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• **INOUE, Manabu**
Kashiwa-shi,
Chiba 2778525 (JP)

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(71) Applicant: **THINK LABORATORY CO., LTD.**
Chiba, 227-8525 (JP)

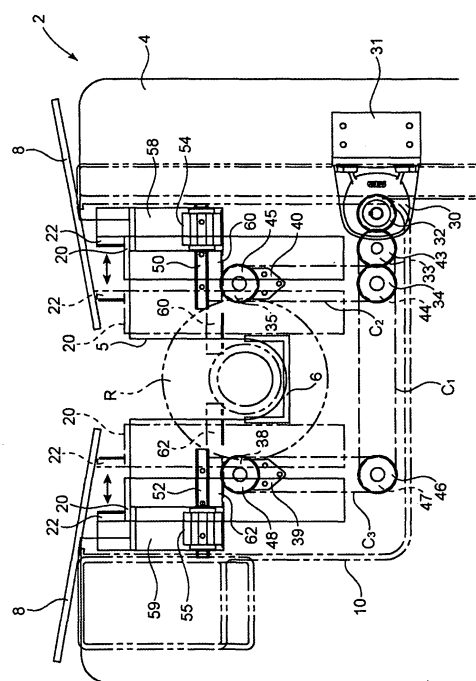
(74) Representative: **Grünecker, Kinkeldey,**
Stockmair & Schwanhäusser
Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

(72) Inventors:
• **MATSUMOTO, Noriko**
Kashiwa-shi,
Chiba 2778525 (JP)

(54) **GRAVURE CYLINDER-USE COPPER PLATING METHOD AND DEVICE**

(57) The present invention provides a copper plating method and apparatus for a gravure cylinder in which copper plating with more uniform thickness can be provided over a full length of a gravure cylinder without causing defects such as rashes and pits irrespective of a size of the gravure cylinder, concentration of a copper plating solution can be managed automatically, a consumption amount of an additive is reduced to make it possible to perform a plating treatment within a short period of time, a power supply cost is reduced, and handling is easy with excellent visibility. A gravure cylinder in a hollow cylindrical shape is held at both ends in a longitudinal direction. The gravure cylinder is accommodated in a plating bath filled with a copper plating solution. The gravure cylinder is energized so that the gravure cylinder functions as a cathode while being rotated at a predetermined speed. A pair of anode chambers in a long box shape, in which insoluble anodes are provided upright slidably to both sides of the gravure cylinder in the plating bath and energized so as to function as an anode, are brought close to both side surfaces of the gravure cylinder at a predetermined interval. Copper plating is provided on an outer peripheral surface of the gravure cylinder.

FIG.1



Description

Technical Field

[0001] The present invention relates to a copper plating method and apparatus for a gravure cylinder for providing an outer peripheral surface of a hollow cylindrical gravure cylinder (also called a plate-making roll), used for gravure printing, with copper plating as a printing material for forming a printing surface, and more particularly, to a copper plating method and apparatus for a gravure cylinder, in which copper plating is provided using an insoluble anode.

Background Art

[0002] In gravure printing, minute concave portions (cells) are formed on a gravure cylinder in accordance with plate-making information to produce a printing surface, and the cells are filled with ink so that the ink is transferred to an object to be printed. In a general gravure cylinder, a cylindrical iron core or aluminum core is used as a base, a plurality of layers such as an underlying layer and a peeling layer are formed on an outer peripheral surface of the base, and a copper plating layer (printing material) for forming a printing surface is formed on the plurality of layers. Then, cells are formed on the copper plating layer in accordance with print-making information by a laser exposure apparatus, and thereafter, the resultant base is plated with chromium or the like for enhancing printing durability of a gravure cylinder, whereby plate making (production of a printing surface) is completed.

[0003] Conventionally, as a method and apparatus for providing copper plating on an outer peripheral surface of a gravure cylinder, the use of a phosphorus-containing copper ball as a soluble anode is well known. According to the conventional method and apparatus, both ends in a longitudinal direction of a gravure cylinder are held so as to be rotated and energized by a pair of roll chucks, the gravure cylinder is accommodated in a plating bath in which a plating solution is stored while the gravure cylinder is being rotated, and a current with a current density of about 10 to 15 A/dm² is allowed to flow between the phosphorus-containing copper ball (soluble anode) in the plating solution and the gravure cylinder (cathode), whereby copper is deposited on an outer peripheral surface of the gravure cylinder, which functions as a cathode, with the result that copper plating is provided (for example, see Patent Documents 1 and 2).

[0004] However, in general, a phosphorus-containing copper ball used in a copper plating method and apparatus for a gravure cylinder contains 350 to 700 ppm of phosphorus and 2 to 5 ppm of oxygen, and the rest of the ball is composed of copper and impurities. Due to the impurities contained in the ball inevitably, anode sludge is generated during a plating treatment, which causes defects such as rashes (minute protrusions) and pits (pin-

holes) on the outer peripheral surface of the gravure cylinder. Although there is a phosphorus-containing copper ball of high purity for producing a semiconductor and the like, such a ball is expensive and is not adopted for a gravure cylinder in terms of cost-efficiency. Furthermore, in order to prevent the dissolution amount of a phosphorus-containing ball in a copper plating solution from increasing excessively to enhance the copper ion concentration, making it impossible to perform an appropriate plating treatment, it is also necessary to dilute the solution by removing a plating solution periodically, thereby adjusting the copper ion concentration appropriately and disposing a waste liquid. Furthermore, since a current is concentrated in the vicinity of both ends of the gravure cylinder, the peripheral surface in the vicinity of both ends is plated thickly compared with a body portion, with the result that it is necessary to separately perform treatment of making the thickness of plating uniform by follow-up polishing or the like.

[0005] On the other hand, in addition to a method using a phosphorus-containing copper ball as a soluble anode, a copper plating method using an insoluble anode is known. According to an example of a plating method and apparatus for a gravure cylinder using an insoluble anode, for example, a titanium plate coated with iridium oxide or the like as an insoluble anode is used, a plating bath and a copper dissolution bath are prepared, the copper plating material (e.g., copper oxide or copper carbide) are dissolved in the dissolution bath, the resultant solution is supplied to a plating solution in the plating bath, and a current is supplied between an insoluble anode and a gravure cylinder forming a cathode, whereby copper plating is provided (for example, see Patent Document 3).

[0006] According to the above-mentioned method and apparatus, anode sludge is not generated so that defects such as rashes and pits are not caused, however, there is still a problem that the peripheral surface in the vicinity of both ends of a gravure cylinder is plated thickly. In order to solve this problem, the applicant of the present invention has already proposed a copper plating method and apparatus for a gravure cylinder in which an insoluble anode positioned below a gravure cylinder is configured so as to be lifted in a plating bath, the insoluble anode is brought close to a lower surface of the gravure cylinder with a gap of 5 mm to 30 mm in accordance with gravure cylinders of various sizes, whereby a current is not concentrated in the vicinity of both ends of the gravure cylinder, plating with a uniform thickness can be provided over the full length of the gravure cylinder, and the concentration of copper and the concentration of sulfuric acid in the plating solution can be adjusted automatically (Patent Document 4).

[0007] However, even with the above proposal, there are the following problems. Since an insoluble anode is placed directly in the plating solution, the consumption amount of additives such as a brightener and a burn stopping agent is remarkably large (for example, the con-

sumption amount is about 100 cc/1000 AH in a case of using a phosphorus-containing ball as a soluble anode, whereas the consumption amount is about 600 cc/1000 AH in a case of setting an insoluble anode directly in a plating solution). Since a current density is about 15 to 20 A/dm² and a voltage is 10 to 15 V for the purpose of preventing a burn, a plating treatment takes a long time, which results in a large power supply cost. The uniformity of a plating thickness is insufficient. Since the insoluble anode is positioned below the gravure cylinder, visibility is poor, and operability is poor.

[0008] [Patent Document 1] JP 57-36995 B

[Patent Document 2] JP 11-61488 A

[Patent Document 3] JP 2005-29876 A

[Patent Document 4] JP 2005-133139 A

Disclosure of the Invention

Problem to be solved by the Invention

[0009] The present invention has been achieved in view of the above-mentioned problems, and it is an object of the present invention to provide a copper plating method and apparatus for a gravure cylinder in which copper plating with more uniform thickness can be provided over a full length of a gravure cylinder without causing defects such as rashes and pits irrespective of a size of the gravure cylinder, concentration of a copper plating solution can be managed automatically, a consumption amount of an additive is reduced to make it possible to perform a plating treatment within a short period of time, a power supply cost is reduced, and handling is easy with excellent visibility

Means for solving the Problems

[0010] A copper plating method for a gravure cylinder according to the present invention comprises: holding a gravure cylinder in a hollow cylindrical shape at both ends in a longitudinal direction, accommodating the gravure cylinder in a plating bath filled with a copper plating solution; energizing the gravure cylinder so that the gravure cylinder functions as a cathode while being rotated at a predetermined speed; bringing a pair of anode chambers in a long box shape, in which insoluble anodes are provided upright slidably to both sides of the gravure cylinder in the plating bath and energized so as to function as an anode, close to both side surfaces of the gravure cylinder at a predetermined interval; and providing copper plating on an outer peripheral surface of the gravure cylinder.

[0011] More specifically, since the insoluble anode is placed in an anode chamber without being directly set in a plating solution, and a slide-type anode chamber with a mechanism capable of sliding the anode chambers on both sides of a gravure cylinder is set, whereby copper plating can be provided under the condition that the anode chambers are brought close to both side surfaces of the gravure cylinder. Because of this, copper plating with

more uniform thickness can be provided without having rashes and pits, the consumption amount of additives can be reduced, a plating thickness can be made uniform with respect to gravure cylinders of various sizes. The time and power supply cost for a plating treatment can be reduced, and anode chambers are positioned on both sides of a gravure cylinder, so visibility and operation are excellent.

[0012] It is preferable that a cation exchange film is provided on a side surface of the anode chamber on the gravure cylinder side, and it is preferable that the anode chamber has a length equal to or larger than the full length of the gravure cylinder in a longitudinal direction. The reason for this is to provide copper plating with a uniform thickness over the full length of the gravure cylinder. Furthermore, it is desirable that the inside of the anode chamber is filled with an acidic electrolyte solution, and when the liquid amount in the anode chamber is measured to be insufficient, water is supplied.

[0013] It is preferable that the copper plating solution contains copper sulfate, sulfuric acid, hydrochloric acid, and an additive, and when the specific gravity of the copper plating solution and the concentration of sulfuric acid are measured, in a case where the specific gravity is too high, water is supplied, and in a case where the concentration of sulfuric acid is too high, cupric oxide powder is supplied. This makes it unnecessary to perform the conventional periodical maintenance of a copper plating solution and disposal of a waste liquid. Furthermore, it is preferable that the copper plating solution is obtained by removing impurities with a filter.

[0014] The predetermined interval (interval at which the anode chamber is brought close to the gravure cylinder side surface) is about 1 mm to 50 mm, preferably about 3 mm to 40 mm, and most preferably about 5 mm to 30 mm. In terms of the uniformity of a plating thickness, it is preferable that the interval at which the anode chamber is brought close to the gravure cylinder side surface be small as much as possible. However, if the interval is too small, there is a fear that the anode chamber and the gravure cylinder may come into contact with each other during a plating treatment.

[0015] The copper plating apparatus for a gravure cylinder according to the present invention provides an outer peripheral surface of a gravure cylinder with copper plating, and comprises: a plating bath filled with a copper plating solution; chuck means for holding the gravure cylinder in a hollow cylindrical shape at both ends in a longitudinal direction so that the gravure cylinder is capable of being rotated and energized, and accommodating the gravure cylinder in the plating bath; and a pair of anode chambers in a long box shape which are provided upright slidably to both sides of the gravure cylinder in the plating bath and in which an insoluble anode energized so as to function as an anode.

[0016] It is preferable that a cation exchange film be provided on a side surface of the anode chamber on the gravure cylinder side and the anode chamber has a

length equal to or larger than a full length of the gravure cylinder in a longitudinal direction thereof. Further, it is preferable that, in the apparatus, an inside of the anode chamber be filled with an acidic electrolyte solution, and the apparatus further includes an anode chamber liquid amount supply mechanism that measures a liquid amount in the anode chamber and supplies water in a case where the liquid amount is insufficient.

[0017] It is preferable that the copper plating solution contains copper sulfate, sulfuric acid, chlorine, and an additive, and the apparatus further includes a copper plating solution automatic control mechanism that measures a specific gravity and a sulfuric acid concentration of the copper plating solution, and supplies water in a case where the specific gravity is too high and supplies cupric oxide powder in a case where the sulfuric acid concentration is too high. Preferably, the apparatus further includes a filter that removes impurities in the copper plating solution.

Effects of the Invention

[0018] The present invention can exhibit the remarkable effect of providing a copper plating method and apparatus for a gravure cylinder, in which copper plating with more uniform thickness can be provided over the full length of a gravure cylinder without causing defects such as rashes and pits irrespective of the size of the gravure cylinder, the concentration of a copper plating solution can be managed automatically, the consumption amount of additives can be reduced, a plating treatment can be performed within a short period of time, a power supply cost can be reduced, and handling is easy with excellent visibility.

Brief Description of the Drawings

[0019]

FIG. 1 is an explanatory front view showing an exemplary main portion structure of a copper plating apparatus for a gravure cylinder of the present invention.

FIG. 2 is an explanatory plan view showing the exemplary main portion structure of the copper plating apparatus for a gravure cylinder of the present invention.

FIG. 3 is an explanatory side view showing the exemplary main portion structure of the copper plating apparatus for a gravure cylinder of the present invention.

FIG. 4 is a schematic explanatory view showing an example of an anode chamber of the present invention.

FIG. 5 is a schematic explanatory view showing an exemplary basic structure of the copper plating apparatus for a gravure cylinder of the present invention.

FIG. 6 is a conceptual explanatory diagram showing an exemplary copper plating solution automatic control mechanism of the present invention.

FIG. 7 is a schematic explanatory diagram showing an exemplary anode chamber liquid amount supply mechanism of the present invention.

Description of Symbols

[0020] 2: a copper plating apparatus for a gravure cylinder, 4: a base, 6: a bearing, 8: a cover plate, 10: a plating bath, 11: a discharge duct, 12: a collecting bath, 14: a chuck means, 15: a liquid resistant adaptor, 16: a spindle, 18: a sprocket, 20: an anode chamber, 22: a lead bar, 23: an anode case, 24: an insoluble anode, 25: an attachment jig, 26: a cation exchange film, 27: an attachment jig, 28: a pressure flange, 30: a geared motor, 31: an attachment angle, 32, 33, 34, 35, 38: spur gears, 39, 40: fittings, 43, 44, 45, 46, 47, 48: sprockets, 50, 52: linear rails, 54, 55: guide members, 58, 59: attachment frames, 60, 62: racks, 70: a reservoir bath, 80: a filter, 86: a heater, 88: a heat exchanger, 90: an automatic addition apparatus, 100: a copper plating solution automatic control mechanism, 102: a dissolution bath, 104: a powder supply apparatus, 105: a screw conveyor, 106: a powder storing hopper, 108: a pure water pressure bath, 110: a controller, 112: a specific gravity sensor, 114: a sulfuric acid sensor, 200: an anode chamber liquid amount supply mechanism, 210: a pure water bath, 212: a float, 220: a pure water pressure bath, C, C1, C2, C3: chains, F: a copper plating solution, M: a cylinder rotation motor, P1, P2, P3, P3: pumps, R: a gravure cylinder, S: an acidic electrolyte solution, VT: an adjustment valve, VE: an electromagnetic valve, W: pure water

Best Mode for carrying out the Invention

[0021] Hereinafter, an embodiment of the present invention will be described with reference to the attached drawings. Illustrated examples are shown for illustrative purposes. Therefore, it is natural that they can be modified variously as long as they do not extend beyond the technical idea of the present invention.

[0022] FIG. 1 is an explanatory front view showing an exemplary main portion structure of a copper plating apparatus for a gravure cylinder according to the present invention. FIG. 2 is an explanatory plan view showing an exemplary main portion structure of the copper plating apparatus for a gravure cylinder according to the present invention. FIG. 3 is an explanatory side view showing the exemplary main portion structure of the copper plating apparatus for a gravure cylinder according to the present invention. FIG. 4 is a schematic explanatory view showing an example of an anode chamber in the present invention. FIG. 5 is a schematic explanatory view showing an exemplary basic structure of the copper plating apparatus for a gravure cylinder according to the present invention. FIG. 6 is a conceptual explanatory view showing

an example of a copper plating solution automatic control mechanism in the present invention. FIG. 7 is a schematic explanatory view showing an example of an anode chamber liquid amount supply mechanism in the present invention.

[0023] In the drawings, reference numeral 2 denotes the copper plating apparatus for a gravure cylinder of the present invention. The copper plating apparatus for a gravure cylinder 2 of the present invention provides the outer peripheral surface of a gravure cylinder R in a hollow cylindrical shape with copper plating, and includes a plating bath 10, chuck means 14, and a pair of anode chambers 20, 20 (see FIGS. 1 to 5). The plating bath 10 and the chuck means 14 have substantially the same structures as those of conventional apparatuses (see Patent Documents 1 to 3), so the repeated descriptions thereof will be omitted. The plating bath 10 is used for a plating treatment, which is filled with a copper plating solution F and is capable of soaking the gravure cylinder R in the copper plating solution F completely. On the periphery of the plating bath 10, a collecting bath (overflow box) 12 for collecting the overflowed copper plating solution F (see FIGS. 2, 3, and 5) is provided, and below the plating bath 10, a reservoir bath 70 for storing the copper plating solution F is provided so as to be communicated with the collecting bath 12 (see FIGS. 5 and 6). In the reservoir bath 70, a heater 86 and a heat exchanger 88 for keeping the copper plating solution F at a predetermined liquid temperature (e.g., about 40°C) are provided, and a filter 80 for removing impurities in the copper plating solution F, a pump P1 for pumping up the copper plating solution F from the reservoir bath 70 so that the copper plating liquid F circulates to the plating bath 10, and the like are provided (see FIGS. 5 and 6). The chuck means 14 is a roll chuck apparatus (see Patent Documents 1 to 3) for holding both ends of the gravure cylinder R in a longitudinal direction and accommodating the gravure cylinder R in the plating bath 10, and includes a spindle 16 axially supported by a bearing 6 and a liquid resistant adaptor 15 for preventing the entry of the copper plating solution F. The chuck means 14 is rotated at a predetermined speed (e.g., about 120 rpm) via a chain C and a sprocket 18 by a cylinder rotation motor M provided on a base 4, and can be energized so that the gravure cylinder R becomes an cathode (see FIG. 5). In addition, a cover plate 8 that can be open or close above the plating bath 10, a discharge duct 11, and the like are provided appropriately (see FIGS. 1 and 5).

[0024] In the copper plating apparatus for a gravure cylinder 2 of the present invention, as slide-type anode chambers, the pair of anode chambers 20, 20 are provided upright so as to be slidable to both sides of the gravure cylinder in the plating bath 10 (FIGS. 1 to 5). The anode chambers 20, 20 are members having a long box shape with a length equal to or larger than the full length of the gravure cylinder R in the longitudinal direction (see FIGS. 2 to 5), and as shown in FIG. 4, an anode case 23 is filled with an acidic electrolyte solution S such as a

sulfuric acid aqueous solution, and an insoluble anode 24 is placed with an attachment jig 25. The insoluble anode 24 is obtained by coating the surface of a titanium plate with iridium oxide or the like, and is energized via a lead bar 22 so as to function as an anode. On the side surface of the anode chamber 20 on the gravure cylinder side, a cation exchange film 26 is placed with an attachment jig 27 and a pressure flange 28.

[0025] The mechanism that enables the pair of anode chambers 20, 20 to slide on both sides of the gravure cylinder R is not particularly limited. An example will be described with reference to FIGS. 1 to 3. The base 4 is provided outside the front surface of the plating bath 10, and linear rails 50, 52 are provided on an inner wall surface of the base 4. Racks 60, 62 are provided so as to reciprocate due to the forward and reverse rotations of spur gears 35, 38 in parallel to the linear rails 50, 52, and are connected to guide members 54, 55 slidably engaged with the linear rails 50, 52 via the attachment frames 58, 59. The end portions of the lead bars 22, 22 of the anode chambers 20, 20 are connected respectively to upper ends of the attachment frames 58, 59 (see FIGS. 1 to 3).

[0026] Regarding the spur gears 35, 38 that allow the racks 60, 62 to reciprocate, the gear 35 is fixed to the base 4 with a fitting 40 so as to rotate coaxially with a sprocket 45 on the outer wall surface side of the base 4. On the other hand, the spur gear 38 is fixed to the base 4 with a fitting 39 so as to rotate coaxially with a sprocket 48 on the outer wall surface side of the base 4. Right below the sprocket 45, a sprocket 44 is provided so as to rotate coaxially with the spur gear 34, and right below the other sprocket 48, a sprocket 47 is provided so as to rotate coaxially with the sprocket 46. On the outer wall surface of the base 4, a geared motor 30 is set via an attachment angle 31, and a spur gear 32 is provided. The spur gear 33 is provided so as to rotate coaxially with a sprocket 43 in such a manner as to be engaged with the spur gear 32. A chain C1 is engaged between the sprockets 43, 46, a chain C2 is engaged between sprockets 44, 45, and a chain C3 is engaged between sprockets 47, 48. Thus, due to the forward and reverse drive of the geared motor 30, the spur gears 35, 38 rotate forwardly and reversely, and the racks 60, 62 reciprocate, and in synchronization therewith, the anode chambers 20, 20 are slidable exactly along the linear rails 50, 52 (see FIGS. 1 to 3).

[0027] The interval at which the anode chamber 20 is brought close to the side surface of the gravure cylinder R is about 1 mm to 50 mm, preferably about 3 mm to 40 mm, and most preferably 5 mm to 30 mm. Considering the uniformity of a plating thickness, it is considered to be preferable that the anode chamber 20 is brought as close as to the side surface of the gravure cylinder R. However, when the anode chamber 20 is brought too close to the side surface of the gravure cylinder R, the anode chamber 20 and the gravure cylinder R may come into contact with each other during a copper plating treatment.

[0028] It is desirable that the copper plating apparatus for a gravure cylinder 2 of the present invention further has a copper plating solution automatic control mechanism 100 and an anode chamber liquid amount supply mechanism 200 (see FIGS. 6 and 7). A reservoir bath 70 for storing the copper plating solution F is provided below the plating bath 10, and the copper plating solution F is pumped up with the pump P1 to be supplied to the plating bath 10, while the filter 80 is removing impurities. Furthermore, an automatic addition apparatus 90 provided with a pump P4 for supplying additives such as a brightener and a burn stopping agent is placed (see FIG. 6).

[0029] The copper plating solution automatic control mechanism 100 adjusts the concentrations of copper and sulfuric acid in the copper plating solution F stored in the reservoir bath 70. In the case where the copper plating solution F contains, for example, copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) with a concentration of 200 to 250 g/L, sulfuric acid (H_2SO_4) with a concentration of 50 to 70 g/L, chlorine (Cl) with a concentration of 50 to 200 ppm, and additives with a concentration of 1 to 10 mL/L such as a brightener and a burn stopping agent, as copper plating with respect to the gravure cylinder R proceeds, the concentration of copper ions in the copper plating solution F decreases, and free sulfuric acid increases. Thus, the copper plating solution automatic control mechanism 100 is introduced (see FIG. 6) for the purpose of adding cupric oxide (CuO) to effect a reaction: $\text{CuO} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{H}_2\text{O}$ to adjust the reduced concentration of copper ions. This is preferable because it is not necessary to perform the conventional periodic maintenance of the copper plating solution F and the disposal of a waste liquid.

[0030] The copper plating solution automatic control mechanism 100 samples the copper plating solution F in the reservoir bath 70 by a controller 110 provided with a specific gravity sensor 112 and a sulfuric acid sensor 114, performs required adjustment in a dissolution bath 102, and pumps up the adjusted copper plating solution F with the pump P3 from the dissolution bath 102 to supply it to the reservoir bath 70. That is, the copper plating solution F in the reservoir bath 70 is pumped up with the pump P2, and the specific gravity (concentration of copper) of the copper plating solution F and the concentration of sulfuric acid in the copper plating solution F are measured with the specific gravity sensor 112 and the sulfuric acid sensor 114 provided in the controller 110. In the case of determining that the specific gravity (concentration of copper) is too high (for example, exceeds a concentration range of 200 to 250 g/L), the controller 110 controls an electromagnetic valve VE so as to supply water from a pure water pressure bath 108 to the dissolution bath 102. In the case of determining that the concentration of sulfuric acid is too high (for example, exceeds a concentration range of 50 to 70 g/L), the controller 110 controls a powder supply apparatus 104 with a screw conveyor 105 so as to supply cupric oxide powder from a powder storing hopper 106 to the dissolution bath 102 (see FIG. 5). The water supply amount, when

the electromagnetic valve VE is opened, can be adjusted by opening or closing an adjustment valve VT. Owing to the copper plating solution automatic control mechanism 100 thus configured, the concentration adjustment of the copper plating solution F can be managed automatically, for example, the concentration of copper sulfate can be managed in a range of 200 to 250 g/L, and the concentration of sulfuric acid can be managed in a range of 50 to 70 g/L. While the case of using cupric oxide powder has been illustrated as a preferable example, powder of copper carbonate, copper sulfate, or the like may be used as powder to be supplied.

[0031] Furthermore, the anode chamber liquid amount supply mechanism 200 measures the liquid amount of an acidic electrolyte solution S filling the inside of the anode chamber 20, and supplies water in a case of a shortage of a liquid amount. The anode case 23 of the anode chamber 20 is filled with the acidic electrolyte solution S composed of a sulfuric acid aqueous solution with a concentration of sulfuric acid of about 40 to 150 g/L (see FIGS. 4 and 7), and water is consumed by being electrolyzed with the insoluble anode 24 to generate oxygen, so water is supplied automatically. That is, a pure water bath 210 is provided so as to be communicated with the anode case 23 of the anode chamber 20, and pure water W is stored in the pure water bath 210, whereby a liquid level of the pure water W is detected with a float 212. When the decrease in a liquid level is detected by the float 212, the electromagnetic valve VE is controlled to supply the pure water W from the pure water pressure bath 220 (see FIG. 7). The water supply amount when the electromagnetic valve VE is opened can be adjusted by opening or closing the adjustment valve VT. Owing to the anode chamber liquid amount supply mechanism 200 thus configured, a required liquid amount can be kept automatically for the acidic electrolyte solution S in the anode chamber 20.

Examples

[0032] The present invention will be described more specifically by way of examples below. It should be noted that these examples are shown for illustrative purposes and should not be interpreted in a limited manner.

[0033] In the following Examples 1 to 4, the following common structure was used. As a copper plating solution, a copper sulfate plating solution was used, which had a copper sulfate concentration of 220 g/L, a sulfuric acid concentration of 60 g/L, a chlorine concentration of 120 ppm, and contained, as additives, 5 mL/L of "Cosmo RS-MU (produced and sold by Daiwa Special Chemical Co., Ltd.) and 2 mL/L of "Cosmo RS-1) (produced and sold by Daiwa Special Chemical Co., Ltd.). As powder supplied by the copper plating solution automatic control mechanism, cupric oxide powder "Fusible copper oxide (ES-CuO)" (produced and sold by Tsurumi Soda Co., Ltd.) was used. As an insoluble anode in the anode chamber, an anode obtained by coating the surface of titanium

plate with iridium oxide was used. As an acidic electrolyte solution filling the anode chamber, a sulfuric acid aqueous solution with a sulfuric acid concentration of 100 g/L was used. As a cation exchange film, "Selemion" (produced and sold by Asahi Glass Co., Ltd.) was used. As a copper plating solution automatic control mechanism and an anode chamber liquid amount supply mechanism, apparatuses with the above-mentioned mechanisms are configured. As the specific gravity sensor in the copper plating solution automatic control mechanism, "SG-1" (produced and sold by Japan Aqua Co., Ltd.) was used. As the sulfuric acid concentration sensor, "DM-1" (produced and sold by Japan Aqua Co., Ltd.) was used.

(Example 1)

[0034] As a gravure cylinder, a cylindrical base with an aluminum core having a circumference of a circle of 450 mm and a full length of 1100 mm was used. The gravure cylinder was placed in a plating bath under the condition that both ends of the gravure cylinder were chucked. Anode chambers were brought close to gravure cylinder side surfaces up to an interval of 20 mm with a slide mechanism controlled by a computer, and the copper plating solution was overflowed, whereby the gravure cylinder was soaked completely. With the rotation speed of the gravure cylinder being set to be 120 ppm, copper plating was provided at a liquid temperature of 40°C, a current density of 18 A/dm², and a voltage of 5.4 V until the thickness became 80 μm. The time required for a plating treatment was about 20 minutes. There were no rashes and pits on a plating surface, and plating with a uniform thickness was provided over the full length of the gravure cylinder. Furthermore, the copper plating solution automatic control mechanism was operated normally, and the composition of the copper plating solution was kept in an appropriate range. The anode chamber liquid amount supply mechanism was operated normally, and the liquid amount in the anode chamber was kept at an appropriately amount. The consumption amount of the additives was reduced (i.e., 60 cc/1000 AH).

(Example 2)

[0035] As a gravure cylinder, a cylindrical base with an aluminum core having a circumference of a circle of 600 mm and a full length of 1100 mm was used. The gravure cylinder was placed in a plating bath. Anode chambers were brought close to the gravure cylinder up to an interval of 20 mm with a slide mechanism controlled by a computer, and the plating solution was overflowed, whereby the gravure cylinder was soaked completely. With the rotation speed of the gravure cylinder being set to be 120 ppm, copper plating was provided at a liquid temperature of 40°C, a current density of 18 A/dm², and a voltage of 6.0 V until the thickness became 80 μm. The time required for a plating treatment was about 20 minutes. There were no rashes and pits on a plating surface,

and plating with a uniform thickness was provided over the full length of the gravure cylinder. Furthermore, the copper plating solution automatic control mechanism was operated normally, and the composition of the copper plating solution was kept in an appropriate range. The anode chamber liquid amount supply mechanism was operated normally, and the liquid amount in the anode chamber was kept at an appropriately amount. The consumption amount of the additives was reduced (i.e., 60 cc/1000 AH).

(Example 3)

[0036] As a gravure cylinder, a cylindrical base with an aluminum core having a circumference of a circle of 940 mm and a full length of 1100 mm was used. The gravure cylinder was placed in a plating bath under the condition that both ends of the gravure cylinder were chucked. Anode chambers were brought close to the gravure cylinder up to an interval of 20 mm with a slide mechanism controlled by a computer, and the plating solution was overflowed, whereby the gravure cylinder was soaked completely. With the rotation speed of the gravure cylinder being set to be 120 ppm, copper plating was provided at a liquid temperature of 40°C, a current density of 18 A/dm², and a voltage of 7.7 V until the thickness became 80 μm. The time required for a plating treatment was about 20 minutes. There were no rashes and pits on a plating surface, and plating with a uniform thickness was provided over the full length of the gravure cylinder. Furthermore, the copper plating solution automatic control mechanism was operated normally, and the composition of the copper plating solution was kept in an appropriate range. The anode chamber liquid amount supply mechanism was operated normally, and the liquid amount in the anode chamber was kept at an appropriately amount. The consumption amount of the additives was reduced (i.e., 60 cc/1000 AH).

(Example 4)

[0037] As a gravure cylinder, a cylindrical base with an aluminum core having a circumference of a circle of 940 mm and a full length of 1100 mm was used. The gravure cylinder was placed in a plating bath under the condition that both ends of the gravure cylinder were chucked. Anode chambers were brought close to the gravure cylinder up to an interval of 5 mm with a slide mechanism controlled by a computer, and the plating solution was overflowed, whereby the gravure cylinder was soaked completely. With the rotation speed of the gravure cylinder being set to be 120 ppm, copper plating was provided at a liquid temperature of 40°C, a current density of 30 A/dm², and a voltage of 7.9 V until the thickness became 80 μm. The time required for a plating treatment was about 12 minutes. There were no rashes and pits on a plating surface, and plating with a uniform thickness was provided over the full length of the gravure cylinder. Fur-

thermore, the copper plating solution automatic control mechanism was operated normally, and the composition of the copper plating solution was kept in an appropriate range. The anode chamber liquid amount supply mechanism was operated normally, and the liquid amount in the anode chamber was kept at an appropriately amount. The consumption amount of the additives was reduced (i.e., 60 cc/1000 AH).

Claims

1. A copper plating method for a gravure cylinder, comprising:

holding a gravure cylinder in a hollow cylindrical shape at both ends in a longitudinal direction; accommodating the gravure cylinder in a plating bath filled with a copper plating solution; energizing the gravure cylinder so that the gravure cylinder functions as a cathode while being rotated at a predetermined speed; bringing a pair of anode chambers in a long box shape, in which insoluble anodes are provided upright slidably to both sides of the gravure cylinder in the plating bath and energized so as to function as an anode, close to both side surfaces of the gravure cylinder at a predetermined interval; and providing copper plating on an outer peripheral surface of the gravure cylinder.

2. A copper plating method for a gravure cylinder according to claim 1, wherein a cation exchange film is provided on a side surface of the anode chamber on the gravure cylinder side.

3. A copper plating method for a gravure cylinder according to claim 1 or 2, wherein the anode chamber has a length equal to or larger than a full length of the gravure cylinder in a longitudinal direction.

4. A copper plating method for a gravure cylinder according to any one of claims 1 to 3, wherein an inside of the anode chamber is filled with an acidic electrolyte solution, a liquid amount in the anode chamber is measured, and in a case where the liquid amount is insufficient, water is supplied.

5. A copper plating method for a gravure cylinder according to any one of claims 1 to 4, wherein the copper plating liquid contains copper sulfate, sulfuric acid, chlorine, and an additive, a specific gravity and a sulfuric acid concentration of the copper plating solution are measured, in a case where the specific gravity is too high, water is supplied, and in a case where the sulfuric acid concentration is too high, cupric oxide powder is supplied.

6. A copper plating method for a gravure cylinder according to any one of claims 1 to 5, wherein the copper plating solution is obtained by removing impurities with a filter.

7. A copper plating method for a gravure cylinder according to any one of claims 1 to 6, wherein the predetermined interval is 1 mm to 50 mm.

8. A copper plating apparatus for a gravure cylinder that provides an outer peripheral surface of a gravure cylinder with copper plating, comprising:

a plating bath filled with a copper plating solution;
 chuck means for holding the gravure cylinder in a hollow cylindrical shape at both ends in a longitudinal direction so that the gravure cylinder is capable of being rotated and energized, and accommodating the gravure cylinder in the plating bath; and
 a pair of anode chambers in a long box shape which are provided upright slidably to both sides of the gravure cylinder in the plating bath and in which an insoluble anode energized so as to function as an anode is provided.

9. A copper plating apparatus for a gravure cylinder according to claim 8, wherein a cation exchange film is provided on a side surface of the anode chamber on the gravure cylinder side.

10. A copper plating apparatus for a gravure cylinder according to claim 8 or 9, wherein the anode chamber has a length equal to or larger than a full length of the gravure cylinder in a longitudinal direction thereof.

11. A copper plating apparatus for a gravure cylinder according to any one of claims 8 to 10, wherein an inside of the anode chamber is filled with an acidic electrolyte solution, and the apparatus further comprises an anode chamber liquid amount supply mechanism that measures a liquid amount in the anode chamber and supplies water in a case where the liquid amount is insufficient.

12. A copper plating apparatus for a gravure cylinder according to any one of claims 8 to 11, wherein the copper plating solution contains copper sulfate, sulfuric acid, chlorine, and an additive, and the apparatus further comprises a copper plating solution automatic control mechanism that measures a specific gravity and a sulfuric acid concentration of the copper plating solution, and supplies water in a case where the specific gravity is too high and supplies cupric oxide powder in a case where the sulfuric acid concentration is too high.

13. A copper plating apparatus for a gravure cylinder according to any one of claims 8 to 12, further comprising a filter that removes impurities in the copper plating solution.

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FIG.1

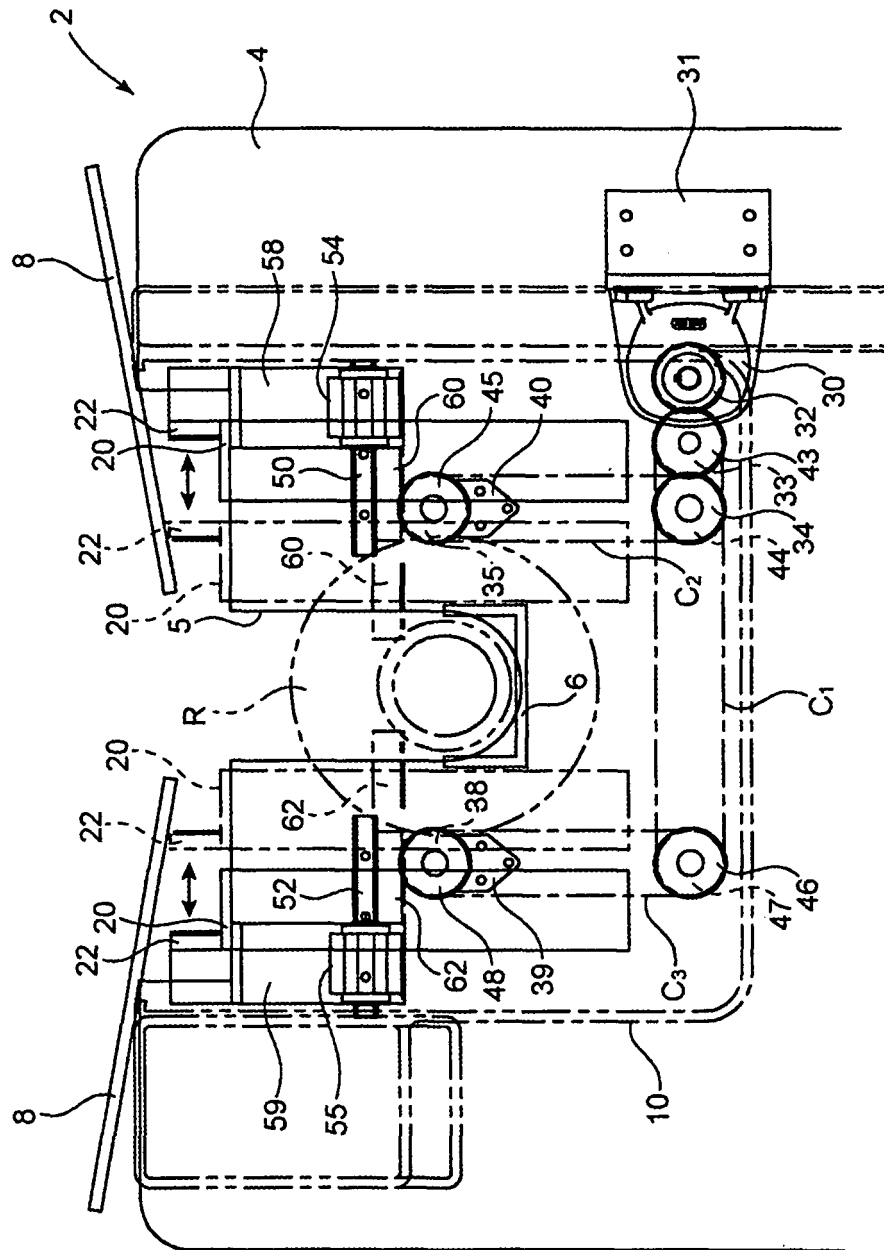


FIG.2

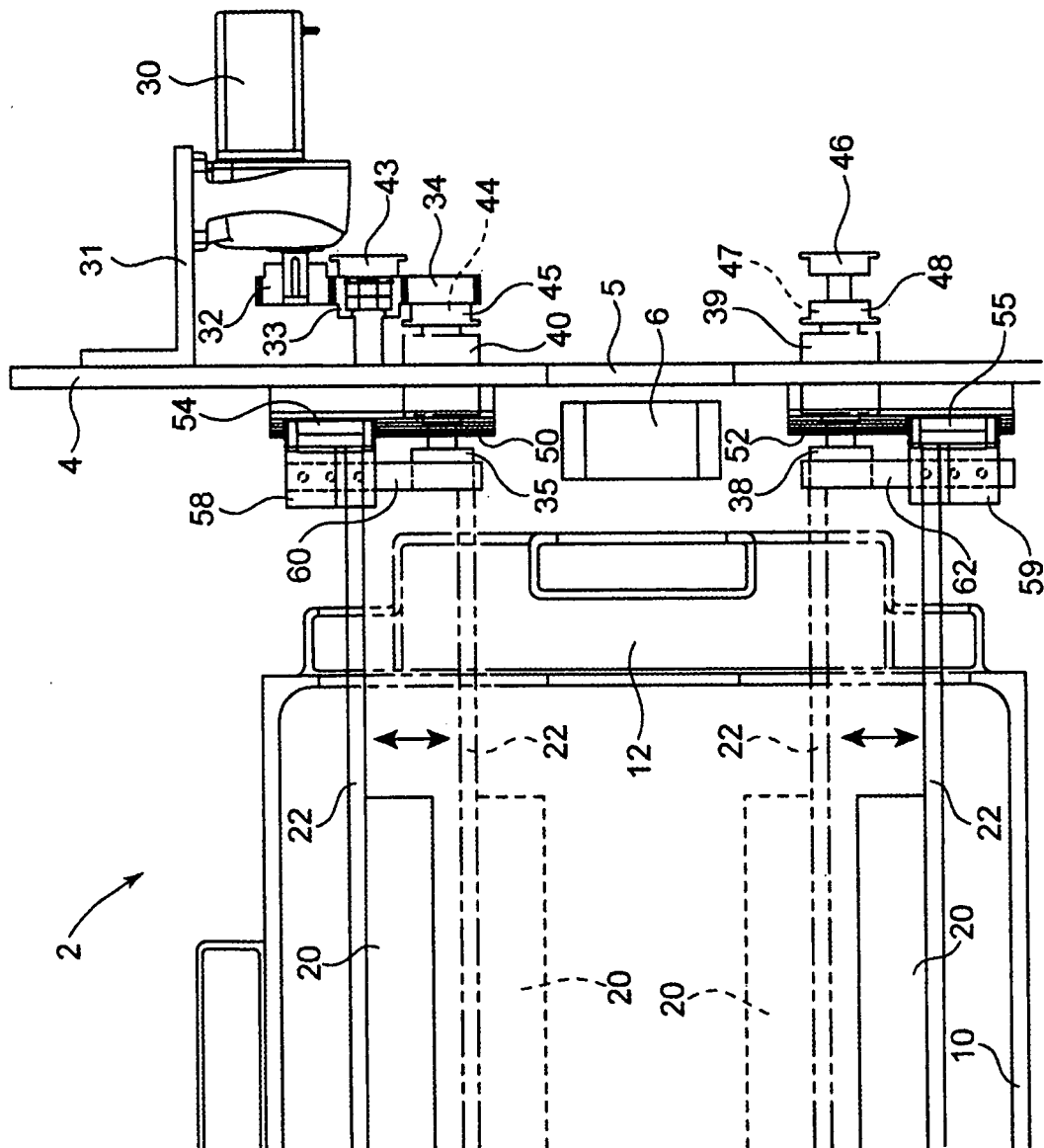


FIG.3

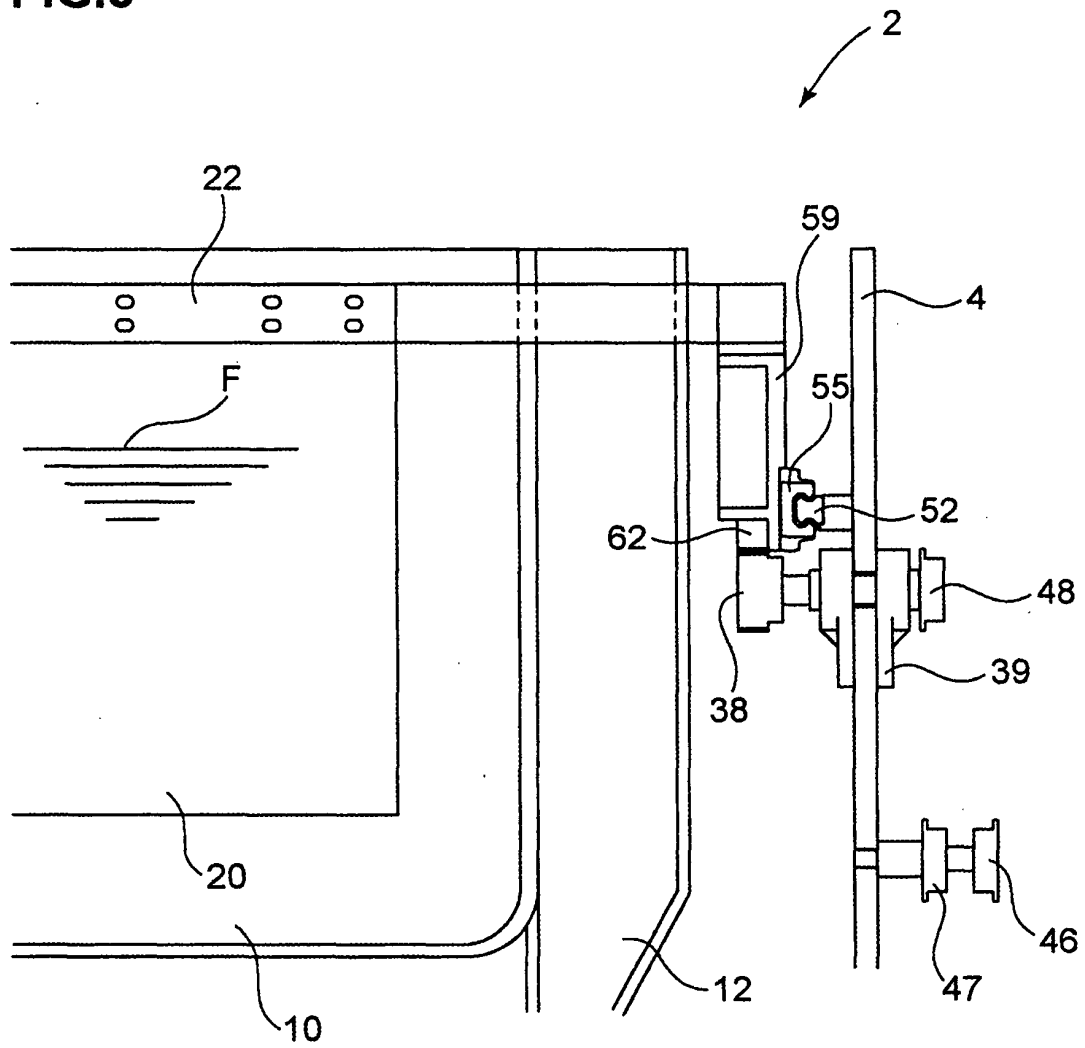


FIG.4

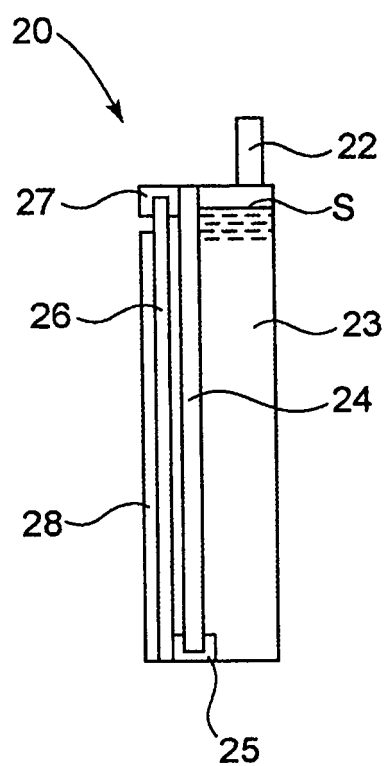


FIG.5

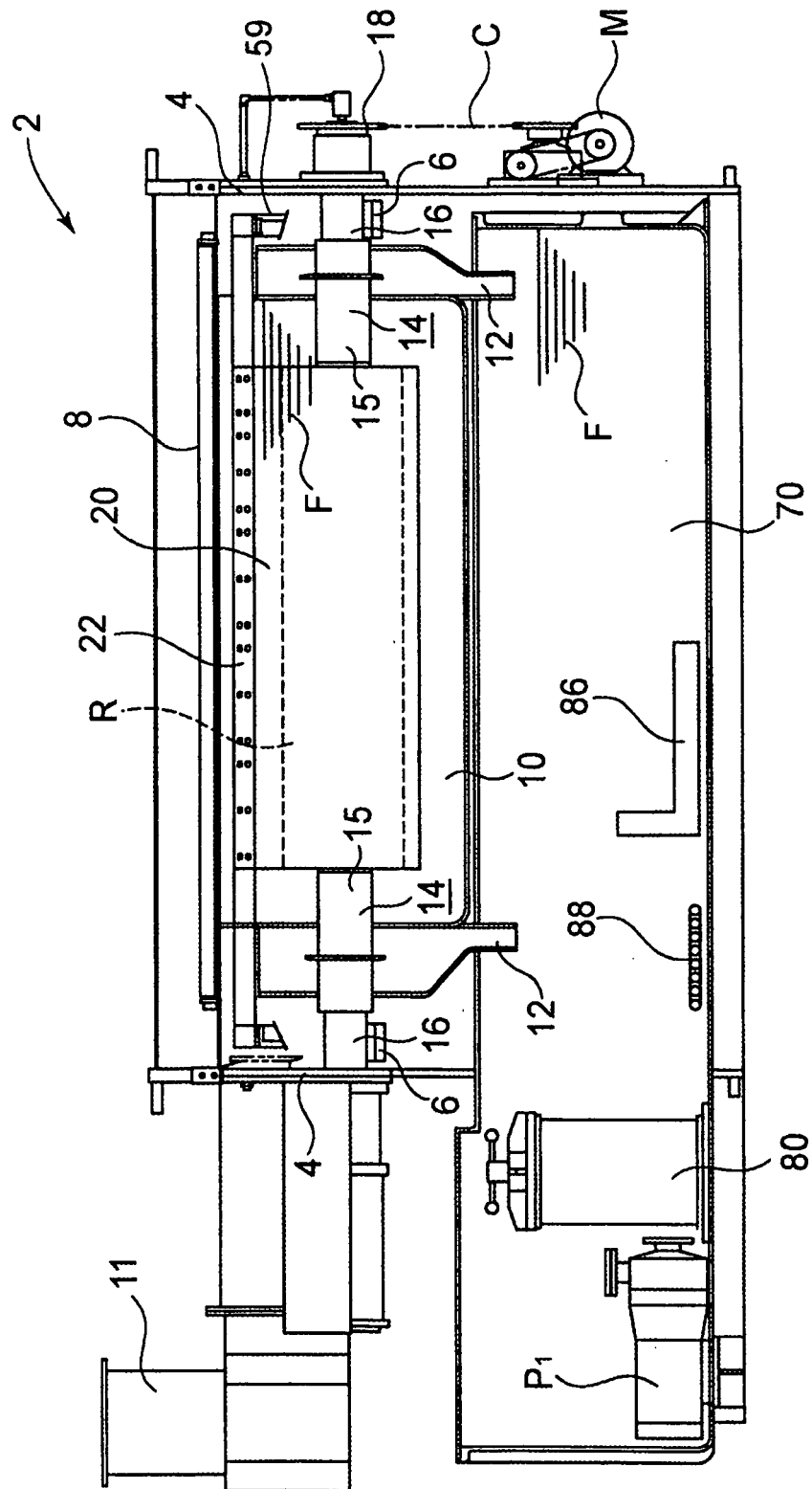


FIG.6

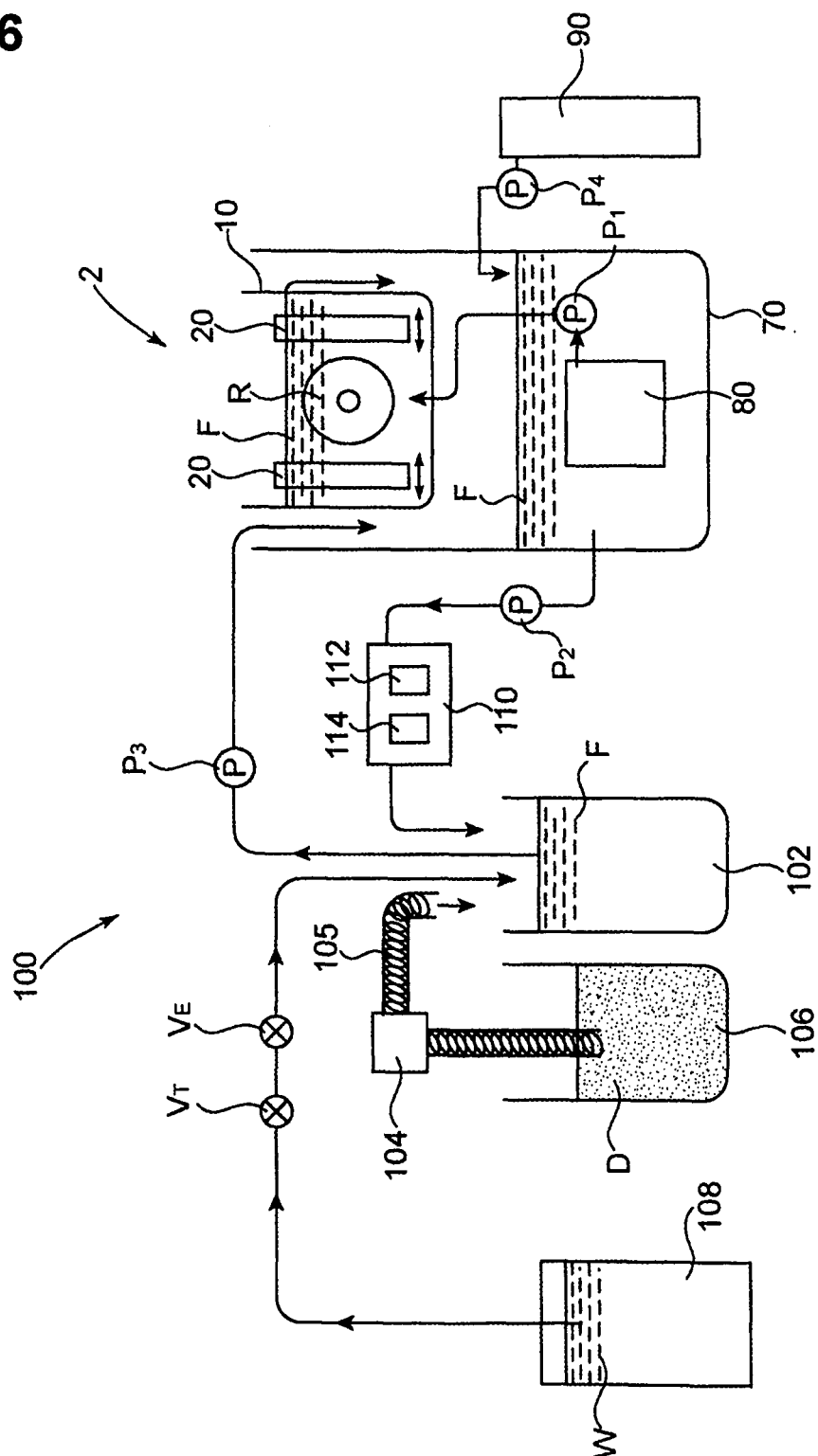
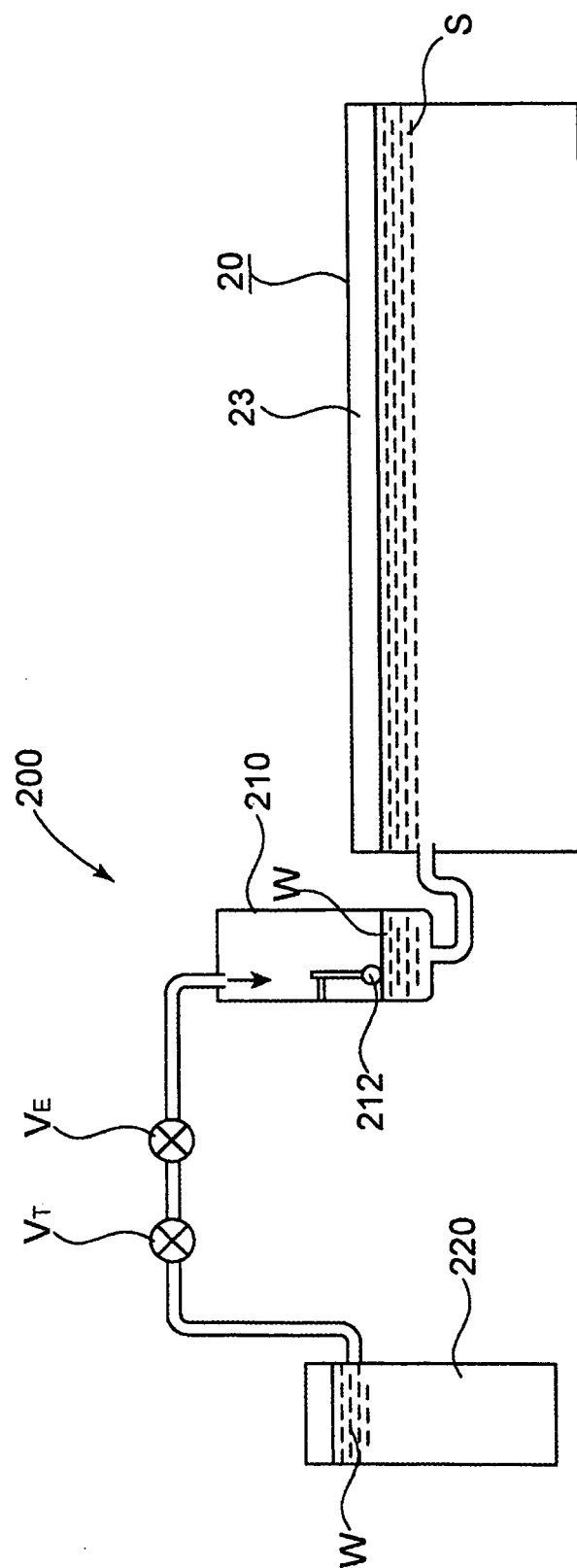


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/310209

A. CLASSIFICATION OF SUBJECT MATTER

C25D17/00(2006.01)i, B41N3/03(2006.01)i, C25D7/04(2006.01)i, C25D21/14(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C25D17/00, B41N3/03, C25D7/04, C25D21/14

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2006

Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-29876 A (Think Laboratory Co., Ltd.), 03 February, 2005 (03.02.05), Par. Nos. [0014], [0015] (Family: none)	1-13
Y	JP 2004-269955 A (Osaka-fu), 30 September, 2004 (30.09.04), Claims; Par. No. [0006] (Family: none)	1-13
Y	JP 2000-17495 A (Rikkusu Kabushiki Kaisha), 18 January, 2000 (18.01.00), Par. No. [0012] (Family: none)	1-13

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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Date of the actual completion of the international search
28 August, 2006 (28.08.06)Date of mailing of the international search report
05 September, 2006 (05.09.06)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/310209

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 8-193299 A (Mitsui High-Tec Inc.), 30 July, 1996 (30.07.96), Par. No. [0007] (Family: none)	4, 11
Y	JP 63-60295 A (Mitsubishi Metal Corp.), 16 March, 1988 (16.03.88), Full text (Family: none)	5, 12

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 57036995 B [0008]
- JP 11061488 A [0008]
- JP 2005029876 A [0008]
- JP 2005133139 A [0008]