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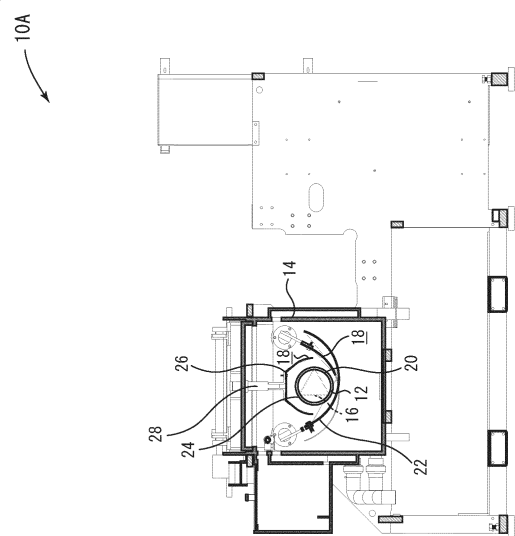
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(54) **APPARATUS AND METHOD FOR TRIVALENT CHROMIUM PLATING FOR CYLINDER**

(57) Provided are a cylinder trivalent chromium plating apparatus and a cylinder trivalent chromium plating method that use a trivalent chromium plating solution to perform trivalent chromium plating with good deposition, uniformity and excellent printing durability without forming undeposited portions of the plating. The cylinder trivalent chromium plating apparatus includes: a plating bath configured to store a trivalent chromium plating solution; a chuck means for holding a cylinder to be processed at both ends in a longitudinal direction thereof so as to be rotated and energized, and accommodating the cylinder to be processed in the plating bath in a horizontal direction; and insoluble electrodes configured to be supplied with a predetermined current, the insoluble electrodes being brought close to an outer peripheral surface of the cylinder to be processed at predetermined intervals to plate the outer peripheral surface with trivalent chromium, the insoluble electrodes being surrounding insoluble electrodes configured to surround a periphery of the outer peripheral surface of the cylinder to be processed.

Fig.1



## Description

### Technical Field

**[0001]** The present invention relates to a cylinder trivalent chromium plating apparatus and a cylinder trivalent chromium plating method for plating an outer peripheral surface of a long and hollow roll with a trivalent chromium plating solution through use of an insoluble electrode when manufacturing, for example, a hollow and tubular gravure cylinder to be used for gravure printing (also referred to as "plate-making roll").

### Background Art

**[0002]** In gravure printing, minute recesses (cells) are formed in a hollow and tubular cylinder to be processed based on plate-making information to produce a printing surface, and the cells are filled with ink so that the ink is transferred onto an object to be printed. In general gravure cylinders, a tubular iron or aluminum core (hollow roll) is used as a base, and a plurality of layers such as an underlying layer and a separation layer are formed on an outer peripheral surface of the base. On those layers, a copper plating layer or any other plating layer is formed. Then, cells are formed in the copper plating layer or any other plating layer by a laser exposure apparatus based on plate-making information, and then the resultant base is plated with chromium or any substance for enhancing printing durability of the gravure cylinder, so that an operation for plate-making (making a printing plate surface) is completed. In this general chromium plating, a hexavalent chromium plating layer is formed.

**[0003]** However, in a chromium plating process, a hexavalent chromium plating solution which is highly toxic is used. Thus, extra cost for keeping the safety of work is incurred, and there is also a problem in that pollution may be caused. Accordingly, at present, an emergence of a surface reinforcing coating layer which can replace the hexavalent chromium plating layer is expected.

**[0004]** In place of the plating method of forming the hexavalent chromium plating layer obtained with use of the hexavalent chromium plating solution, there is given a trivalent chromium plating method of forming a chromium plating layer with use of a trivalent chromium plating solution. As the trivalent chromium plating solution, for example, the trivalent chromium plating solution as disclosed in Patent Document 1 is given.

**[0005]** Moreover, the applicant of the subject application has already proposed a cylinder plating apparatus, including: a plating bath configured to store a plating solution; a chuck means for holding a cylinder to be processed at both ends in a longitudinal direction thereof so as to be rotated and energized, and accommodating the cylinder to be processed in the plating bath; and a pair of opposed insoluble electrodes, which are vertically installed so as to face both side surfaces of the cylinder to be processed in the plating bath, and are configured to

be supplied with a predetermined current, the pair of opposed insoluble electrodes being brought close to both the side surfaces of the cylinder to be processed at predetermined intervals to plate an outer peripheral surface of the cylinder to be processed, each of the pair of opposed insoluble electrodes having a shape in which at least a lower part thereof is curved inward, at least the lower part comprising a comb-like portion, the pair of opposed insoluble electrodes facing each other in a staggered pattern so that projections of the comb-like portion of one of the pair of opposed insoluble electrodes are located at positions of recesses of the comb-like portion of another one of the pair of opposed insoluble electrodes, each of the pair of opposed insoluble electrodes being configured to rotate about an upper end thereof so that a distance of closeness of each of the pair of opposed insoluble electrodes to the outer peripheral surface of the cylinder to be processed is adjustable depending on a diameter of the cylinder to be processed (Patent Document 2).

**[0006]** With the cylinder plating apparatus in Patent Document 2, in general chromium plating using the hexavalent chromium plating solution, a chromium plating layer (hexavalent chromium plating layer) which satisfies surface properties required for gravure printing, such as hardness, abrasion resistance and uniform electrodeposition and is thus excellent in printing durability can be obtained.

**[0007]** However, when trivalent chromium plating using the trivalent chromium plating solution is performed with the cylinder plating apparatus in Patent Document 2, as shown in the photograph of FIG. 11, a black portion is formed in a center portion of the cylinder. The black portion indicates a state in which an undeposited portion is formed in part of the cylinder. The undeposited portion means such a state that plating is hardly deposited. As described above, when the trivalent chromium plating using the trivalent chromium plating solution is performed with the cylinder plating apparatus in Patent Document 2, there is a problem in that the undeposited portion is formed in part of the cylinder.

### Prior Art Documents

Patent Documents

### [0008]

Patent Documents 1: JP 2019-123927 A  
Patent Documents 2: WO 2015/151665 A1

### Summary of the Invention

### Problems to be solved by the Invention

**[0009]** The present invention has been made in view of the problems of the related art described above, and an object of the present invention is to provide a cylinder

trivalent chromium plating apparatus and a cylinder trivalent chromium plating method that use a trivalent chromium plating solution to perform trivalent chromium plating with good deposition, uniformity and excellent printing durability without forming undeposited portions of the plating.

#### Means for solving the Problems

**[0010]** According to the present invention, there is provided a cylinder trivalent chromium plating apparatus, including: a plating bath configured to store a trivalent chromium plating solution; a chuck means for holding a cylinder to be processed at both ends in a longitudinal direction thereof so as to be rotated and energized, and accommodating the cylinder to be processed in the plating bath in a horizontal direction; and insoluble electrodes configured to be supplied with a predetermined current, wherein the insoluble electrodes are brought close to an outer peripheral surface of the cylinder to be processed at predetermined intervals to plate the outer peripheral surface with the trivalent chromium plating solution, and wherein the insoluble electrodes are surrounding insoluble electrodes configured to surround a periphery of the outer peripheral surface of the cylinder to be processed.

**[0011]** It is preferred that the surrounding insoluble electrodes include lower-side surrounding insoluble electrodes configured to surround a periphery of a lower outer peripheral surface of the cylinder to be processed which is accommodated in the plating bath in the horizontal direction and/or upper-side surrounding insoluble electrodes configured to surround a periphery of an upper outer peripheral surface of the cylinder to be processed which is accommodated in the plating bath in the horizontal direction.

**[0012]** It is preferred that the upper-side surrounding insoluble electrode and/or the lower-side surrounding insoluble electrode be a crossing electrode.

**[0013]** It is preferred that the surrounding insoluble electrodes be brought close to the outer peripheral surface of the cylinder to be processed in accordance with a cylinder diameter thereof by an air cylinder or an electric motor.

**[0014]** It is preferred that the surrounding insoluble electrodes be brought close to the outer peripheral surface of the cylinder to be processed in accordance with a cylinder diameter thereof by rotary motion of arms or movement of the arms of increasing or decreasing a distance therebetween.

**[0015]** According to the present invention, there is provided a trivalent chromium plating method, including plating the cylinder to be processed with the trivalent chromium plating solution through use of the cylinder trivalent chromium plating apparatus.

**[0016]** According to the present invention, there is provided a gravure cylinder manufacturing method, including manufacturing a gravure cylinder by plating the cylinder to be processed with the trivalent chromium

plating solution through use of the cylinder trivalent chromium plating apparatus.

#### Advantageous Effects of the Invention

**[0017]** According to the present invention, a significant effect of providing a cylinder trivalent chromium plating apparatus and a cylinder trivalent chrome plating method that use a trivalent chromium plating solution to perform trivalent chromium plating with uniformity and excellent printing durability can be achieved.

#### Brief Description of the Drawings

**[0018]**

FIG. 1 is a left side view for illustrating a cylinder trivalent chromium plating apparatus according to a first embodiment of the present invention.

FIG. 2(a) is a main part perspective view of the cylinder trivalent chromium plating apparatus according to the first embodiment as seen from a left side.

FIG. 2(b) is a main part perspective view of the cylinder trivalent chromium plating apparatus according to the first embodiment as seen from a right side.

FIG. 3 is a left side view for illustrating a cylinder trivalent chromium plating apparatus according to a second embodiment of the present invention.

FIG. 4(a) is a main part perspective view of the cylinder trivalent chromium plating apparatus according to the second embodiment as seen from the left side.

FIG. 4(b) is a main part perspective view of the cylinder trivalent chromium plating apparatus according to the second embodiment as seen from the right side.

FIG. 5 is a left side view for illustrating a cylinder trivalent chromium plating apparatus according to a third embodiment of the present invention.

FIG. 6(a) is a main part perspective view of the cylinder trivalent chromium plating apparatus according to the third embodiment as seen from the left side.

FIG. 6(b) is a main part perspective view of the cylinder trivalent chromium plating apparatus according to the third embodiment as seen from the right side.

FIG. 7 is a left side view for illustrating a cylinder trivalent chromium plating apparatus according to a fourth embodiment of the present invention.

FIG. 8 is a perspective view of the cylinder trivalent chromium plating apparatus according to the fourth embodiment as seen from the left side.

FIG. 9 is a plan view of the cylinder trivalent chromium plating apparatus according to the fourth embodiment as seen from above.

FIG. 10(a) is a main part perspective view of the cylinder trivalent chromium plating apparatus according to the fourth embodiment as seen from the left side.

FIG. 10(b) is a main part perspective view of the cylinder trivalent chromium plating apparatus according to the fourth embodiment as seen from the right side.

FIG. 11 is a photograph of a gravure cylinder manufactured by performing trivalent chromium plating using a trivalent chromium plating solution with a cylinder plating apparatus in Patent Document 2.

#### Mode for carrying out the Invention

**[0019]** Embodiments of the present invention are described below with reference to the accompanying drawings, but illustrated examples are merely described as examples, and hence it is understood that various modifications may be made without departing from the technical spirit of the present invention.

**[0020]** In FIG. 1 and FIGS. 2, a cylinder trivalent chromium plating apparatus 10A is shown as a first embodiment of a cylinder trivalent chromium plating apparatus according to the present invention.

**[0021]** The cylinder trivalent chromium plating apparatus 10A is a plating apparatus for trivalent chromium plating a cylinder 12 to be processed. The cylinder trivalent chromium plating apparatus 10A includes: a plating bath 14 configured to store a trivalent chromium plating solution; a chuck means 16 for holding the cylinder 12 to be processed at both ends in a longitudinal direction thereof so as to be rotated and energized, and accommodating the cylinder 12 to be processed in the plating bath in a horizontal direction; and insoluble electrodes 18 configured to be supplied with a predetermined current. The insoluble electrodes 18 are brought close to an outer peripheral surface of the cylinder 12 to be processed at predetermined intervals to plate the outer peripheral surface with the trivalent chromium plating solution. The insoluble electrodes 18 are surrounding insoluble electrodes configured to surround a periphery of the outer peripheral surface of the cylinder 12 to be processed.

**[0022]** The surrounding insoluble electrodes 18 include a lower-side surrounding insoluble electrode 22 configured to surround a periphery of a lower outer peripheral surface 20 of the cylinder 12 to be processed which is accommodated in the plating bath 14 in the horizontal direction and/or an upper-side surrounding insoluble electrode 26 configured to surround a periphery of an upper outer peripheral surface 24 of the cylinder 12 to be processed which is accommodated in the plating bath 14 in the horizontal direction. In FIG. 1, an example of including both the lower-side surrounding insoluble electrode 22 and the upper-side surrounding insoluble electrode 26 is given.

**[0023]** It is preferred that a mesh-like electrode be used as the surrounding insoluble electrodes to be used in the

cylinder trivalent chromium plating apparatus according to the present invention including the above-mentioned surrounding insoluble electrode 18 or a surrounding insoluble electrode in an embodiment to be described later.

5 The mesh-like electrode is used because an electric field is generated on a back surface of the surrounding insoluble electrode as well as a front surface thereof, and hence the surface area effective as the electrodes is increased in the surrounding insoluble electrode, with the result that the current density of the surrounding insoluble electrode is reduced to prolong its life. It is preferred that the mesh-like electrode as described in Patent Document 2 be used as the mesh-like electrode.

**[0024]** In the cylinder trivalent chromium plating apparatus 10A, the lower-side surrounding insoluble electrode 22 is a crossing electrode. The crossing electrode herein corresponds to electrode in which a pair of insoluble electrodes each having a comb-like portion formed at an end portion thereof cross each other in a staggered position. That is, the crossing electrode is an electrode in which a pair of lower-side surrounding insoluble electrodes (22a and 22b) face each other in a staggered position to be crossed each other so that projections of the comb-like portion of the lower-side surrounding insoluble electrode 22b of one of the pair of lower-side surrounding insoluble electrodes are located at positions of recesses of the comb-like portion of the lower-side surrounding insoluble electrode 22a of another one of the pair of lower-side surrounding insoluble electrodes.

**[0025]** The upper-side surrounding insoluble electrode 26 of the surrounding insoluble electrodes 18 is moved up and down by an air cylinder 28 so as to be brought close to the outer peripheral surface of the cylinder 12 to be processed in accordance with a cylinder diameter thereof. In place of the air cylinder 28, an electric motor may be used to cause the upper-side surrounding insoluble electrode 26 to be moved up and down so that the upper-side surrounding insoluble electrode 26 is brought close to the outer peripheral surface of the cylinder 12 to be processed in accordance with the cylinder diameter thereof.

**[0026]** A degree of which the projections of the comb-like portion of the lower-side surrounding insoluble electrode 22b are inserted into the positions of the recesses of the comb-like portion of the lower-side surrounding insoluble electrode 22a is adjusted by rotary motion of arms 30a and 30b. With this, the lower-side surrounding insoluble electrode 22 of the surrounding insoluble electrodes 18 is brought close to the outer peripheral surface of the cylinder 12 to be processed in accordance with the cylinder diameter thereof.

**[0027]** Hitherto, as shown in Patent Document 2, electrodes are located only at a lower part of the cylinder 12 to be processed which is installed in the horizontal direction. However, in the present invention, the electrodes are arranged on an upper side of the cylinder 12 to be processed so as to cover the cylinder 12 to be processed. Specifically, the present invention is characterized in that the electrodes are provided over an entire periphery of

the cylinder 12 to be processed. In the illustrated example, the upper-side surrounding insoluble electrode 26 and the lower-side surrounding insoluble electrode 22 are supplied with power from the same power source. Moreover, although a diameter of the cylinder 12 to be processed varies, the configuration of the present invention can be applied to the cylinder 12 to be processed having various diameter sizes by moving the upper-side surrounding insoluble electrode 26 and the lower-side surrounding insoluble electrode 22.

**[0028]** With the above-mentioned configuration, even when the trivalent chromium plating using the trivalent chromium plating solution is performed, a cylinder which is satisfactory, fine and uniform in deposition, and is excellent in printing durability can be obtained without a problem that an undeposited portion is formed in part of the cylinder 12 to be processed. The cylinder is excellent in printing durability, and hence the cylinder can be applied to a gravure cylinder. Moreover, the cylinder trivalent chromium plating apparatus 10A has also an effect of reducing a voltage by approximately 50% as compared with the cylinder plating apparatus having the configuration in which the electrodes are provided only on a lower side as shown in Patent Document 2.

**[0029]** As the trivalent chromium plating solution, the plating solution as described in Patent Document 1 can be used. In particular, hexavalent chromium is toxic, and hence it is preferred that a trivalent chromium plating solution using trivalent chromium be used, and that a trivalent chromium plating solution containing trivalent chromium such as chromium trichloride ( $\text{CrCl}_3$  ( $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ )) be used. Moreover, as described in Patent Document 1, as a solution of chromium trichloride, it is preferred that a solution of chloride (calcium chloride or lithium chloride) be used without using water, and that a solution having high-concentration calcium halide dissolved therein be used. In addition, it is preferred that a solution having a specific decomposition potential as described in Patent Document 1 be used as the plating solution.

**[0030]** The cylinder 12 to be processed is accommodated in the plating bath 14 in the horizontal direction. That is, the plating apparatus according to the present invention is a horizontal plating apparatus which accommodates the cylinder 12 to be processed in a horizontal manner. In the case of the horizontal plating apparatus, when the electrode is provided on the upper side of the cylinder 12 to be processed, there arises a problem of taking the cylinder 12 to be processed into or out of the plating bath 14. Such problem of taking the cylinder 12 to be processed into or out of the plating bath 14 is solved by causing the upper-side surrounding insoluble electrode 26 to be moved up and down by the air cylinder 28.

**[0031]** It is also conceivable to adopt a mode of a vertical plating apparatus in which the cylinder 12 to be processed is accommodated in a vertical manner in the plating apparatus in the vertical direction. However, even when, for example, a tubular electrode is arranged at the

periphery of the cylinder 12 to be processed which is set up in the vertical direction, fine trivalent chromium plating cannot be performed. One problem of such vertical plating apparatus is as follows. A time period in which the cylinder 12 to be processed is immersed in the trivalent chromium plating solution differs between upper part and lower part thereof because the plating solution accumulates from a lower side of the plating bath. The trivalent chromium plating solution is acidic, and hence a surface of the cylinder 12 to be processed may be corroded or the surface of the cylinder 12 to be processed may become rough.

**[0032]** Another problem of such vertical plating apparatus is as follows. In the vertical plating apparatus, the cylinder to be processed is exposed to a state similar to electroless plating during a period in which the plating solution accumulates from the lower side of the plating bath. Accordingly, when the plating solution contains impurities such as Ni or Fe, the impurities may deposit on the surface of the cylinder to be processed only by immersing the cylinder to be processed in the plating solution.

**[0033]** The plating apparatus according to the present invention is a horizontal plating apparatus in which the cylinder 12 to be processed is accommodated in the plating bath 14 in the horizontal direction. Thus, the plating solution can be put under a state in which the cylinder 12 to be processed is rotating. Accordingly, the problem that only part of the surface of the cylinder becomes rough can be avoided.

**[0034]** Next, a cylinder trivalent chromium plating apparatus 10B is shown in FIG. 3 and FIGS. 4 as a second embodiment of the cylinder trivalent chromium plating apparatus according to the present invention.

**[0035]** The cylinder trivalent chromium plating apparatus 10B includes: a plating bath 34 configured to store a trivalent chromium plating solution; a chuck means 36 for holding the cylinder 12 to be processed at both ends in the longitudinal direction thereof so as to be rotated and energized, and accommodating the cylinder 12 to be processed in the plating bath in the horizontal direction; and insoluble electrodes 38 configured to be supplied with a predetermined current. The insoluble electrodes 38 are brought close to the outer peripheral surface of the cylinder 12 to be processed at predetermined intervals to plate the outer peripheral surface with the trivalent chromium plating solution. The insoluble electrodes 38 are surrounding insoluble electrodes which surround the periphery of the outer peripheral surface of the cylinder 12 to be processed.

**[0036]** In FIG. 3, the surrounding insoluble electrodes 38 include: lower-side surrounding insoluble electrode 42 configured to surround a periphery of a lower outer peripheral surface 40 of the cylinder 12 to be processed which is accommodated in the plating bath 34 in the horizontal direction; and upper-side surrounding insoluble electrode 46 configured to surround a periphery of an upper outer peripheral surface 44 of the cylinder 12 to be

processed which is accommodated in the plating bath 34 in the horizontal direction.

**[0037]** In the cylinder trivalent chromium plating apparatus 10B, the lower-side surrounding insoluble electrode 42 is a crossing electrode.

**[0038]** The upper-side surrounding insoluble electrode 46 of the surrounding insoluble electrodes 38 are opened and closed between a state of covering the upper part of the cylinder 12 to be processed and an open state by rotary motion of arms 48a and 48b. With this, the upper-side surrounding insoluble electrode 46 is brought close to the outer peripheral surface of the cylinder 12 to be processed in accordance with the cylinder diameter thereof. The arms 48a and 48b are driven by a drive source (not shown).

**[0039]** Moreover, a degree of which projections of a comb-like portion of the lower-side surrounding insoluble electrode 42b are inserted into positions of recesses of a comb-like portion of the lower-side surrounding insoluble electrode 42a is adjusted by rotary motion of arms 50a and 50b. With this, the lower-side surrounding insoluble electrodes 42 (42a and 42b) of the surrounding insoluble electrodes 38 are brought close to the outer peripheral surface of the cylinder 12 to be processed in accordance with the cylinder diameter thereof.

**[0040]** With the above-mentioned configuration, even when the trivalent chromium plating using the trivalent chromium plating solution is performed, a cylinder which is satisfactory, fine and uniform in deposition, and is excellent in printing durability can be obtained without a problem that an undeposited portion is formed in part of the cylinder 12 to be processed. The cylinder is excellent in printing durability, and hence the cylinder can be applied to a gravure cylinder. Moreover, the cylinder trivalent chromium plating apparatus 10B has also an effect of reducing a voltage by approximately 50% as compared with the cylinder plating apparatus having the configuration in which the electrodes are provided only on the lower side as shown in Patent Document 2.

**[0041]** Next, a cylinder trivalent chromium plating apparatus 10C is shown in FIG. 5 and FIGS. 6 as a third embodiment of the cylinder trivalent chromium plating apparatus according to the present invention.

**[0042]** The cylinder trivalent chromium plating apparatus 10C includes: a plating bath 54 configured to store a trivalent chromium plating solution; a chuck means 56 for holding the cylinder 12 to be processed at both ends in the longitudinal direction thereof so as to be rotated and energized, and accommodating the cylinder 12 to be processed in the plating bath in the horizontal direction; and insoluble electrodes 58 configured to be supplied with a predetermined current. The insoluble electrodes 58 are brought close to the outer peripheral surface of the cylinder 12 to be processed at predetermined intervals to plate the outer peripheral surface with the trivalent chromium plating solution. The insoluble electrodes 58 are surrounding insoluble electrodes configured to surround the periphery of the outer peripheral surface of the cylinder 12 to be processed.

der 12 to be processed.

**[0043]** In FIG. 5, the surrounding insoluble electrodes 58 include a left-side surrounding insoluble electrode 62 configured to surround a periphery of a left-side outer peripheral surface 60 of the cylinder 12 to be processed which is accommodated in the plating bath 54 in the horizontal direction and a right-side surrounding insoluble electrode 66 configured to surround a periphery of a right-side outer peripheral surface 64 of the cylinder 12 to be processed which is accommodated in the plating bath 54 in the horizontal direction.

**[0044]** In the cylinder trivalent chromium plating apparatus 10C, the left-side surrounding insoluble electrode 62 and the right-side surrounding insoluble electrode 66 form a crossing electrode.

**[0045]** The left-side surrounding insoluble electrode 62 and the right-side surrounding insoluble electrode 66 of the surrounding insoluble electrodes 58 are opened and closed between a state of covering the periphery of the cylinder 12 to be processed and an open state by movement of arms 68a and 68b of increasing or decreasing a distance therebetween. When a degree of which projections of a comb-like portion of the right-side surrounding insoluble electrode 66 are inserted into positions of recesses of a comb-like portion of the left-side surrounding insoluble electrode 62 is adjusted as described above, the left-side surrounding insoluble electrode 62 and the right-side surrounding insoluble electrode 66 are brought close to the outer peripheral surface of the cylinder 12 to be processed in accordance with the cylinder diameter thereof. The arms 68a and 68b are driven by a drive source (not shown).

**[0046]** With the above-mentioned configuration, even when the trivalent chromium plating using the trivalent chromium plating solution is performed, a cylinder which is satisfactory, fine and uniform in deposition, and is excellent in printing durability can be obtained without a problem that an undeposited portion is formed in part of the cylinder 12 to be processed. The cylinder is excellent in printing durability, and hence the cylinder can be applied to a gravure cylinder. Moreover, the cylinder trivalent chromium plating apparatus 10C has also an effect of reducing a voltage by approximately 50% as compared with the cylinder plating apparatus having the configuration in which the electrodes are provided only on the lower side as shown in Patent Document 2.

**[0047]** Next, a cylinder trivalent chromium plating apparatus 10D is shown in FIG. 7 to FIGS. 10 as a fourth embodiment of the cylinder trivalent chromium plating apparatus according to the present invention.

**[0048]** The cylinder trivalent chromium plating apparatus 10D includes: a plating bath 74 configured to store a trivalent chromium plating solution; a chuck means 76 for holding the cylinder 12 to be processed at both ends in the longitudinal direction thereof so as to be rotated and energized, and accommodating the cylinder 12 to be processed in the plating bath in the horizontal direction; and insoluble electrodes 78 configured to be supplied

with a predetermined current. The insoluble electrodes 78 are brought close to the outer peripheral surface of the cylinder 12 to be processed at predetermined intervals to plate the outer peripheral surface with the trivalent chromium plating solution. The insoluble electrodes 78 are surrounding insoluble electrodes configured to surround the periphery of the outer peripheral surface of the cylinder 12 to be processed.

[0049] In FIG. 7, the surrounding insoluble electrodes 78 include a lower-side surrounding insoluble electrode 82 configured to surround a periphery of a lower outer peripheral surface 80 of the cylinder 12 to be processed which is accommodated in the plating bath 74 in the horizontal direction and an upper-side surrounding insoluble electrode 86 configured to surround a periphery of an upper outer peripheral surface 84 of the cylinder 12 to be processed which is accommodated in the plating bath 74 in the horizontal direction.

[0050] In the cylinder trivalent chromium plating apparatus 10D, each of the lower-side surrounding insoluble electrode 82 and the upper-side surrounding insoluble electrode 86 is a crossing electrode.

[0051] A degree of which projections of a comb-like portion of the lower-side surrounding insoluble electrode 82b are inserted into positions of recesses of a comb-like portion of the lower-side surrounding insoluble electrode 82a is adjusted by rotary motion of arms 90a and 90b. With this, the lower-side surrounding insoluble electrode 82 of the surrounding insoluble electrodes 78 is brought close to the outer peripheral surface of the cylinder 12 to be processed in accordance with the cylinder diameter thereof. The arms 90a and 90b are driven by a drive source (not shown).

[0052] Moreover, a degree of which projections of a comb-like portion of the upper-side surrounding insoluble electrode 86b are inserted into positions of recesses of a comb-like portion of the upper-side surrounding insoluble electrode 86a is adjusted by rotary motion of arms 92a and 92b. With this, the upper-side surrounding insoluble electrode 86 of the surrounding insoluble electrodes 78 is brought close to the outer peripheral surface of the cylinder 12 to be processed in accordance with the cylinder diameter thereof. The arms 92a and 92b are driven by a drive source (not shown).

[0053] With the above-mentioned configuration, even when the trivalent chromium plating using the trivalent chromium plating solution is performed, a cylinder which is satisfactory, fine and uniform in deposition, and is excellent in printing durability can be obtained without a problem that an undeposited portion is formed in part of the cylinder 12 to be processed. The cylinder is excellent in printing durability, and hence the cylinder can be applied to a gravure cylinder. Moreover, the cylinder trivalent chromium plating apparatus 10D has also an effect of reducing a voltage by approximately 50% as compared with the cylinder plating apparatus having the configuration in which the electrodes are provided only on the lower side as shown in Patent Document 2.

[0054] A trivalent chromium plating method according to the present invention includes plating the cylinder 12 to be processed with the trivalent chromium plating solution through use of the cylinder trivalent chromium plating apparatus 10A to 10D according to the present invention. According to the trivalent chromium plating method of the present invention, even when the trivalent chromium plating using the trivalent chromium plating solution is performed, a cylinder which is satisfactory, fine and uniform in deposition, and is excellent in printing durability can be obtained without a problem that an undeposited portion is formed in part of the cylinder 12 to be processed. The cylinder is excellent in printing durability, and hence the cylinder can be applied to a gravure cylinder.

[0055] A gravure cylinder manufacturing method according to the present invention includes manufacturing a gravure cylinder by plating the cylinder to be processed with the trivalent chromium plating solution through use of the cylinder trivalent chromium plating apparatus 10A to 10D according to the present invention. According to the gravure cylinder manufacturing method of the present invention, even when the trivalent chromium plating using the trivalent chromium plating solution is performed, a gravure cylinder which is satisfactory, fine and uniform in deposition, and is excellent in printing durability can be obtained without a problem that an undeposited portion is formed in part of the cylinder 12 to be processed.

#### Description of Reference Numerals

[0056] 10A, 10B, 10C, 10D: trivalent chromium plating apparatus, 12: cylinder to be processed, 14, 34, 54, 74: plating bath, 16, 36, 56, 76: chuck means, 18, 38, 58, 78: surrounding insoluble electrode, 20, 40, 80: lower outer peripheral surface, 22, 22a, 22b, 42, 42a, 42b, 82, 82a, 82b: lower-side surrounding insoluble electrode, 24, 44, 84: upper outer peripheral surface, 26, 46, 86, 86a, 86b: upper-side surrounding insoluble electrode, 28: air cylinder, 30a, 30b, 48a, 48b, 50a, 50b, 68a, 68b, 90a, 90b, 92a, 92b: arm, 60: left-side outer peripheral surface, 62: left-side surrounding insoluble electrode, 64: right-side outer peripheral surface, 66: right-side surrounding insoluble electrode.

#### Claims

1. A cylinder trivalent chromium plating apparatus, comprising:

a plating bath configured to store a trivalent chromium plating solution;  
a chuck means for holding a cylinder to be processed at both ends in a longitudinal direction thereof so as to be rotated and energized, and accommodating the cylinder to be processed in the plating bath in a horizontal direc-

- tion; and  
 insoluble electrodes configured to be supplied  
 with a predetermined current,  
 wherein the insoluble electrodes are brought  
 close to an outer peripheral surface of the cy-  
 linder to be processed at predetermined inter-  
 vals to plate the outer peripheral surface with the  
 trivalent chromium plating solution, and  
 wherein the insoluble electrodes are surround-  
 ing insoluble electrodes configured to surround  
 a periphery of the outer peripheral surface of the  
 cylinder to be processed.
2. The cylinder trivalent chromium plating apparatus  
 according to claim 1, wherein the surrounding insolu-  
 ble electrodes include lower-side surrounding insolu-  
 ble electrode configured to surround a periphery  
 of a lower outer peripheral surface of the cylinder to  
 be processed which is accommodated in the plating  
 bath in the horizontal direction and/or upper-side  
 surrounding insoluble electrode configured to sur-  
 round a periphery of an upper outer peripheral sur-  
 face of the cylinder to be processed which is accom-  
 modated in the plating bath in the horizontal direc-  
 tion.
3. The cylinder trivalent chromium plating apparatus  
 according to claim 2, wherein the upper-side sur-  
 rounding insoluble electrode and/or the lower-side  
 surrounding insoluble electrode is a crossing elec-  
 trode.
4. The cylinder trivalent chromium plating apparatus  
 according to claim 1, wherein the surrounding insolu-  
 ble electrodes are brought close to the outer per-  
 ipheral surface of the cylinder to be processed in  
 accordance with a cylinder diameter thereof by an air  
 cylinder or an electric motor.
5. The cylinder trivalent chromium plating apparatus  
 according to claim 1, wherein the surrounding insolu-  
 ble electrodes are brought close to the outer per-  
 ipheral surface of the cylinder to be processed in  
 accordance with a cylinder diameter thereof by ro-  
 tary motion of arms or movement of the arms of  
 increasing or decreasing a distance therebetween.
6. A trivalent chromium plating method, comprising  
 plating the cylinder to be processed with the trivalent  
 chromium plating solution through use of the cylinder  
 trivalent chromium plating apparatus of any one of  
 claims 1 to 5.
7. A gravure cylinder manufacturing method, compris-  
 ing manufacturing a gravure cylinder by plating the  
 cylinder to be processed with the trivalent chromium  
 plating solution through use of the cylinder trivalent  
 chromium plating apparatus of any one of claims 1 to

5.

**Amended claims under Art. 19.1 PCT**

1. (amended) A cylinder trivalent chromium plating ap-  
 paratus, comprising:
- a plating bath configured to store a trivalent  
 chromium plating solution;  
 a chuck means for holding a cylinder to be  
 processed at both ends in a longitudinal direc-  
 tion thereof so as to be rotated and energized,  
 and accommodating the cylinder to be pro-  
 cessed in the plating bath in a horizontal direc-  
 tion;  
 insoluble electrodes configured to be supplied  
 with a predetermined current,  
 wherein the insoluble electrodes are brought  
 close to an outer peripheral surface of the cy-  
 linder to be processed at predetermined inter-  
 vals to plate the outer peripheral surface with the  
 trivalent chromium plating solution,  
 wherein the insoluble electrodes are surround-  
 ing insoluble electrodes configured to surround  
 a periphery of the outer peripheral surface of the  
 cylinder to be processed, and  
 wherein the surrounding insoluble electrodes  
 include lower-side surrounding insoluble elec-  
 trode configured to surround a periphery of a  
 lower outer peripheral surface of the cylinder to  
 be processed which is accommodated in the  
 plating bath in the horizontal direction and/or  
 upper-side surrounding insoluble electrode con-  
 figured to surround a periphery of an upper outer  
 peripheral surface of the cylinder to be pro-  
 cessed which is accommodated in the plating  
 bath in the horizontal direction.
2. (deleted)
3. (amended) The cylinder trivalent chromium plating  
 apparatus according to claim 1, wherein the upper-  
 side surrounding insoluble electrode and/or the low-  
 er-side surrounding insoluble electrode is a crossing  
 electrode.
4. The cylinder trivalent chromium plating apparatus  
 according to claim 1, wherein the surrounding insolu-  
 ble electrodes are brought close to the outer per-  
 ipheral surface of the cylinder to be processed in  
 accordance with a cylinder diameter thereof by an air  
 cylinder or an electric motor.
5. The cylinder trivalent chromium plating apparatus  
 according to claim 1, wherein the surrounding insolu-  
 ble electrodes are brought close to the outer per-  
 ipheral surface of the cylinder to be processed in  
 accordance with a cylinder diameter thereof by ro-



tary motion of arms or movement of the arms of increasing or decreasing a distance therebetween.

6. (amended) A trivalent chromium plating method, comprising plating the cylinder to be processed with the trivalent chromium plating solution through use of the cylinder trivalent chromium plating apparatus of any one of claims 1, 3 to 5. 5
7. (amended) A gravure cylinder manufacturing method, comprising manufacturing a gravure cylinder by plating the cylinder to be processed with the trivalent chromium plating solution through use of the cylinder trivalent chromium plating apparatus, wherein the cylinder trivalent chromium plating apparatus comprises: a plating bath configured to store a trivalent chromium plating solution; a chuck means for holding a cylinder to be processed at both ends in a longitudinal direction thereof so as to be rotated and energized, and accommodating the cylinder to be processed in the plating bath in a horizontal direction; and insoluble electrodes configured to be supplied with a predetermined current, wherein the insoluble electrodes are brought close to an outer peripheral surface of the cylinder to be processed at predetermined intervals to plate the outer peripheral surface with the trivalent chromium plating solution, and wherein the insoluble electrodes are surrounding insoluble electrodes configured to surround a periphery of the outer peripheral surface of the cylinder to be processed. 10 15 20 25 30
8. (added) A gravure cylinder manufacturing method, comprising manufacturing a gravure cylinder by plating the cylinder to be processed with the trivalent chromium plating solution through use of the cylinder trivalent chromium plating apparatus of any one of claims 1, 3 to 5. 35

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Fig.1

10A

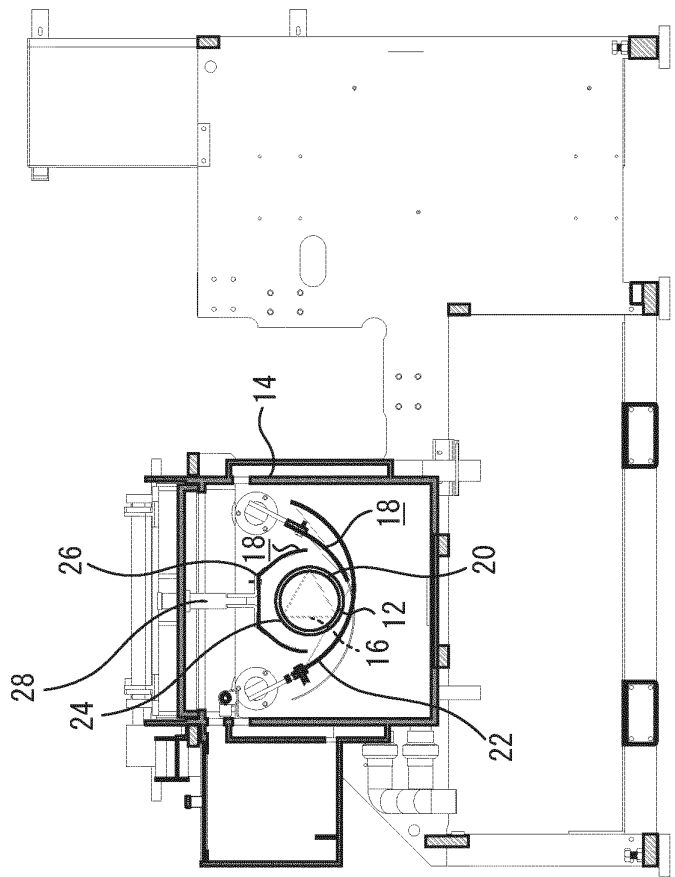


Fig.2(a)

10A

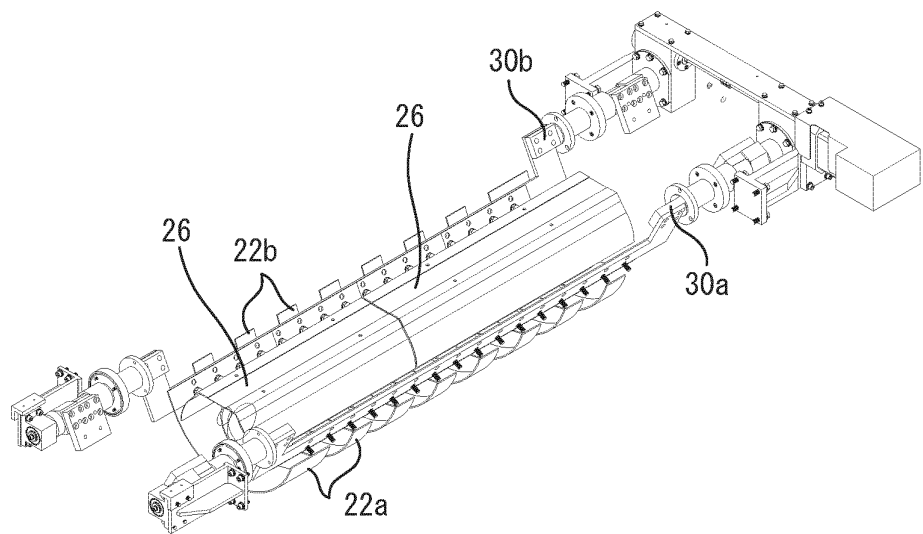


Fig.2(b)

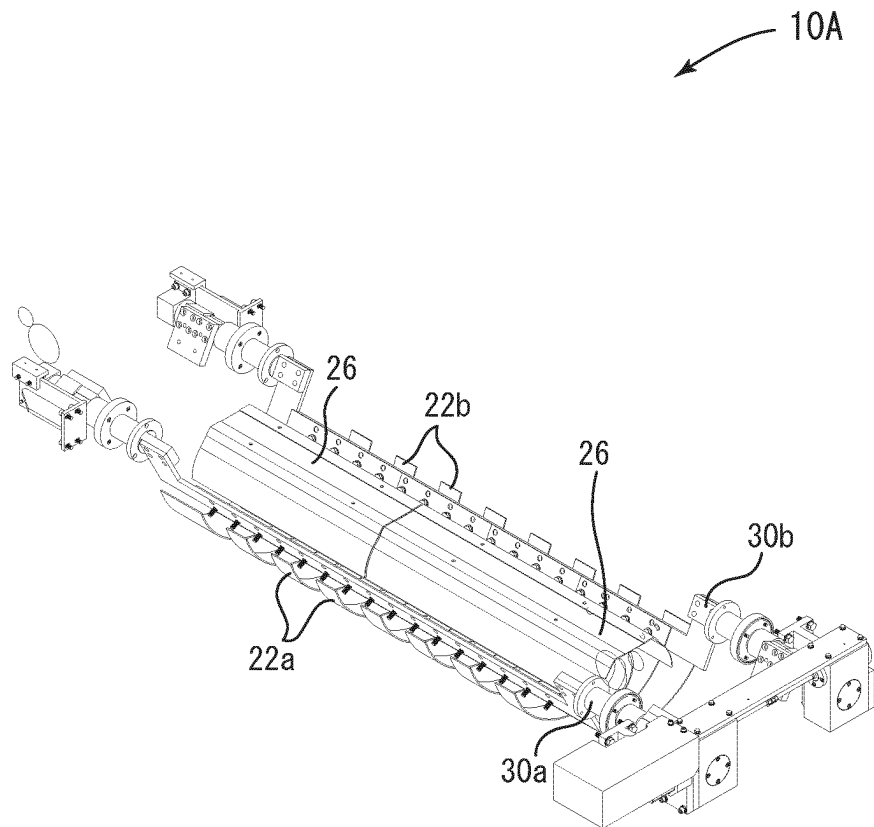


Fig.3

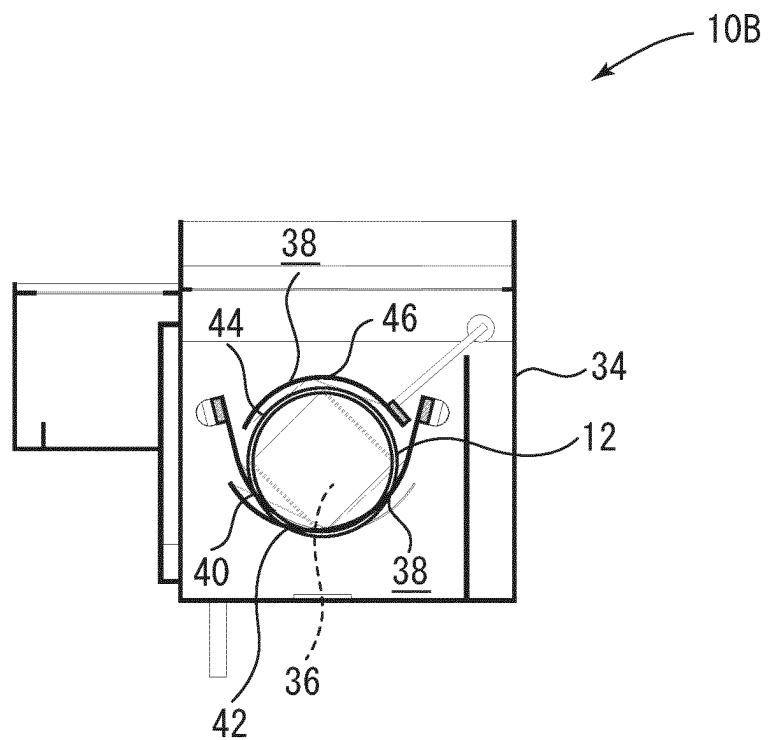


Fig.4(a)

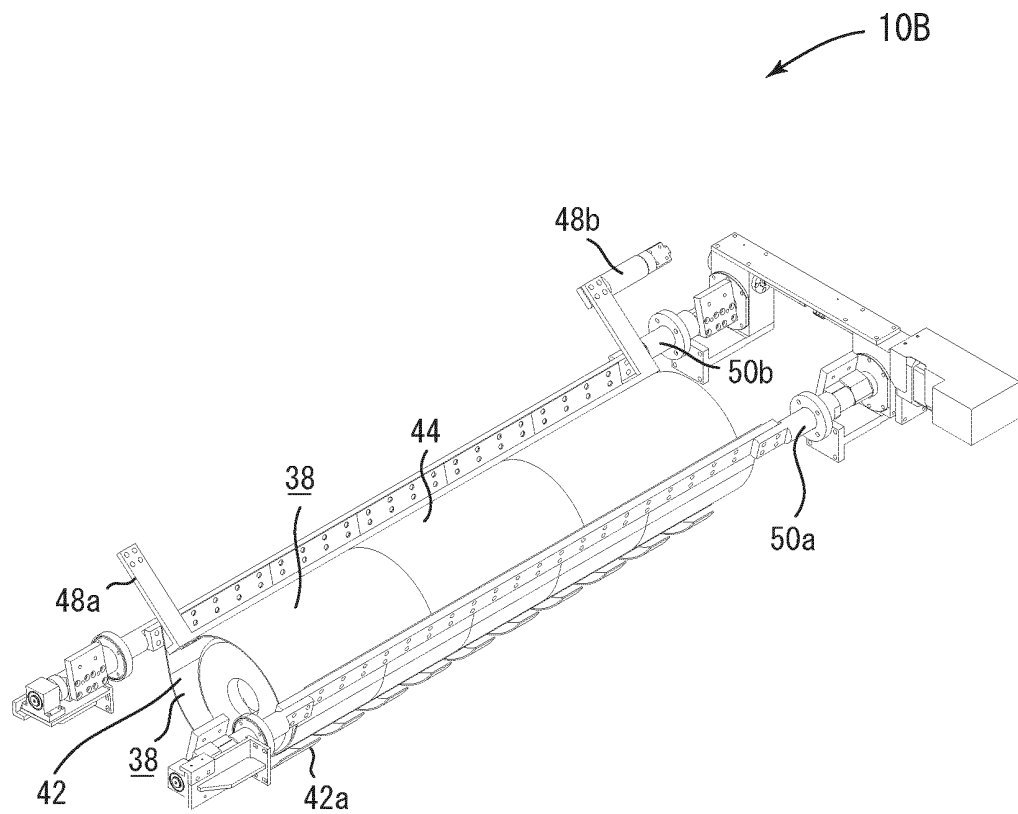


Fig.4(b)

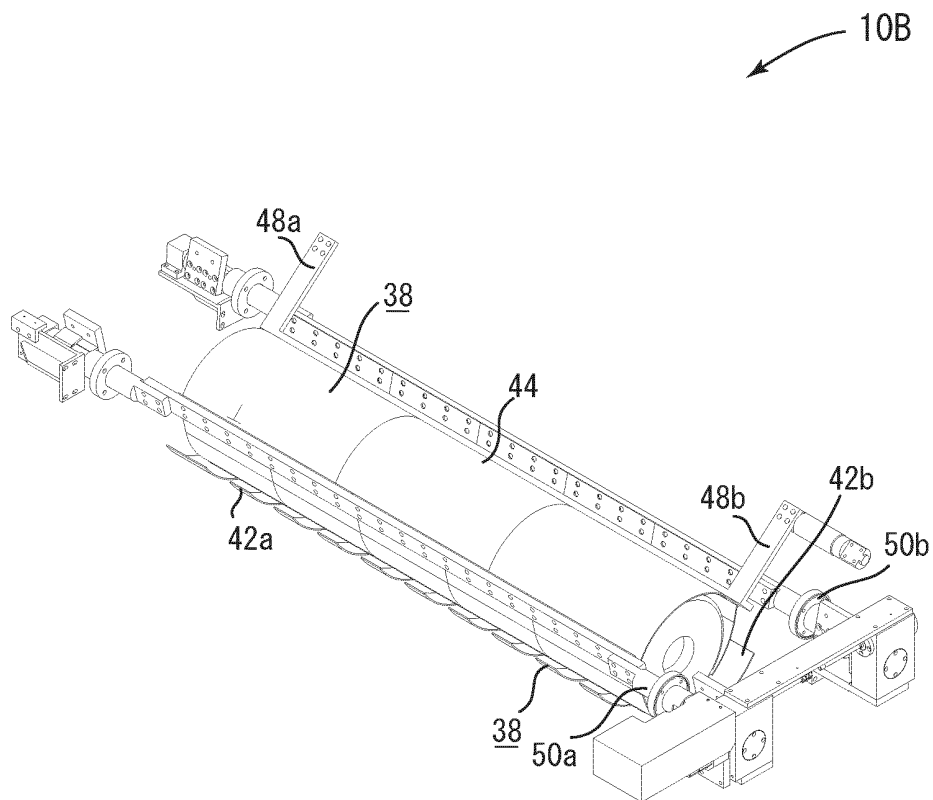


Fig.5

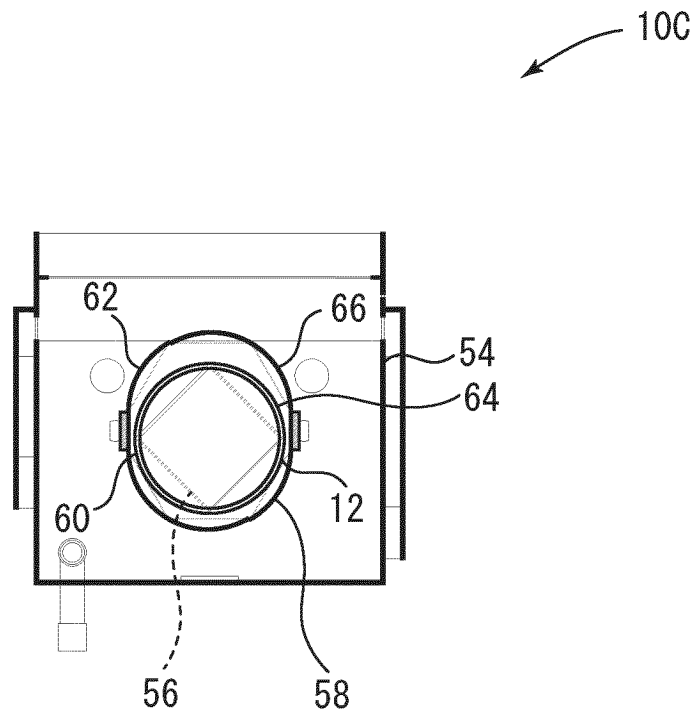


Fig.6(a)

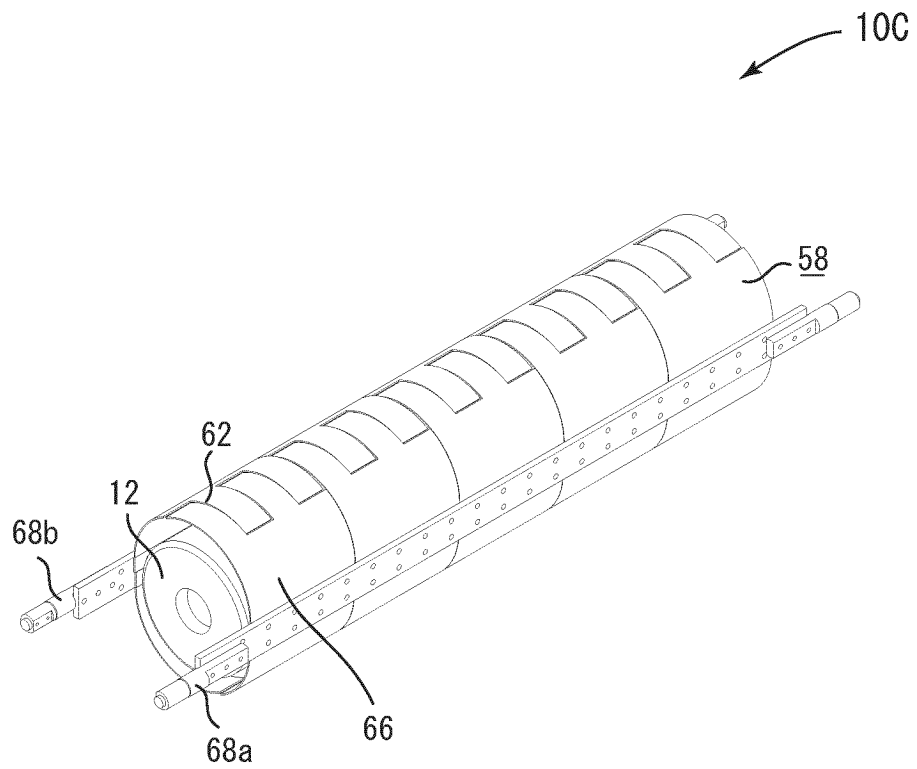


Fig.6(b)

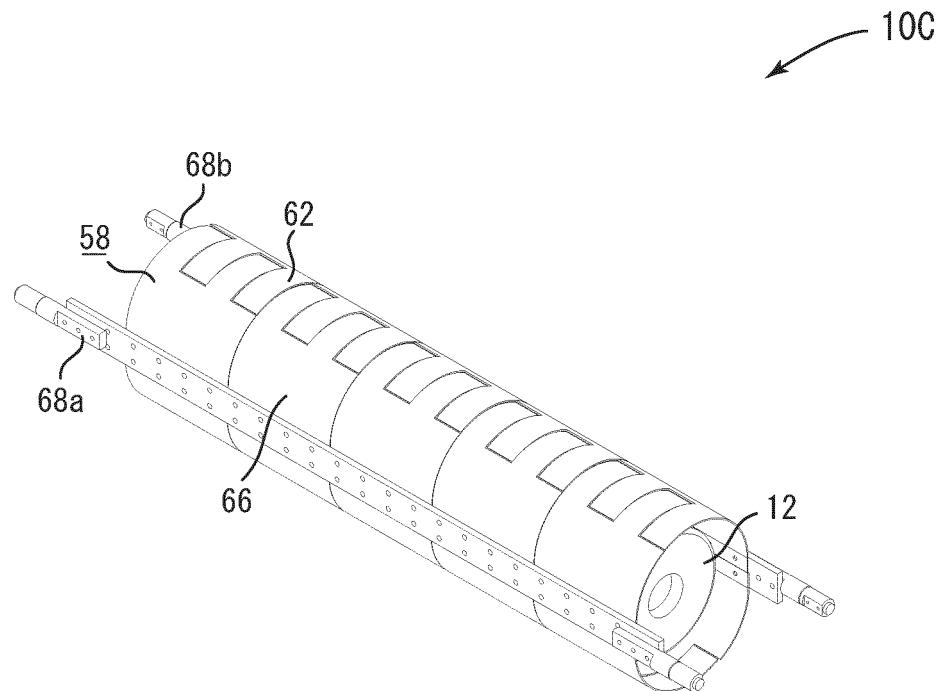


Fig.7

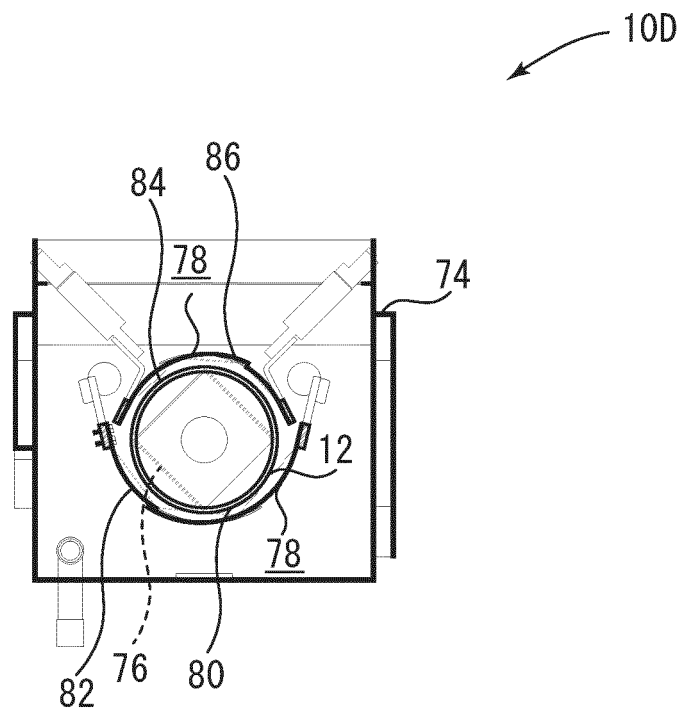


Fig.8

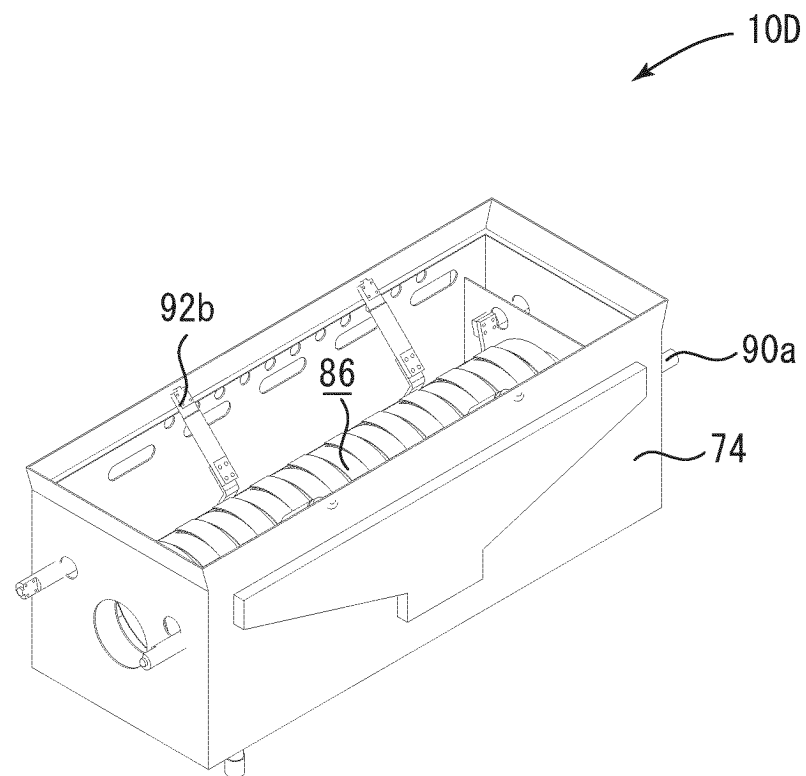


Fig.9

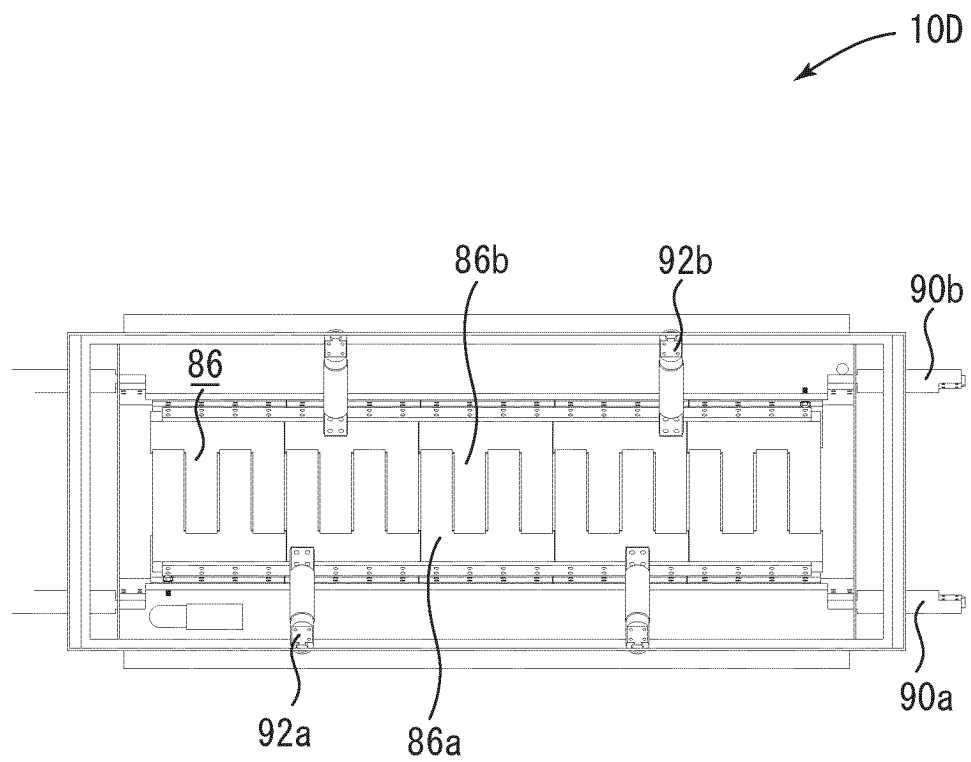


Fig.10(a)

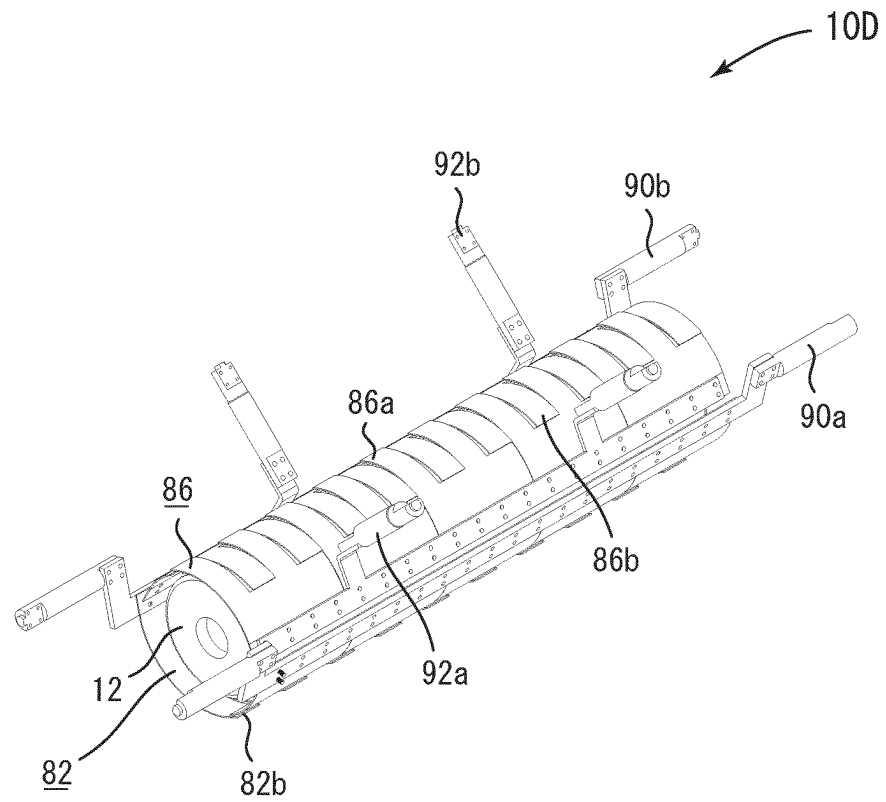


Fig.10(b)

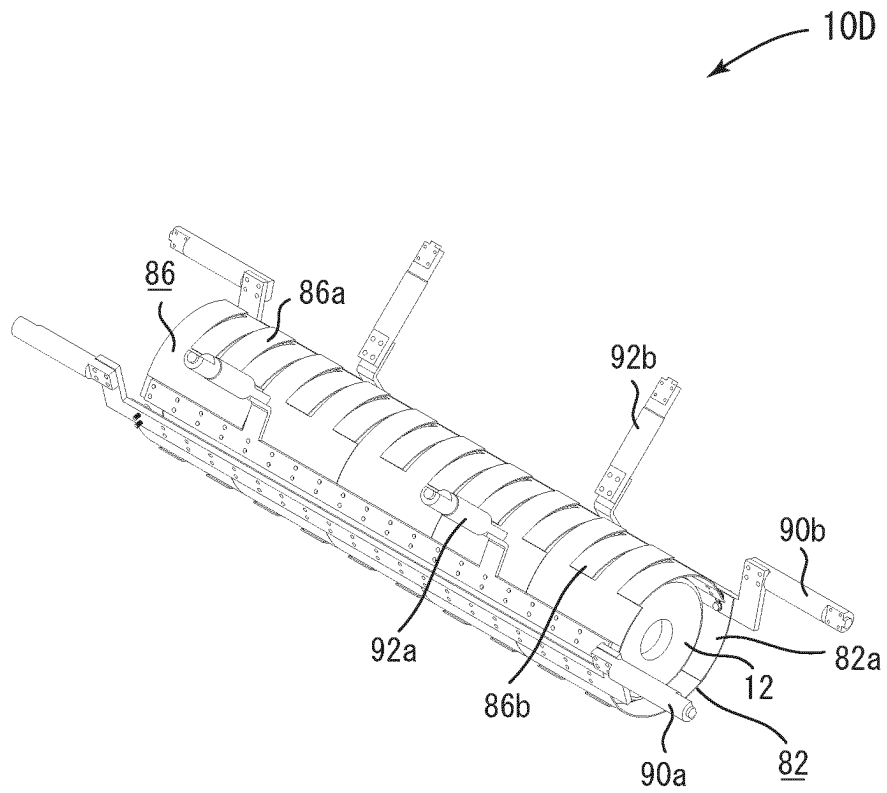




Fig.11



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/005674

## A. CLASSIFICATION OF SUBJECT MATTER

**C25D 21/00**(2006.01)i; **C25D 7/00**(2006.01)i; **C25D 7/04**(2006.01)i; **C25D 17/08**(2006.01)i; **C25D 17/12**(2006.01)i  
 FI: C25D21/00 J; C25D7/00 U; C25D7/04; C25D17/08 K; C25D17/12 J; C25D21/00 G; C25D21/00 K

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)

C25D7/00, 7/04, 17/08, 17/12, 21/00

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

Published examined utility model applications of Japan 1922-1996  
 Published unexamined utility model applications of Japan 1971-2023  
 Registered utility model specifications of Japan 1996-2023  
 Published registered utility model applications of Japan 1994-2023

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. |
|-----------|----------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | US 2018/0016688 A1 (ACROM S.A.) 18 January 2018 (2018-01-18)<br>claims 1, 8, paragraph [0019], fig. 1, 3-4, 10 | 1, 6                  |
| A         |                                                                                                                | 2-5, 7                |
| A         | JP 49-010828 A (SHINOZAKI, Saburo) 30 January 1974 (1974-01-30)                                                | 1-7                   |
| A         | JP 10-121291 A (MDC MAX DAETWYLER BLEIENBACH AG) 12 May 1998<br>(1998-05-12)                                   | 1-7                   |
| A         | WO 2012/043513 A1 (THINK LABORATORY CO., LTD.) 05 April 2012 (2012-04-05)                                      | 1-7                   |
| A         | WO 2019/164445 A1 (ABSOLICON SOLAR COLLECTOR AB) 29 August 2019<br>(2019-08-29)                                | 1-7                   |

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

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

19 April 2023

Date of mailing of the international search report

09 May 2023

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)  
 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915  
 Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT  
Information on patent family members

International application No.

PCT/JP2023/005674

| Patent document<br>cited in search report | Publication date<br>(day/month/year) | Patent family member(s) | Publication date<br>(day/month/year) |
|-------------------------------------------|--------------------------------------|-------------------------|--------------------------------------|
| US 2018/0016688 A1                        | 18 January 2018                      | WO 2016/120700 A1       |                                      |
|                                           |                                      | EP 3172360 A1           |                                      |
|                                           |                                      | CH 710741 A             |                                      |
|                                           |                                      | CN 107250441 A          |                                      |
|                                           |                                      | KR 10-2017-0107494 A    |                                      |
|                                           |                                      | MX 2017009794 A         |                                      |
| JP 49-010828 A                            | 30 January 1974                      | (Family: none)          |                                      |
| JP 10-121291 A                            | 12 May 1998                          | EP 829558 A1            |                                      |
| WO 2012/043513 A1                         | 05 April 2012                        | US 2013/0153410 A1      |                                      |
|                                           |                                      | EP 2623646 A1           |                                      |
|                                           |                                      | CN 102933751 A          |                                      |
|                                           |                                      | KR 10-2013-0114573 A    |                                      |
| WO 2019/164445 A1                         | 29 August 2019                       | US 2020/0347505 A1      |                                      |
|                                           |                                      | EP 3724558 A1           |                                      |
|                                           |                                      | CN 111727349 A          |                                      |

Form PCT/ISA/210 (patent family annex) (January 2015)

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2019123927 A [0008]
- WO 2015151665 A1 [0008]