] As discussed in the Background section, during the partial plating of an article, a ring-shaped discoloration, also referred to as a demarcation line, is often formed around the article near the surface of the plating fluid bath. It has been previously theorized by others that the demarcation line was formed at the surface of the plating fluid bath. Through

various experiments, the inventors have discovered that the demarcation line actually forms on the article a relatively short distance above the surface of the plating fluid bath. The inventors theorized that the demarcation line is formed by ejection of the plating fluid and subsequent impingement of the vapors onto the article. Based on this theory, the inventors have devised a method of preventing or reducing the occurrence of the formation of the demarcation line on articles.

[0072] With reference again to **FIG. 3**, the electroplating cell **300** includes an gas-flow system **328** for directing gas flow toward or away from the articles while they undergo the electroplating process. As discussed above, the gas-flow system **328** includes a pipe **332** for routing gas flow towards or away from a nozzle **330** that includes an opening configured to direct gas towards or pull gas from the articles. Examples of gases that can be used include air, nitrogen gas, argon gas, etc. The continued gas flow towards or away from the articles while they undergo an electroplating process prevents and/or reduces the impingement of the vapors on the articles. Thus, with the use of the gas-flow system **328**, the discoloration of the articles may be prevented or substantially reduced.

[0073] E. Providing a Cathode Connection to the Articles

[0074] **FIG. 7A** illustrates a side view of an exemplary cathode contact system **360** in accordance with another embodiment of the invention. The cathode contact system **360** is configured to provide a cathode contact to the articles while preventing contamination of the electroplating cell **300**. The cathode contact system **360** comprises a point of electrical cathode contact **361**, a resilient device **362** including a brush **363** situated at its lower end, an exterior cathode contact wheel **364**, an interior cathode contact wheel **367**, a drive shaft **366**, and a pair of bearings **365** for the wheels **364** and **367**.

[0075] The point of contact **361**, which in this example is a bolt threaded into a housing and secured by a lock nut, is electrically coupled to the resilient device **362** including the brush **363**. The resilient device **362** is resilient generally in the vertical direction and absorbs upward vertical energy produced by the rotating exterior cathode contact wheel **364**. The brush **363** makes electrical contact to the perimeter of the exterior cathode contact wheel **364**. The drive shaft **366** is rotationally coupled and makes electrical contact to the exterior cathode contact wheel **364** and the interior cathode contact wheel **367**. The bearings **365** secure the wheels **364** and **367** to fixed members, such as the frame **352** of the transportation system **350**, while allowing the wheels to rotate. The interior cathode contact wheel **367** is rotationally and electrically coupled to the conveyor belt **370**. The conveyor belt **370**, in turn, is electrically coupled to the articles **500** by way of their respective insert carriers **375**.

[0076] Thus, with the exemplary cathode contact system **360** of the invention, a cathode voltage potential is applied to the articles by way of the point of contact **361**, resilient device **362** including its brush **363**, the exterior cathode contact wheel **364**, the drive shaft **366**, the interior cathode contact wheel **367**, the conveyor belt **370**, and the insert carriers **375**. An advantage of the cathode contact system **360** is that the brush **363** makes electrical contact to the exterior cathode contact wheel **364** at a location outside of the electroplating cell **300**. In this manner, particles of the

brush **363** that flake off as it makes contact with the moving exterior cathode contact wheel **364** does not contaminate the plating fluid bath. Thus, a cathode contact may be provided to moving articles in a contaminant free manner because a fixed member (e.g., brush **363**) makes contact with a moving member (e.g., wheel **364**) outside of the electroplating cell **300**.

[0077] **FIG. 7B** illustrates a side view of another exemplary cathode contact system **380** in accordance with another embodiment of the invention. The cathode contact system **380** comprises an electrical conduit **382** and a brush **384**. The electrical conduit **382** may be routed from outside of the electroplating cell where it receives the cathode potential, through an opening within a wall of the transport system frame **352**, and downwards towards the conveyor belt **370**. The brush **384**, electrically connected to the lower end of the electrical conduit **382**, makes electrical contact to the conveyor belt **370**. Thus, a cathode potential is applied to the article **500** by way of the electrical conduit **382**, brush **384**, conveyor belt **370**, and insert carrier **375**. The contact of the brush **384** to the conveyor belt **370** may be configured such that there is no or minimal contamination of the plating fluid by particles emanating from the brush **384** as a result of its frictional contact with the moving conveyor belt **370**.

[0078] F. Improving the Cathode Contact to the Articles

[0079] **FIG. 8** illustrates a side view of an exemplary cathode contact preload system **390** in accordance with another embodiment of the invention. The cathode contact preload system **390** applies a continuous downward force on the articles **500** to ensure that they make good electrical and physical contact with their corresponding insert carriers **375** while the articles are being plated. In particular, the cathode contact preload system **390** comprises an endless belt **392** rotationally supported by a pair of idle wheels **394** (only one shown). The cathode contact preload system **390** further comprises a drive belt **396** rotationally coupling one of the idle wheels **394** to a drive wheel **377** rotationally coupled to the conveyor belt **370**. In this manner, the endless belt **392** moves at substantially the same speed as the conveyor belt **370** that transports the articles **500** through the various processing stations.

[0080] **FIG. 9A** illustrates a side view of the exemplary endless belt **392** of the cathode contact preload mechanism **390** in contact with a pair of articles **500** in accordance with another embodiment of the invention. The endless belt **392**, being made of a resilient material (e.g., rubber), makes contact to the top regions the articles **500**. The resilient nature of the belt **392** results in the belt **392** exerting a substantially downward force **F** against the tops of the articles **500**. This downward force **F** forces the articles against the insert carriers **375**, thereby providing a positive electrical and physical contact of the articles **500** to the insert carriers **375** as the articles **500** are transported through the various processing stations of the electroplating system **200**. As discussed above, the conveyor belt **370** as well as the insert carriers **375** are electrically coupled to the cathode terminal of a power supply. Thus, the downward force **F** exerted by the belt **392** against the articles **500** allows a consistently good cathode contact to be made to the articles while they undergo the electroplating process.

[0081] As an alternative embodiment, the endless belt **392** may be made of an electrically conductive material (e.g., a

conductive rubber or a metal band). In such a case, the cathode contact to the articles 500 may be made by way of the endless belt 392. Also, in such a case, the conveyor belt 370 and the insert carrier 375 need not be made of an electrically conductive material. Again, this is because the endless belt 392 provides the cathode contact to the articles 500. The cathode contact to the electrically-conductive, conveyor belt 392 may be made by a sliding contact member that slides against the moving belt 392 or a rotating contact member that rotates against the moving belt 392.

[0082] FIG. 9B illustrates a side view of another exemplary endless belt 398 in accordance with another embodiment of the invention. In this example, the endless belt 398 is made of an electrically conductive material (e.g., a metal). In addition, the endless belt 398 includes a plurality of spaced-apart, spring-loaded fingers 399 configured to register with the top end of the articles 500. Accordingly, the cathode contact to the articles 500 may be made by way of the endless belt 398 and the respective spring-loaded fingers 399.

[0083] FIG. 10 illustrates a block diagram of an exemplary synchronization system 1000 to synchronize the speed of the article transport conveyor belt 370 with the cathode contact conveyor belt 392 (or belt 398) in accordance with another embodiment of the invention. The synchronization system 1000 comprises the drive motor 373 for the article transport conveyor belt 370, a controller 1002, and a variable-speed or DC servo drive motor 1004 for the cathode contact conveyor belt 392. The drive motor 373 for the article transport conveyor belt 370 may include the motor portion 373a as well as a revolution per minute (RPM) encoder 373b which generates a signal indicative of the speed of the motor portion 373a. It shall be understood that the RPM encoder 373b may be integrated with the motor portion 373a, or may be separate there from. It shall be understood that the belt 370 may be replaced with other types of conveyable structures, such as a chain or cable.

[0084] The controller 1002 receives the signal generated by the RPM encoder 373b. Based on this signal, the controller 1002 generates a speed control signal for the cathode contact motor 1004. Since the cathode contact motor 1004 and cathode contact conveyor belt 392 may be configured to have different speed control characteristics, the controller 1002 performs the appropriate calculations to generate a speed control signal for the cathode contact motor 1004 such that the movement of the cathode contact conveyor belt 392 is substantially in synchronous with the movement of the article transport conveyor belt 370. This ensures that the preload cathode contact to the articles by the article transport conveyor belt 370 is substantially fixed as the articles are transported through the various cells of the electroplating system 200.

III. Transport System

[0085] A. First Embodiment

[0086] With reference again to FIGS. 1, 8 and 9, the transportation system 204 comprises an endless, electrically-conductive conveyor belt 370 that is rotationally supported by a drive wheel 371 and an idle wheel 372. The drive wheel 371 is rotationally coupled to a drive motor 373 for moving the conveyor belt 370. The transportation system 204 may further include a tension wheel 374 to keep the conveyor belt

370 desirably taut during transportation of the articles 500. The endless belt 370 further comprises a plurality of spaced-apart thru-holes 370a configured to respectively receive insert carriers 375 that hold articles. The insert carriers 375 snap into the respective openings 370a such that insert carriers 375 are secured to the conveyor belt 370.

[0087] FIG. 11 illustrates a side view of a portion of the exemplary article transport system 204 in accordance with another embodiment of the invention. As shown, the endless belt 370 includes an overlap region 372 where two portions of the belt overlap and are attached together to make the belt endless. In the overlap region 372, the thru-holes 370a of the overlapping portions of the belt 370 register with each other, i.e., they are substantially coaxial. The overlapping portions of the belt 370 may be attached to each other by epoxy, mechanical or others means. Also, in the overlap region 372, the insert carriers 375 are inserted through respective registered pairs of openings 370a.

[0088] The conveyor belt 370 is made out of relatively high tensile strength material so as to prevent unwanted flexing in the region where the articles 500 are carried. This further ensures that the vertical position of the articles 500 is substantially stable to control the amount of partial plating of the articles. Furthermore, the position of the conveyor belt 370 is such that it does not contact the plating solution. This reduces the amount of maintenance (e.g., cleaning and/or replacement) required on the conveyor belt 370. It shall be understood that the belt 370 may be replaced with other types of conveyable structures, such as a chain or cable.

[0089] FIG. 12A illustrates a side view of an exemplary carrier 375a supporting an article 500a in accordance with another embodiment of the invention. An advantage of the article transport system 204 of the electroplating system 200 is that it is relatively easy to configure the system to handle different types of articles. In particular, insert carriers may be designed to hold different types of articles while still being able to be properly attached to the conveyor belt 370. More specifically, the interior configurations of various types of insert carriers may be designed to properly support different articles. While, the outside configuration of such various types of insert carriers may be kept substantially the same so that they can be properly attached to the conveyor belt 370.

[0090] In this example, the interior configuration of the insert carrier 375a is designed to support an elongated cylindrical-shaped article 500a (e.g., a pin) that includes a ridged portion that makes contact with the interior of the insert carrier 375a. The upper interior walls of the insert carrier 375a is angled inward to guide the article 500a while it is being fully inserted into the insert carrier 375a. The external configuration of the insert carrier 375a is designed to friction fit into the thru-holes 370a of the conveyor belt 370. As discussed below, if a different type article is to be plated, the interior configuration of the insert carrier may be designed differently to properly accommodate the article, while the exterior configuration be kept the same so that it properly interfaces with the conveyor belt 370.

[0091] FIG. 12B illustrates a side view of another exemplary carrier 375b supporting another article 500b in accordance with another embodiment of the invention. In this example, the interior configuration of the insert carrier 375b is designed to support an elongated cylindrical-shaped

article **500b** that includes a cylindrical flange structure that makes contact with the interior of the insert carrier **375b**. Similar to insert carrier **375a**, the upper interior walls of the insert carrier **375b** is angled inward to guide the article **500b** while it is being fully inserted into the insert carrier **375b**. The external configuration of the insert carrier **375b** is substantially the same as that of insert carrier **375a** so that it can be friction fit into the thru-holes **370a** of the conveyor belt **370**.

[0092] Thus, the plating of different articles is facilitated with the customizable insert carriers **375**. The conveyor belt **370** may be populated with the first-type insert carriers **375a** to support first-type articles **500a** while they undergo the various processes performed by the electroplating system **200**. Once the processes are completed on the first-type articles **500a**, the first-type insert carriers **375a** are removed from the conveyor belt **370**, and the conveyor belt **370** is then populated with the second-type insert carriers **375b** to support second-type articles **500b** while they undergo the various processes performed by the electroplating system **200**.

[0093] B. Second Embodiment

[0094] FIGS. 13A-D illustrate front, side, top and open views of another exemplary article transport system **1300** in accordance with another embodiment of the invention. The article transport system **1300** comprises a conveyor belt **1302** and a multi-article carrier **1304** supported by the conveyor belt **1302**. The multi-article carrier **1304** comprises a base **1306** and a cover **1308** connected to the base **1306** via a hinge **1310**. The bottom of the base **1306** includes a plurality of openings **1312** to receive there thru the articles **500**. The openings **1312** register with corresponding openings of the conveyor belt **1302** such that the articles **500** extend there thru below the conveyor belt **1302** and into the electroplating cell **1350**. The openings **1312** may be configured into a single row, into an array consisting of a plurality of rows, or into any other pattern.

[0095] The cover **1308** of the multi-article carrier **1304** comprises a cathode contact port **1314** to receive the cathode potential. The cover **1308** further includes an internal electrical conduit **1316** which is electrically coupled to the cathode contact port **1314** and routes the cathode potential towards the articles **500**. The cover **1308** further comprises a plurality of spring-loaded cathode fingers **1318** that make pressured electrical contact to the respective articles **500**. The spring-loaded cathode fingers **1318** are electrically connected to the electrical conduit **1316**. Thus, the articles **500** receive the cathode potential by way of the cathode contact port **1314**, internal electrical conduit **1316**, and respective spring-loaded cathode fingers **1318**.

[0096] In operation, at a loading station, an empty carrier **1304** has its cover **1308** initially in an open position as shown in FIG. 13D. The articles **500** are then inserted into the holes **1312** of base **1306** of the empty carrier **1304** such that articles **500** extend below the conveyor belt **1302**. Once the articles **500** are properly inserted into the holes **1312** and are supported by the carrier **1304** and conveyor belt **1302** in a substantially vertical orientation, the cover **1308** is then closed as shown in FIG. 13A. As discussed above, in the closed position, the spring-loaded cathode fingers **1318** make pressured electrical contact to the respective articles **500**. It shall be understood that the conveyor belt **1302** may

be some other type of movable supporting structure, such as a chain or cable. In addition, the conveyor belt **1302** can be an electrical conductor (e.g., a metal or conductive rubber) and/or a non-electrical conductor.

[0097] While the invention has been described in connection with various embodiments, it will be understood that the invention is capable of further modifications. This application is intended to cover any variations, uses or adaptation of the invention following, in general, the principles of the invention, and including such departures from the present disclosure as come within the known and customary practice within the art to which the invention pertains.

It is claimed:

1. An electroplating system, comprising:
 - a container adapted to support a plating fluid bath;
 - an anode electrode positioned within said container and adapted to make contact with said plating fluid bath;
 - a support structure adapted to support an article in a manner that only a portion of said article is immersed in said plating fluid bath; and
 - a gas flow system adapted to cause gas flow proximate an interface of said article to said plating fluid bath.
2. The electroplating system of claim 1, wherein said gas flow system is adapted to direct gas flow towards said interface of said article to said plating fluid bath.
3. The electroplating system of claim 1, wherein said gas flow system is adapted to direct gas flow away from said interface of said article to said plating fluid bath.
4. The electroplating system of claim 1, wherein said gas flow system comprises:
 - a pipe fluidly coupled to a pressurized gas source; and
 - a nozzle fluidly coupled to said pipe.
5. The electroplating system of claim 1, wherein said gas comprises any one or more of the following air, nitrogen gas, and/or argon gas.
6. A method of electroplating an article, comprising:
 - forming a plating fluid bath;
 - immersing only a portion of an article in said plating fluid bath;
 - generating a plating current through said plating fluid bath and said article;
 - producing gas flow proximate an interface of said article to said plating fluid bath while said plating current is flowing through said plating fluid bath and said article.
7. The method of claim 6, wherein said gas flow is directed towards said interface of said article to said plating fluid bath.
8. The method of claim 6, wherein said gas flow is directed away from said interface of said article to said plating fluid bath.
9. The method of claim 6, wherein said gas comprises any one or more of the following air, nitrogen gas, and/or argon gas.
10. An electroplating system, comprising:
 - a pre-processing station including one or more pre-processing cells;

an electroplating station including one or more electroplating cells;

a post-processing station including one or more post-processing cells; and

a transport system adapted to transport articles horizontally through said pre-processing station, said electroplating station, and said post-processing station;

wherein at least one of said electroplating cell comprises:

a container adapted to support a plating fluid bath;

an anode electrode positioned within said container and adapted to make contact with said plating fluid bath;

wherein said transport system is adapted to support said articles in a manner that only selected portions of said articles are immersed in said plating fluid bath; and

a gas flow system adapted to cause gas flow proximate respective interfaces of said articles to said plating fluid bath.

11. The electroplating system of claim 10, wherein said gas flow system is adapted to direct gas flow towards said respective interfaces of said articles to said plating fluid bath.

12. The electroplating system of claim 10, wherein said gas flow system is adapted to direct gas flow away from said respective interfaces of said articles to said plating fluid bath.

13. The electroplating system of claim 10, wherein said gas flow system comprises:

a pipe fluidly coupled to a pressurized gas source; and

a nozzle fluidly coupled to said pipe.

14. The electroplating system of claim 10, wherein said gas comprises any one or more of the following air, nitrogen gas, and/or argon gas.

* * * * *