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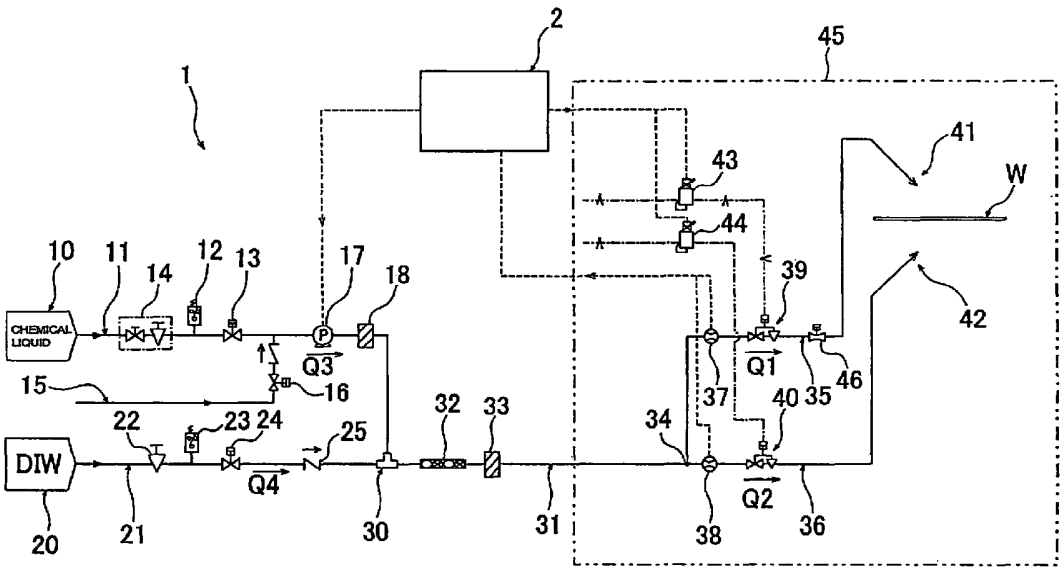
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(54) **Title:** TREATMENT LIQUID SUPPLY APPARATUS, SUBSTRATE TREATMENT APPARATUS AND TREATMENT LIQUID PREPARATION METHOD



(57) **Abstract:** In a treatment liquid supply apparatus, a chemical liquid and pure water are mixed with each other in a mixing portion to prepare a treatment liquid thereby, which is supplied to a substrate as an object to be treated. By means of a constant-flow pump provided in a chemical liquid supply tube, a flow rate of the chemical liquid flowing into the mixing portion is controlled. By means of constant-flow valves provided in treatment liquid supply tubes respectively, flow rates of the treatment liquid flowing from treatment liquid supply portions to the substrate are controlled. Due to this control, a concentration of the chemical liquid in the treatment liquid is controlled to a predetermined value.

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DESCRIPTION

TREATMENT LIQUID SUPPLY APPARATUS, SUBSTRATE TREATMENT APPARATUS AND TREATMENT LIQUID PREPARATION METHOD

TECHNICAL FIELD

The present invention relates to a treatment liquid supply apparatus adapted to prepare a treatment liquid by mixing a plurality of types of liquids and supply the treatment liquid to a treatment section. The present invention also relates to a substrate treatment apparatus comprising such a treatment liquid supply apparatus, and a treatment liquid preparation method.

TECHNICAL BACKGROUND

Conventionally, there is known a treatment liquid supply apparatus adapted to prepare a treatment liquid by mixing a plurality of types of liquids supplied from a plurality of liquid supply sources, and supply the treatment liquid to a treatment section. Japanese Patent Public Disclosure No. 2000-21838 discloses such a treatment liquid supply apparatus. This apparatus is used for supplying a cleaning liquid prepared by mixing a chemical liquid with pure water to a cleaning apparatus for cleaning substrates, such as semiconductor wafers. In this treatment liquid supply apparatus, the liquids are mixed with each other in a mixing portion at which flow passages from liquid supply sources corresponding to the respective liquids are joined together. A flow rate control means is disposed in each of the flow passages in which the liquids flow before

they are mixed in the mixing portion, and thus flow rates of the liquids supplied to the mixing portion are controlled, to thereby enable a treatment liquid having a predetermined concentration to be supplied at a predetermined flow rate.

As mentioned above, in the treatment liquid supply apparatus disclosed in Japanese Patent Public Disclosure No. 2000-21838, a flow rate control means is disposed in each of the flow passages for the respective liquids before they are mixed with each other. However, in general, a part such as a flow rate control valve or a flow rate control pump forming the flow rate control means is relatively expensive as compared to other parts of a treatment liquid supply apparatus, and therefore the treatment liquid supply apparatus becomes costly as a result of provision of the flow rate control means in each of the flow passages. Further, a plurality of flow rate control means must be controlled for preparing a treatment liquid, which leads to a complicate operation process.

Further, in a treatment liquid supply apparatus of this type, in a case that a treatment liquid is supplied to a plurality of treatment sections, flow rates of a plurality of flows of the treatment liquid respectively supplied to the plurality of treatment sections must be individually controlled. Therefore, by using treatment liquid feeding rate control means, the respective flow rates of the flows of the treatment liquid supplied to

the plurality of treatment sections are individually controlled. In this case, however, if an error is generated in the flow rate controlled by either the flow rate control means for controlling the flow rates of the liquids prior to mixing or the treatment liquid feeding rate control means for controlling the flow rate of the treatment liquid, there is no means to absorb this error. This causes an imbalance in a flow rate between an inflow and an outflow in the mixing portion, which leads to an operation error in the treatment liquid supply apparatus.

DISCLOSURE OF THE INVENTION

In view of the above, the present invention has been made. It is an object of the present invention to provide a treatment liquid supply apparatus which has a simple structure with a reduced number of flow rate control means, and which is therefore capable of being easily controlled, and which is capable of absorbing an error generated in the flow rate controlled by the flow rate control means. It is another object of the present invention to provide a substrate treatment apparatus using the above-mentioned treatment liquid supply apparatus. It is a further object of the present invention to provide a treatment liquid preparation method.

The present invention provides a treatment liquid supply apparatus comprising:

a plurality of liquid supply sources from which

different types of liquids are individually supplied;

a mixing portion in which the liquids supplied from said plurality of liquid supply sources are mixed with each other, to thereby prepare a treatment liquid; and

a treatment liquid supply portion for supplying the treatment liquid prepared in the mixing portion to a treatment section,

wherein:

said plurality of liquid supply sources comprises at least one liquid supply source provided with liquid flow rate control means, and a single liquid supply source provided without liquid flow rate control means,

said liquid flow rate control means being adapted to control a flow rate of the liquid supplied from said at least one liquid supply source to the mixing portion;

said treatment liquid supply portion is provided with treatment liquid flow rate control means, said treatment liquid flow rate control means being adapted to control a flow rate of the treatment liquid supplied from the treatment liquid supply portion; and

a concentration of the liquid from the at least one liquid supply source in the treatment liquid is controlled to a predetermined value by controlling, prior to mixing in the mixing portion, the flow rate of the liquid from the at least one liquid supply source to a predetermined value by the liquid flow rate control means, and controlling the flow rate of the treatment

liquid to a predetermined value by the treatment liquid flow rate control means.

In the treatment liquid supply apparatus, said predetermined value of the flow rate controlled by the liquid flow rate control means may be determined, based on a target value of the concentration of the liquid from the at least one liquid supply source in the treatment liquid and/or a target value of the flow rate of the treatment liquid.

The treatment liquid supply apparatus may further comprise treatment liquid flow rate measurement means adapted to measure the flow rate of the treatment liquid supplied from the treatment liquid supply portion, and said predetermined value of the flow rate of the treatment liquid may be determined, based on a value measured by the treatment liquid flow rate measurement means.

The treatment liquid supply apparatus may further comprise treatment liquid concentration measurement means adapted to measure the concentration of the liquid from the at least one liquid supply source in the treatment liquid, and said predetermined value of the flow rate controlled by the liquid flow rate control means may be determined, based on the value measured by the treatment liquid flow rate measurement means and/or a value measured by the treatment liquid concentration measurement means.

The treatment liquid supply apparatus may comprise

two or more treatment liquid supply portions, and each of the two or more treatment liquid supply portions may be provided with the treatment liquid flow rate control means.

The treatment liquid supply apparatus may comprise two or more treatment liquid supply units, each including the two or more treatment liquid supply portions provided with treatment liquid flow rate control means.

In the treatment liquid supply apparatus, the liquid supplied from said at least one liquid supply source provided with liquid flow rate control means may be a chemical liquid and the liquid supplied from said single liquid supply source provided without liquid flow rate control means may be a solvent.

In the treatment liquid supply apparatus, the liquid flow rate control means and/or the treatment liquid flow rate control means may be a constant-flow valve or a constant-flow pump controlled by an electro-pneumatic regulator.

The present invention also provides a substrate treatment apparatus comprising the above-mentioned treatment liquid supply apparatus, wherein the treatment liquid prepared by the treatment liquid supply apparatus is supplied to a substrate treatment section in which a substrate is treated.

The present invention further provides a treatment liquid preparation method for mixing a plurality of

types of liquids to prepare a treatment liquid, wherein said plurality of types of liquids comprises at least one liquid having a controlled flow rate and a single liquid having an uncontrolled flow rate, and a concentration of the at least one liquid in the treatment liquid is controlled to a predetermined value by controlling the flow rate of the at least one liquid and a flow rate of the treatment liquid to respective predetermined values.

Thus, in a treatment liquid supply apparatus of the present invention, a plurality of liquid supply sources comprises at least one liquid supply source provided with liquid flow rate control means, and a single liquid supply source provided without liquid flow rate control means. The liquid flow rate control means is adapted to control a flow rate of a liquid supplied from the at least one liquid supply source to a mixing portion. A treatment liquid supply portion is provided with treatment liquid flow rate control means, which is adapted to control a flow rate of a treatment liquid supplied from the treatment liquid supply portion. A concentration of the liquid from the at least one liquid supply source in the treatment liquid is controlled to a predetermined value by controlling the flow rate of the liquid from the at least one liquid supply source to a predetermined value by the liquid flow rate control means, and controlling the flow rate of the treatment liquid to a predetermined value by the treatment liquid

flow rate control means.

With this arrangement, the flow rate of the liquid supplied from the liquid supply source provided without liquid flow rate control means can be automatically controlled, based on a balance in flow rate between an inflow and an outflow in the mixing portion. Therefore, even if an error is generated in the flow rate controlled by either the liquid flow rate control means or the treatment liquid flow rate control means, this error can be absorbed by the automatically controlled flow rate of the liquid supplied without liquid flow rate control means. Therefore, a problem such as an operation error in the treatment liquid supply apparatus can be avoided.

Further, since the liquid flow rate control means is not provided in either one of the plurality of liquid supply sources, the number of liquid flow rate control means provided in the treatment liquid supply apparatus can be reduced, thus achieving a reduction in cost and simplification of a process for operation of the treatment liquid supply apparatus.

In the treatment liquid supply apparatus of the present invention, the predetermined value of the flow rate controlled by the liquid flow rate control means may be determined, based on a target value of the concentration of the liquid from the at least one liquid supply source in the treatment liquid and/or a target value of the flow rate of the treatment liquid.

With this arrangement, the flow rate of the liquid to be mixed can be accurately determined, and the concentration of the treatment liquid can be controlled with high precision.

The treatment liquid supply apparatus of the present invention may further comprise treatment liquid flow rate measurement means adapted to measure the flow rate of the treatment liquid supplied from the treatment liquid supply portion, and the predetermined value of the flow rate of the treatment liquid may be determined, based on a value measured by the treatment liquid flow rate measurement means.

With this arrangement, the flow rate of the treatment liquid can be accurately controlled, based on an actual flow rate of the treatment liquid.

The treatment liquid supply apparatus may further comprise treatment liquid concentration measurement means adapted to measure the concentration of the liquid from the at least one liquid supply source in the treatment liquid, and the predetermined value of the flow rate controlled by the liquid flow rate control means may be determined, based on the value measured by the treatment liquid flow rate measurement means and/or a value measured by the treatment liquid concentration measurement means.

With this arrangement, the concentration of the liquid from the at least one liquid supply source in the treatment liquid can be accurately controlled, based on

an actual flow rate and/or an actual concentration of the treatment liquid.

The treatment liquid supply apparatus of the present invention may comprise two or more treatment liquid supply portions, and each of the two or more treatment liquid supply portions may be provided with the treatment liquid flow rate control means.

With this arrangement, if the treatment liquid is supplied to a plurality of treatment sections, the treatment sections can be supplied with the treatment liquid at respective desired flow rates.

The treatment liquid supply apparatus may comprise two or more treatment liquid supply units, each including the two or more treatment liquid supply portions provided with treatment liquid flow rate control means.

With this arrangement, the treatment liquid can be supplied to a plurality of treatment liquid supply units by means of a single treatment liquid supply apparatus, thus achieving a reduction in size of a supply system.

In the treatment liquid supply apparatus of the present invention, the liquid supplied from the at least one liquid supply source provided with liquid flow rate control means may be a chemical liquid and the liquid supplied from the one liquid supply source provided without liquid flow rate control means may be a solvent.

With this arrangement, only the flow rate of the chemical liquid, which is smaller than that of the

solvent and therefore can be controlled with high precision, is controlled without controlling the flow rate of the solvent. Therefore, the concentration of the treatment liquid can be controlled with high precision.

In the treatment liquid supply apparatus of the present invention, the liquid flow rate control means and/or the treatment liquid flow rate control means may be a constant-flow valve or a constant-flow pump controlled by an electro-pneumatic regulator.

With this arrangement, both the flow rate of the liquid before mixing and the flow rate of the treatment liquid after mixing can be controlled with high precision.

A substrate treatment apparatus of the present invention comprises either one of the above-mentioned treatment liquid supply apparatuses, and the treatment liquid prepared by the treatment liquid supply apparatus is supplied to a substrate treatment section in which a substrate is treated.

Therefore, it is possible to provide a substrate treatment apparatus in which a substrate is treated with a treatment liquid prepared by the treatment liquid supply apparatus having either of the above-mentioned effects.

In a treatment liquid preparation method of the present invention for mixing a plurality of types of liquids to prepare a treatment liquid, the plurality of types of liquids comprises at least one liquid having a

controlled flow rate and a single liquid having an uncontrolled flow rate, and a concentration of the at least one liquid in the treatment liquid is controlled to a predetermined value by controlling the flow rate of the at least one liquid and a flow rate of the treatment liquid to respective predetermined values.

With this arrangement, with respect to the one liquid having an uncontrolled flow rate, automatic flow rate control is effected, based on a balance in flow rate between before and after mixing. Therefore, if an error is generated in the controlled flow rate of the at least one liquid or the controlled flow rate of the treatment liquid, this error can be effectively absorbed by the automatically controlled flow rate.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flow diagram schematically indicating an arrangement of a treatment liquid supply apparatus according to a first embodiment of the present invention.

Fig. 2 shows details of an arrangement of a substrate cleaning unit.

Fig. 3 is a flow diagram schematically indicating an arrangement of a treatment liquid supply apparatus according to a second embodiment of the present invention.

Fig. 4 is a flow diagram schematically indicating an arrangement of a treatment liquid supply apparatus according to a third embodiment of the present invention.

Fig. 5 is a flow diagram schematically indicating

an arrangement of a treatment liquid supply apparatus according to a fourth embodiment of the present invention.

Fig. 6 is a schematic plan view of a substrate treatment apparatus comprising a treatment liquid supply apparatus.

BEST MODE FOR CARRYING OUT THE INVENTION

Fig. 1 is a flow diagram schematically indicating an arrangement of a treatment liquid supply apparatus according to a first embodiment of the present invention. A treatment liquid supply apparatus 1 of this embodiment is adapted to supply a treatment liquid prepared by mixing a chemical liquid with pure water to a substrate treatment section, in which a substrate W as an object to be treated, for example, a semiconductor wafer, is treated (e.g., cleaned). The treatment liquid supply apparatus 1 comprises two liquid supply sources; namely, a chemical liquid supply source 10 for supply of a chemical liquid, and a pure water supply source 20 for supply of pure water. The treatment liquid supply apparatus 1 further comprises a mixing portion 30 for preparing a treatment liquid by mixing the chemical liquid with pure water and a treatment liquid supply unit 45 including treatment liquid supply portions 41 and 42 for supply of the treatment liquid prepared in the mixing portion 30.

The chemical liquid supply source 10 contains the chemical liquid (raw liquid) in a predetermined

concentration. The chemical liquid supply source 10 may comprise a storage tank in which the chemical liquid (raw liquid) is stored, or a flow pipe disposed in a factory, or the like. The type of chemical liquid employed is dependent on the type of treatment to which a substrate W is to be subject. For example, if a cleaning liquid is to be prepared as the treatment liquid to clean a substrate W, hydrofluoric acid (HF), ammonia (NH_4OH), and so on, can be supplied as the chemical liquid. The chemical liquid is supplied from the chemical liquid supply source 10 under a predetermined feed pressure and at a predetermined flow rate. For example, hydrofluoric acid may be supplied under a feed pressure of 0.18 to 0.2 MPa at a flow rate of 50 to 100 ml/min.

The chemical liquid supply source 10 is communicated with a chemical liquid supply tube 11. In the chemical liquid supply tube 11, there are provided a pressure sensor 12 for detecting a pressure (initial pressure) of the chemical liquid flowing through the chemical liquid supply tube 11 and an ON/OFF valve 13 for allowing and stopping the supply of chemical liquid. When the pressure of the chemical liquid falls below a predetermined allowable range, the pressure sensor 12 emits an alarm signal or the like, and the supply of the chemical liquid is stopped. Reference numeral 14 denotes a manual valve (toggle valve) for stopping a flow of the chemical liquid for maintenance. Reference numeral 15

denotes a flushing line for flowing cleaning water to the chemical liquid supply tube 11 for maintenance or cleaning. Normally, an ON/OFF valve 16 provided in the flushing line 15 is closed.

A constant-flow pump 17 is provided in the chemical liquid supply tube 11. The constant-flow pump 17 delivers the chemical liquid flowing in the chemical liquid supply tube 11 to the mixing portion 30 at a predetermined flow rate. The constant-flow pump 17 is controlled, based on a signal supplied from a controller 2. The chemical liquid supply tube 11 is also provided with a concentration meter 18 for measuring a concentration ρ of the chemical liquid (raw liquid).

Pure water (DIW), as a solvent, is supplied from the pure water supply source 20 under a predetermined pressure. The pure water supply source 20 may comprise a storage tank in which pure water is stored, a flow pipe disposed in a factory, or the like. The pure water, which is pumped through a pure water supply pump (not shown), is controlled so as to flow under a predetermined pressure at a predetermined flow rate (the description "pure water supply pump" generally refers to a supply pump provided in a line for supplying pure water to each treatment apparatus in a semiconductor manufacturing factory). For example, pure water to be mixed with hydrofluoric acid may be supplied under a feed pressure (initial pressure) of 0.18 to 0.2 MPa at a flow rate of 950 to 1900 ml/min.

The pure water supply source 20 is communicated with a pure water supply tube 21. In the pure water supply tube 21, there are provided a regulator 22, a pressure sensor 23, an ON/OFF valve 24 and a check valve 25. The regulator 22 regulates the pressure of pure water by lowering the pressure of pure water supplied from the pure water supply source 20 to a predetermined level. Thus, the regulator 22 does not serve to control the flow rate of the pure water to a certain level, but rather serves to suppress a variation in the flow of pure water after the flow rate has been controlled to a certain level, so as to achieve stable control. The pressure sensor 23 detects the pressure of pure water flowing in the pure water supply tube 21. When the pressure of pure water falls below a predetermined allowable range, the pressure sensor 23 emits an alarm signal or the like, and the supply of pure water is stopped. The ON/OFF valve 24 allows and stops the supply of pure water.

The chemical liquid supply tube 11 and the pure water supply tube 21 are joined together in the mixing portion 30, and communicated with a treatment liquid supply tube 31 downstream of the mixing portion 30. In the mixing portion 30, the chemical liquid from the chemical liquid supply tube 11 and the pure water from the pure water supply tube 21 are mixed with each other, to thereby prepare a treatment liquid. For example, hydrofluoric acid (HF), as the chemical liquid, and pure

water, as the solvent, are mixed with each other to form diluted hydrofluoric acid (DHF) as the treatment liquid (a cleaning liquid). The mixing portion 30 comprises a T-shaped joint formed so as to enable the chemical liquid supply tube 11 and the pure water supply tube 21 to be connected to the downstream treatment liquid supply tube 31. That is, the mixing portion 30 does not use a tank for mixing of the chemical liquid with pure water.

An in-line mixer 32 and a concentration meter 33 are provided in the treatment liquid supply tube 31. The in-line mixer 32 comprises an inner flow passage in a form that provides a flow resistance, and thus generates a vortex in a flow of the treatment liquid to thereby agitate the treatment liquid. The concentration meter 33 measures a concentration of the chemical liquid in the treatment liquid. As the concentration meter 33, use is made of, for example, an ultrasonic concentration meter. If an abnormal value of a concentration is measured by the concentration meter 33, the concentration meter 33 emits an alarm signal or the like, and the supply of the chemical liquid and pure water is stopped.

The treatment liquid supply tube 31 is communicated with the treatment liquid supply unit 45. In the treatment liquid supply unit 45, the treatment liquid supply tube 31 is bifurcated into two treatment liquid supply tubes 35 and 36 at a bifurcation point 34. The treatment liquid supply tubes 35 and 36 are,

respectively, communicated with the treatment liquid supply portions 41 and 42 for supplying the treatment liquid to an upper surface and a lower surface of a substrate W as an object to be treated. A flowmeter 37 and a constant-flow valve 39 are provided in the treatment liquid supply tube 35. A flowmeter 38 and a constant-flow valve 40 are provided in the treatment liquid supply tube 36. The treatment liquid supply tube 35 is further provided with a suck-back mechanism valve 46 which, when the supply of treatment liquid is stopped, prevents the treatment liquid remaining in the treatment liquid supply portion 41 from dropping onto the upper surface of the substrate W.

The flowmeters 37 and 38, respectively, measure the flow rates of the flows of the treatment liquid in the treatment liquid supply tubes 35 and 36. A degree of opening of each of the constant-flow valves 39 and 40 is controlled according to an air pressure supplied. The air pressure supplied to the constant-flow valves 39 and 40 is controlled by means of electro-pneumatic regulators 43 and 44. A signal is input from the controller 2 to each of the electro-pneumatic regulators 43 and 44, which in turn supplies an air pressure proportional to the signal. Thus, the flow rates in the constant-flow valves 39 and 40 are controlled to predetermined flow rates. Further, the values measured by the flowmeters 37 and 38 are input to the controller 2, thus effecting closed-loop control (CLC), in which

the flow rates in the constant-flow valves 39 and 40 are controlled, based on the measured values of flow rates of the treatment liquid. Instead of the constant-flow valves 39 and 40, constant-pressure valves may be provided. The constant-pressure valve controls the flow rate to a predetermined level by maintaining the pressure of the flow of the liquid at a predetermined level.

Fig. 2 shows details of an arrangement of a substrate cleaning unit as an example of the treatment liquid supply unit 45. In this example, cleaning liquid jet nozzles 51 and 52 are used as the treatment liquid supply portions 41 and 42. The treatment liquid supply tubes 35 and 36 communicated with the cleaning liquid jet nozzles 51 and 52 are omitted in Fig. 2. A substrate cleaning unit 50 in this example comprises the cleaning liquid jet nozzles 51 and 52 for jetting a cleaning liquid onto an upper surface and a lower surface of the substrate W, a plurality of spindles 53 for supporting a peripheral edge of the substrate W and rotate the substrate W in a horizontal plane, and a pair of cleaning members 56 (56a, 56b) in substantially cylindrical forms. Each cleaning member 56 (56a, 56b) comprises a shaft 54 (54a, 54b) and a roll sponge 55 (55a, 55b). The roll sponge 55 is made of a material such as foamed polyurethane, PVA, etc. and extends all the way around the periphery of the shaft 54. The pair of cleaning members 56a and 56b are disposed on

vertically opposite sides of the substrate W held by the spindles 53.

In the substrate cleaning unit 50 arranged as mentioned above, while the cleaning members 56 are held at upwardly and downwardly retreated positions relative to the substrate W, the substrate W is chucked and held by the spindles 53, and rotated. The cleaning members 56 are moved downward or upward while being rotated at a predetermined rpm, to thereby bring the cleaning members 56 into abutment with an upper surface and a lower surface of the substrate W under predetermined pressure, thus rubbing the cleaning members 56 against both surfaces of the substrate W for cleaning.

During cleaning, the cleaning liquid (DHF) is jetted from the cleaning liquid jet nozzles 51 and 52 onto the upper and lower surfaces of the substrate W. The cleaning liquid is prepared by means of the treatment liquid supply apparatus 1. In accordance with the process described below, the feed rate of the chemical liquid (raw liquid) having a predetermined concentration from the chemical liquid supply source 10 is controlled to a predetermined value by the constant-flow pump 17, and the feed rates of the treatment liquid after mixing the chemical liquid with pure water are controlled to predetermined values by the constant-flow valves 39 and 40.

Next, explanation is made with regard to a process for supply of the treatment liquid in the treatment

liquid supply apparatus 1 of Fig. 1. Initially, the controller 2 sets a target set value D (w%) of a concentration of the chemical liquid in the treatment liquid. In a case that hydrofluoric acid is used as the chemical liquid (raw liquid), D = about 0.5%. The controller 2 also sets target set values Q1 (L/m) and Q2 (L/m) of the flow rates of the treatment liquid supplied to the upper and lower surfaces of the substrate W. Then, the ON/OFF valve 13 of the chemical liquid supply tube 11 and the ON/OFF valve 24 of the pure water supply tube 21 are opened, thus starting supply of the chemical liquid and pure water to the mixing portion 30. In the mixing portion 30, the chemical liquid and the pure water are mixed with each other to thereby prepare the treatment liquid, which is in turn supplied through the treatment liquid supply portions 41 and 42 to the substrate W.

In this instance, the flowmeters 37 and 38 measure flow rates q1 and q2 (measured values) of the treatment liquid supplied from the treatment liquid supply portions 41 and 42 to the substrate W. The measured values q1 and q2 are input to the controller 2. The controller 2 compares the measured values q1 and q2 with the target set values Q1 and Q2, and sends signals to the electro-pneumatic regulators 43 and 44 so that any deviations of the measured values q1 and q2 from the target set values Q1 and Q2 can be eliminated, thus controlling the flow rates in the constant-flow valves

39 and 40. Thus, the feed rates of the treatment liquid from the treatment liquid supply portions 41 and 42 are controlled to the target set values Q1 and Q2, respectively.

A set value Q3 of the flow rate of the chemical liquid (raw liquid) supplied from the chemical liquid supply source 10 to the mixing portion 30 is determined in accordance with the following formula (1), based on the target set values Q1 and Q2 of the feed rates of the treatment liquid and the target set value D of the concentration of the chemical liquid in the treatment liquid. In the formula (1), ρ (w%) represents the concentration of the chemical liquid (raw liquid), i.e., a predetermined concentration of the chemical liquid in the chemical liquid supply source 10. When hydrofluoric acid is used as the chemical liquid (raw liquid), ρ = about 5 %.

$$Q3 = (Q1 + Q2) \times (D/\rho) \qquad (1)$$

Then, a signal is supplied to the constant-flow pump 17 so that the flow rate of the chemical liquid (raw liquid) delivered by the constant-flow pump 17 becomes equal to the set value Q3.

As a result, the treatment liquid having a concentration controlled to the set value D is supplied to the upper and lower surfaces of the substrate W at the flow rates Q1 and Q2, respectively. In this instance,

the flow rate Q4 of pure water supplied from the pure water supply source 20 to the mixing portion 30 is automatically controlled to the flow rate Q4 which is determined in accordance with the following formula (2), based on the balance in flow rate between an inflow and an outflow in the mixing portion 30 and the values Q1, Q2 and Q3 which are already determined.

$$Q1 + Q2 = Q3 + Q4 \qquad (2)$$

Thus, by controlling the feed rates Q1 and Q2 of the treatment liquid and the flow rate Q3 of the chemical liquid, the concentration of the treatment liquid can be controlled to the set value D. In this instance, the flow rate Q4 of pure water is automatically controlled, based on the balance in flow rate between the inflow and the outflow in the mixing portion 30. Therefore, if an error is generated in the flow rate controlled by the constant-flow valve 39 or 40, or in the flow rate controlled by the constant-flow pump 17, this error can be absorbed by automatic control of the flow rate Q4 of pure water. Therefore, an operation error in the treatment liquid supply apparatus 1 can be avoided.

Further, the constant-flow pump 17 as the flow rate control means is provided only in the chemical liquid supply tube 11, not in the pure water supply tube 21. Therefore, the number of flow rate control means

that are expensive as compared to other parts of the treatment liquid supply apparatus 1 can be reduced, thus reducing a cost of the treatment liquid supply apparatus 1. Further, only the flow rate of the chemical liquid is controlled without controlling the flow rate of pure water. Therefore, it is possible to provide a treatment liquid supply apparatus that is capable of controlling the concentration of the treatment liquid with high precision by conducting high-precision control of the flow rate of the chemical liquid, which is supplied in a small amount as compared to the solvent (pure water) and thus enables high-precision control of a flow rate.

In this embodiment, the constant-flow pump 17 is provided in the chemical liquid supply tube 11 to thereby control the flow rate of the chemical liquid. However, this does not limit the present invention. The treatment liquid supply apparatus 1 may comprise means adapted to control the flow rate of either one of the chemical liquid and pure water prior to mixing. That is, the constant-flow pump 17 may be provided only in the pure water supply tube 21, not in the chemical liquid supply tube 11, to thereby control the flow rate of pure water. In this case, a set value Q4 of the flow rate of pure water is calculated based on the target set value D or a measured value d of the concentration of the chemical liquid in the treatment liquid, and the flow rate in the constant-flow pump 17 provided in the pure water supply tube 21 is controlled to the set value Q4.

In this case, the flow rate Q3 of the chemical liquid is automatically controlled to the flow rate that is determined based on the values Q1, Q2 and Q4 which are already determined.

Further, in the above embodiment, closed-loop control (CLC) is effected by controlling the flow rates in the constant-flow valves 39 and 40, based on the measured values of flow rates of the treatment liquid as measured by the flowmeters 37 and 38. However, the flow rates in the constant-flow valves 39 and 40 may be controlled based on the predetermined target set values Q1 and Q2 of flow rates, without using the flow rate values measured by the flowmeters 37 and 38. That is, based on the target set values Q1 and Q2 of the feed rates of the treatment liquid, signals are supplied to the electro-pneumatic regulators 43 and 44 so that the flow rates in the constant-flow valves 39 and 40 become equal to the set values Q1 and Q2.

As the treatment liquid supply unit 45, the substrate cleaning unit 50 is shown in the above embodiment. However, the treatment liquid supply unit 45 may be a substrate polishing unit or a substrate plating unit. When a substrate polishing unit or a substrate plating unit is used as the treatment liquid supply unit 45, the treatment liquid to be prepared and supplied by the treatment liquid supply apparatus 1 is an abrasive liquid, which is prepared by mixing an abrasive chemical liquid with pure water, or a plating liquid, which is

prepared by mixing a plating chemical liquid with pure water. In this embodiment, as the treatment liquid supply portions 41 and 42, the pair of cleaning liquid jet nozzles 51 and 52 are used. The number and arrangements of the treatment liquid supply portions are not limited to those in the above embodiment. The number of the treatment liquid supply portions may, for example, be one or three or more. When use is made of a single treatment liquid supply portion, the treatment liquid supply portion is a cleaning liquid jet nozzle or the like for supplying a cleaning liquid to only one of the upper and lower surfaces of the substrate W.

In a case that the chemical liquid which flows in the chemical liquid supply tube 11 is supplied from the chemical liquid supply source 10 under a predetermined pressure, a constant-flow valve may be provided in the chemical liquid supply tube 11, instead of the constant-flow pump 17. When a constant-flow valve is used, it is required to control the pressure so as to establish the relationship (the feed pressure of pure water) $\ll$ (the feed pressure of chemical liquid). When a constant-flow pump is used, due to the delivery pressure of the pump, there is no need to take care of feed pressures of the pure water and the chemical liquid. Constant-flow pumps may also be provided in the treatment liquid supply tubes 35 and 36, in place of the constant-flow valves 39 and 40.

Fig. 3 is a flow diagram schematically showing an

arrangement of a treatment liquid supply apparatus according to a second embodiment of the present invention. In the second embodiment, the portions corresponding to those in the first embodiment are designated by the same reference numerals as used in the first embodiment, and detailed explanation thereof is omitted. A basic process for preparing and supplying a treatment liquid is the same as that in the first embodiment. The same applies to the other embodiments described later. A treatment liquid supply apparatus 1-2 in the second embodiment differs from the treatment liquid supply apparatus 1 in the first embodiment in that the measured value of the concentration of the treatment liquid as measured by the concentration meter 33 is input to the controller 2. With this arrangement, the feed rate of the chemical liquid obtained by the constant-flow pump 17 and the feed rates of the treatment liquid obtained by the constant-flow valves 39 and 40 can be controlled, based on the measured value of the concentration of the treatment liquid.

Specifically, the concentration d (measured value) of the chemical liquid in the treatment liquid prepared in the mixing portion 30 is measured by the concentration meter 33, and the measured value d is input to the controller 2. The controller 2 compares the measured value d with the target set value D of the concentration of the treatment liquid, and controls the flow rate in the constant-flow pump 17 so that any

deviation of the measured value d from the set value D can be eliminated. Consequently, the flow rate in the constant-flow pump 17 is controlled to the value Q3 at which the concentration of the chemical liquid in the treatment liquid becomes D. In this case, the flow rates in the constant-flow valves 39 and 40 may be controlled by feedback control, based on the measured values q1 and q2 of the flowmeters 37 and 38, or may be controlled based on the target set values Q1 and Q2.

In the second embodiment, the measured value of the concentration of the chemical liquid (raw liquid) as measured by the concentration meter 18 in the chemical liquid supply tube 11 is input to the controller 2. With this arrangement, the feed rate Q3 of the chemical liquid in the constant-flow pump 17 can be controlled, based on an actual concentration ρ' (measured value) of the chemical liquid (raw liquid) as measured by the concentration meter 18, the feed rates Q1 and Q2 and the concentration D of the chemical liquid in the treatment liquid. Therefore, if there is a variation in the concentration of the chemical liquid (raw liquid) supplied from the chemical liquid supply source 10, the concentration of the treatment liquid can be controlled with high precision. Both or either one of the measured value of the concentration meter 33 and the measured value of the concentration meter 18 may be input to the controller 2.

Fig. 4 is a flow diagram schematically showing an

arrangement of a treatment liquid supply apparatus according to a third embodiment of the present invention. A treatment liquid supply apparatus 1-3 in the third embodiment differs from the treatment liquid supply apparatus 1-2 in the second embodiment in that two chemical liquid supply sources 10 are provided. Specifically, different types of chemical liquids (raw liquids) are supplied from two chemical liquid supply sources 10-1 and 10-2, and a treatment liquid is prepared by mixing these two types of chemical liquids with pure water supplied from the pure water supply source 20. An example of a combination of two types of chemical liquids supplied from the treatment liquid supply sources 10-1 and 10-2 is a combination of ammonia and hydrogen peroxide. Ammonia hydroxide-hydrogen peroxide water (APM) is prepared as a treatment liquid by mixing these two liquids with pure water. Two chemical liquid supply tubes 11-1 and 11-2 and the pure water supply tube 21 are joined together in the mixing portion 30. The concentration meter 33 may be of a type in which the concentrations of a plurality of chemical liquids in a treatment liquid are individually measured, or a type which measures the concentration of the plurality of chemical liquids in its entirety in the treatment liquid.

In the treatment liquid supply apparatus 1-3 arranged as mentioned above, the controller 2 sets target set values DA and DB of the concentrations of the

chemical liquids (supplied from the treatment liquid supply sources 10-1 and 10-2) in the treatment liquid. Then, based on the target set values DA, Q1 and Q2, and a concentration ρA of the chemical liquid (raw liquid) supplied from the treatment liquid supply source 10-1, a set value Q3A of the flow rate of the chemical liquid supplied from the treatment liquid supply source 10-1 is calculated in accordance with the following formula (3), and based on the target set values DB, Q1 and Q2, and a concentration ρB of the chemical liquid (raw liquid) supplied from the treatment liquid supply source 10-2, a set value Q3B of the flow rate of the chemical liquid supplied from the treatment liquid supply source 10-2 is calculated in accordance with the following formula (4). Based on the calculated values Q3A and Q3B, signals are supplied to constant-flow pumps 17-1 and 17-2, to thereby control the feed rates of the chemical liquids to the values Q3A and Q3B.

$$Q3A = (Q1 + Q2) \times (D/\rho A) \quad (3)$$

$$Q3B = (Q1 + Q2) \times (D/\rho B) \quad (4)$$

The feed rates of the chemical liquids supplied to the mixing portion 30 are controlled to Q3A and Q3B, and the feed rates of the treatment liquid after mixing are controlled to Q1 and Q2. Therefore, the flow rate of pure water is automatically controlled to a predetermined flow rate Q4 in accordance with the

following formula (5), based on the values Q3A, Q3B, Q1 and Q2 and the flow rate balance between the inflow and the outflow in the mixing portion 30.

$$Q1 + Q2 = Q3A + Q3B + Q4 \quad (5)$$

Thus, in the treatment liquid supply apparatus 1-3, only the flow rates of the chemical liquids, each of which is supplied in a small amount and thus enables high-precision control of a flow rate, is controlled, without controlling the flow rate of pure water. Therefore, the concentration of the treatment liquid after mixing can be controlled with high precision.

In the third embodiment, two chemical liquid supply sources are used. However, the number of chemical liquid supply sources may be three or more. That is, three or more types of chemical liquids supplied from three or more chemical liquid supply sources may be mixed with pure water which is supplied from the pure water supply source, to thereby prepare a treatment liquid. In this case also, a constant-flow pump is provided in each of the chemical liquid supply tubes corresponding to the respective chemical liquids, and the feed rate of each of the chemical liquids is controlled so that the content (concentration) of the chemical liquid contained in the treatment liquid becomes a predetermined value. The flow rate of pure water is automatically controlled to a predetermined

value that is determined from the flow rate of each of the chemical liquids and the feed rate of the treatment liquid after mixing.

Fig. 5 is a flow diagram schematically indicating an arrangement of a treatment liquid supply apparatus according to a fourth embodiment of the present invention. A treatment liquid supply apparatus 1-4 in the fourth embodiment differs from the treatment liquid supply apparatus 1-2 in the second embodiment in that two treatment liquid supply units 45 (45-1 and 45-2), each comprising the two treatment liquid supply portions 41 and 42, are provided. Each of the treatment liquid supply units 45-1 and 45-2 has the same arrangement as that of the treatment liquid supply unit 45 in the above-mentioned embodiments. In the treatment liquid supply apparatus 1-4, the treatment liquid supply tube 31 is bifurcated into two treatment liquid supply tubes 48 and 49 at a bifurcated portion 47, and the treatment liquid supply tubes 48 and 49 are connected to the treatment liquid supply units 45-1 and 45-2.

Feed rates Q1-1 and Q2-1 in constant-flow valves 39-1 and 40-1 provided in the treatment liquid supply unit 45-1, and feed rates Q1-2 and Q2-2 in constant-flow valves 39-2 and 40-2 provided in the treatment liquid supply unit 45-2 can be arbitrarily determined. The number of treatment liquid supply units 45 may be three or more.

Next, description is made with regard to an

example of an arrangement of a substrate treatment apparatus comprising a treatment liquid supply apparatus described in either of the above embodiments. Fig. 6 is a schematic plan view of such a substrate treatment apparatus 60. The substrate treatment apparatus 60 comprises a plurality of substrate cleaning units 50 (four substrate cleaning units 50-1 to 50-4 in Fig. 6). Each of the substrate cleaning units 50-1 to 50-4 corresponds to the treatment liquid supply unit 45 in the above embodiments, and a cleaning liquid prepared by either of the treatment liquid supply apparatuses 1 to 1-4 is supplied to the substrate cleaning units 50-1 to 50-4. The substrate treatment apparatus 60 comprises a cleaning portion 61 including the substrate cleaning units 50-1 to 50-4, a transfer portion 71 having a transfer robot 75 for transferring a substrate W, which is disposed on one side of the cleaning portion 61, and a polishing portion (CMP apparatus) 81 having polishing units 82 and 83 for conducting polishing of the substrate W, which is disposed on the other side of the cleaning portion 61.

The transfer portion 71 comprises a plurality of (four in Fig. 6) loading/unloading stages 73, on each of which a cassette 72 for accommodating a number of substrates W is placed. The transfer robot 75 having two hands is disposed adjacent to the loading/unloading stages 73 and adapted to move on a moving mechanism 74. In the cleaning portion 61, the two substrate cleaning

units 50-1 and 50-2 are disposed adjacent to the moving mechanism 74, and the two substrate cleaning units 50-3 and 50-4 are disposed adjacent to the substrate cleaning units 50-1 and 50-2. A stand 62 on which the substrate W is adapted to be placed is provided between the two substrate cleaning units 50-1 and 50-2. Transfer robots 63 and 64 are provided between the substrate cleaning units 50-3 and 50-4. The stand 62 is used for transferring the substrate W between the transfer robot 75 and the transfer robots 63 and 64.

Of the plurality of substrate cleaning units 50-1 to 50-4, substrate cleaning units using the same type of cleaning liquid are connected to the same treatment liquid supply apparatus. If a cleaning operation is conducted in the substrate cleaning units 50-1 and 50-2, using the same type of cleaning liquid, the cleaning liquid is supplied from the treatment liquid supply apparatus 1-4 shown in Fig. 5 to the substrate cleaning units 50-1 and 50-2. In the other substrate cleaning units 50-3 and 50-4, if a different type of a cleaning liquid than in the substrate cleaning units 50-1 and 50-2 is used, the cleaning liquid is supplied from another treatment liquid supply apparatus.

The polishing portion 81 comprises two polishing units 82 and 83. The polishing units 82 and 83, respectively, comprise polishing tables 84 and 85, and top rings 86 and 87 which are adapted to hold substrates W under vacuum pressure and press the substrates W

against upper surfaces of the polishing tables 84 and 85 for polishing. Further, abrasive liquid nozzles 88 and 89 for supplying an abrasive liquid to the polishing tables 84 and 85, and dressers 90 and 91 for dressing the polishing tables 84 and 85 are disposed in the polishing portion 81. Reference numerals 92 and 93 denote turning-over machines for turning-over the substrates W. Reference numerals 94 and 95 denote pushers for transferring the substrates W between the turning-over machines 92 and 93 and the top rings 86 and 87.

Next, a brief explanation is given with regard to an operation for treating a substrate in the substrate treatment apparatus 60 arranged as mentioned above. First, by means of the transfer robot 75, a substrate W is taken out from the cassette 72 and placed on the stand 62. The substrate W is transferred to the turning-over machine 92 or 93 by means of the transfer robot 63 or 64, and further transferred to the top ring 86 or 87 by means of the pusher 94 or 95. The substrate W transferred to the top ring 86 or 87 is then held by a vacuum holding mechanism of the top ring 86 or 87, and transferred to the polishing table 84 or 85. While the polishing table 84 or 85 is being rotated, the substrate W is pressed against a polishing surface of the polishing table 84 or 85, which surface is formed by a polishing pad or abrasive particles attached to the polishing table 84 or 85, to thereby conduct polishing.

After completion of polishing, the substrate W is returned to the turning-over machine 92 or 93 by the same route. By means of the transfer robot 63 or 64, the substrate W is transferred to the substrate cleaning unit 50-3 or 50-4, in which primary cleaning is conducted. For primary cleaning, the cleaning liquid prepared by the treatment liquid supply apparatus 1-4 is supplied to the substrate cleaning unit 50-3 or 50-4. After completion of primary cleaning in the substrate cleaning unit 50-3 or 50-4, the substrate W is transferred to the adjacent substrate cleaning unit 50-1 or 50-2 by the transfer robot 63 or 64, and secondary cleaning is conducted in the substrate cleaning unit 50-1 or 50-2. The substrate cleaning unit 50-1 or 50-2 is supplied with the cleaning liquid from another treatment liquid supply apparatus. After completion of cleaning in the substrate cleaning unit 50-1 or 50-2, the substrate W is returned to the stand 62, and accommodated in the cassette 72 by means of the transfer robot 75.

To treat the substrate W, the target set value D of the concentration of the chemical liquid in the treatment liquid and the target set values Q1 and Q2 of the feed rate of the treatment liquid are set in a control unit (not shown) of the substrate treatment apparatus 60, in addition to other treatment conditions. The input values D, Q1 and Q2 are supplied from the control unit to the controller 2 in the treatment liquid

supply apparatus (1 to 1-4). Then, in the manner described in the above embodiments, a treatment liquid is prepared and supplied to the corresponding substrate cleaning unit.

The substrate treatment apparatus 60 in this embodiment comprises the polishing portion (CMP apparatus) 81 including the polishing units 82 and 83. However, the substrate treatment apparatus 60 may comprise a plating apparatus for conducting plating on the substrate W.

Embodiments of the present invention have been described above. However, the present invention is not limited to the above-described embodiments, and various modifications are possible within the scope of the technical idea disclosed in the claims, specification and drawings. Any forms and materials which are not directly indicated in the specification or drawings are also within the scope of the technical idea of the present invention, as long as working effects of the present invention can be obtained.

CLAIMS

1. A treatment liquid supply apparatus comprising:

a plurality of liquid supply sources from which different types of liquids are individually supplied;

a mixing portion in which the liquids supplied from said plurality of liquid supply sources are mixed with each other, to thereby prepare a treatment liquid; and

a treatment liquid supply portion for supplying the treatment liquid prepared in the mixing portion to a treatment section,

wherein:

said plurality of liquid supply sources comprises at least one liquid supply source provided with liquid flow rate control means, and a single liquid supply source provided without liquid flow rate control means,

said liquid flow rate control means being adapted to control a flow rate of the liquid supplied from said at least one liquid supply source to the mixing portion;

said treatment liquid supply portion is provided with treatment liquid flow rate control means, said treatment liquid flow rate control means being adapted to control a flow rate of the treatment liquid supplied from the treatment liquid supply portion; and

a concentration of the liquid from the at least one liquid supply source in the treatment liquid is controlled to a predetermined value by controlling, prior to mixing in the mixing portion, the flow rate of

the liquid from the at least one liquid supply source to a predetermined value by the liquid flow rate control means, and controlling the flow rate of the treatment liquid to a predetermined value by the treatment liquid flow rate control means.

2. A treatment liquid supply apparatus according to claim 1, wherein said predetermined value of the flow rate controlled by the liquid flow rate control means is determined, based on a target value of the concentration of the liquid from the at least one liquid supply source in the treatment liquid and/or a target value of the flow rate of the treatment liquid.

3. A treatment liquid supply apparatus according to claim 1, wherein the treatment liquid supply apparatus further comprises treatment liquid flow rate measurement means adapted to measure the flow rate of the treatment liquid supplied from the treatment liquid supply portion, and said predetermined value of the flow rate of the treatment liquid is determined, based on a value measured by the treatment liquid flow rate measurement means.

4. A treatment liquid supply apparatus according to claim 3, wherein the treatment liquid supply apparatus further comprises treatment liquid concentration measurement means adapted to measure the concentration of the liquid from the at least one liquid supply source in the treatment liquid, and said predetermined value of the flow rate controlled by the liquid flow rate control

means is determined, based on the value measured by the treatment liquid flow rate measurement means and/or a value measured by the treatment liquid concentration measurement means.

5. A treatment liquid supply apparatus according to any one of claims 1 to 4, wherein the treatment liquid supply apparatus comprises two or more treatment liquid supply portions, and each of the two or more treatment liquid supply portions is provided with the treatment liquid flow rate control means.

6. A treatment liquid supply apparatus according to claim 5, wherein the treatment liquid supply apparatus comprises two or more treatment liquid supply units, each including the two or more treatment liquid supply portions provided with treatment liquid flow rate control means.

7. A treatment liquid supply apparatus according to any one of claims 1 to 6, wherein the liquid supplied from said at least one liquid supply source provided with liquid flow rate control means is a chemical liquid and the liquid supplied from said single liquid supply source provided without liquid flow rate control means is a solvent.

8. A treatment liquid supply apparatus according to any one of claims 1 to 7, wherein the liquid flow rate control means and/or the treatment liquid flow rate control means is a constant-flow valve or a constant-flow pump controlled by an electro-pneumatic regulator.

9. A substrate treatment apparatus comprising a treatment liquid supply apparatus of any one of claims 1 to 8, wherein the treatment liquid prepared by the treatment liquid supply apparatus is supplied to a substrate treatment section in which a substrate is treated.

10. A treatment liquid preparation method for mixing a plurality of types of liquids to prepare a treatment liquid, wherein said plurality of types of liquids comprises at least one liquid having a controlled flow rate and a single liquid having an uncontrolled flow rate, and a concentration of the at least one liquid in the treatment liquid is controlled to a predetermined value by controlling the flow rate of the at least one liquid and a flow rate of the treatment liquid to respective predetermined values.

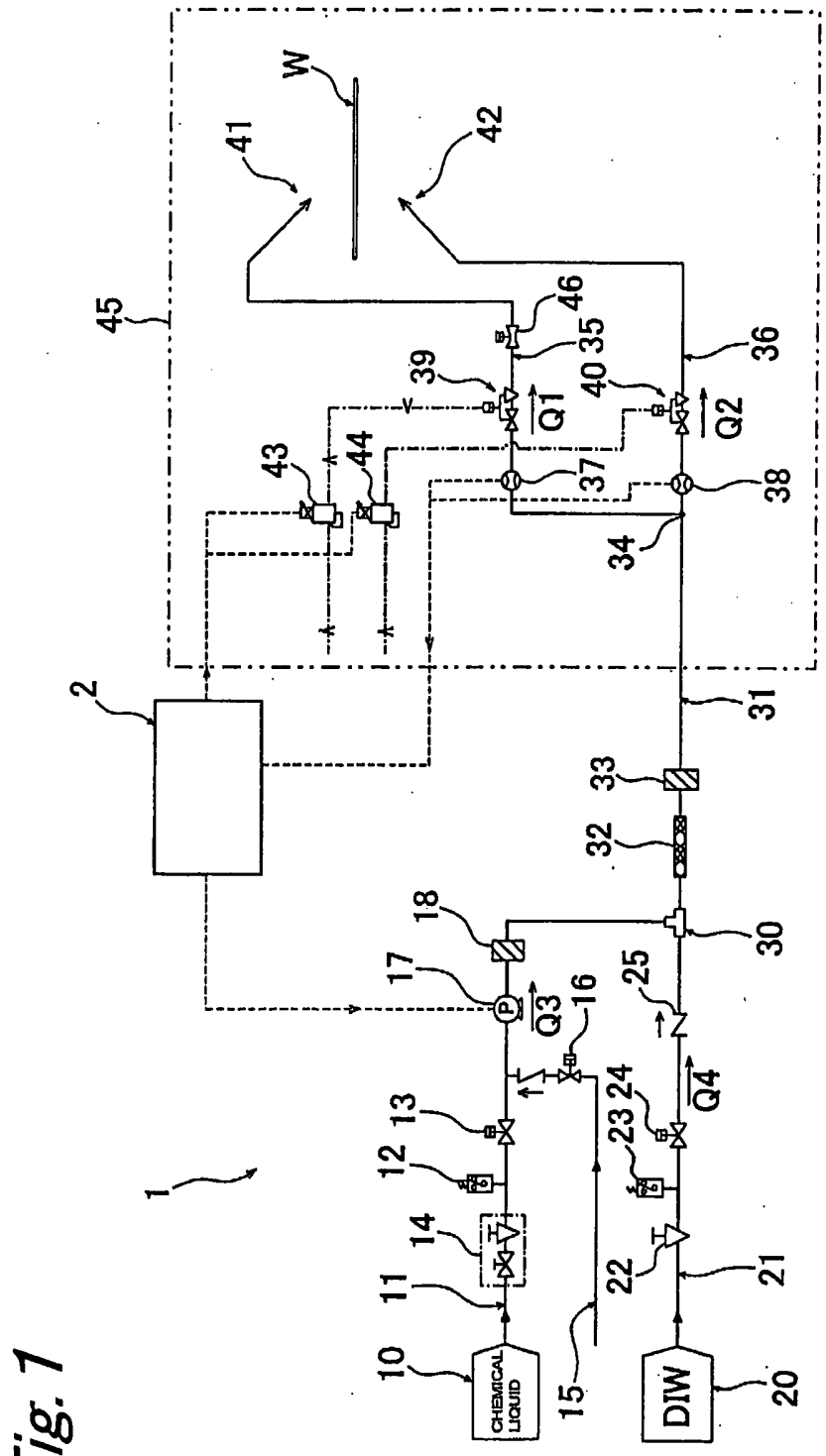
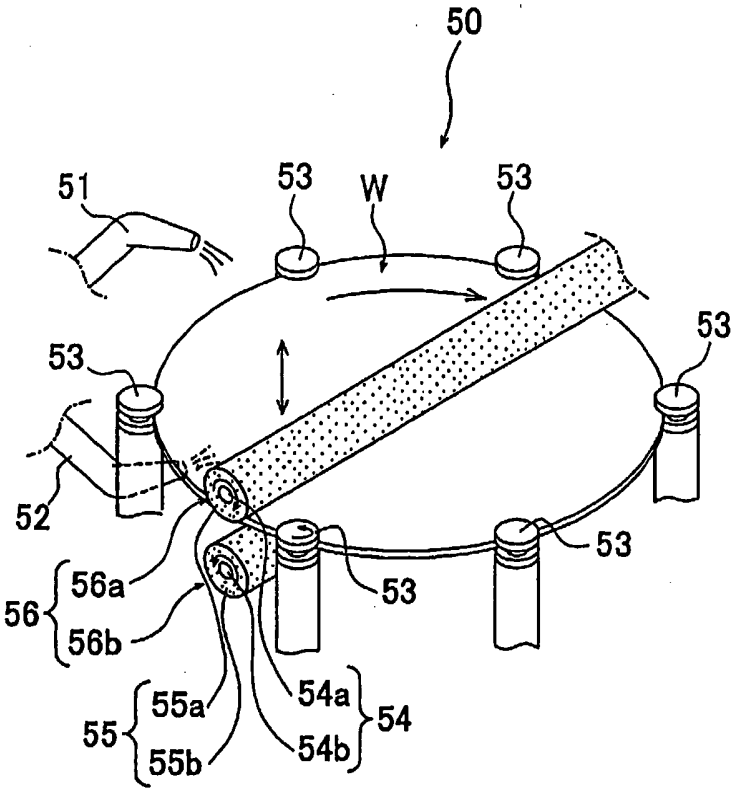

W
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42
45
46
35
36
39
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Q1
Q2
43
44
37
38
34
2
31
33
32
18
30
17
Q3
16
25
Q4
24
13
23
12
1
14
11
22
21
10
CHEMICAL LIQUID
15
DIW
20

Fig. 1

Fig.2



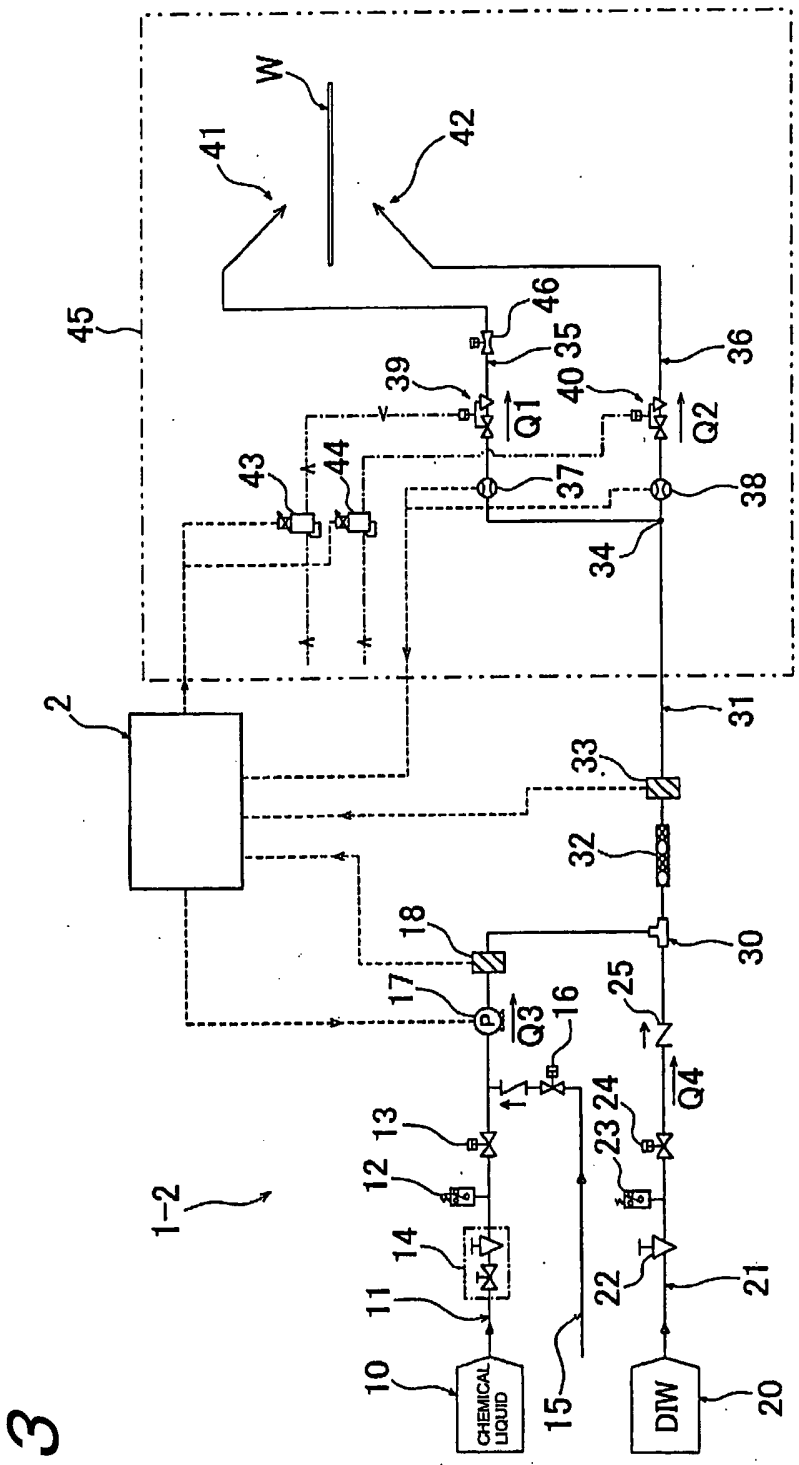
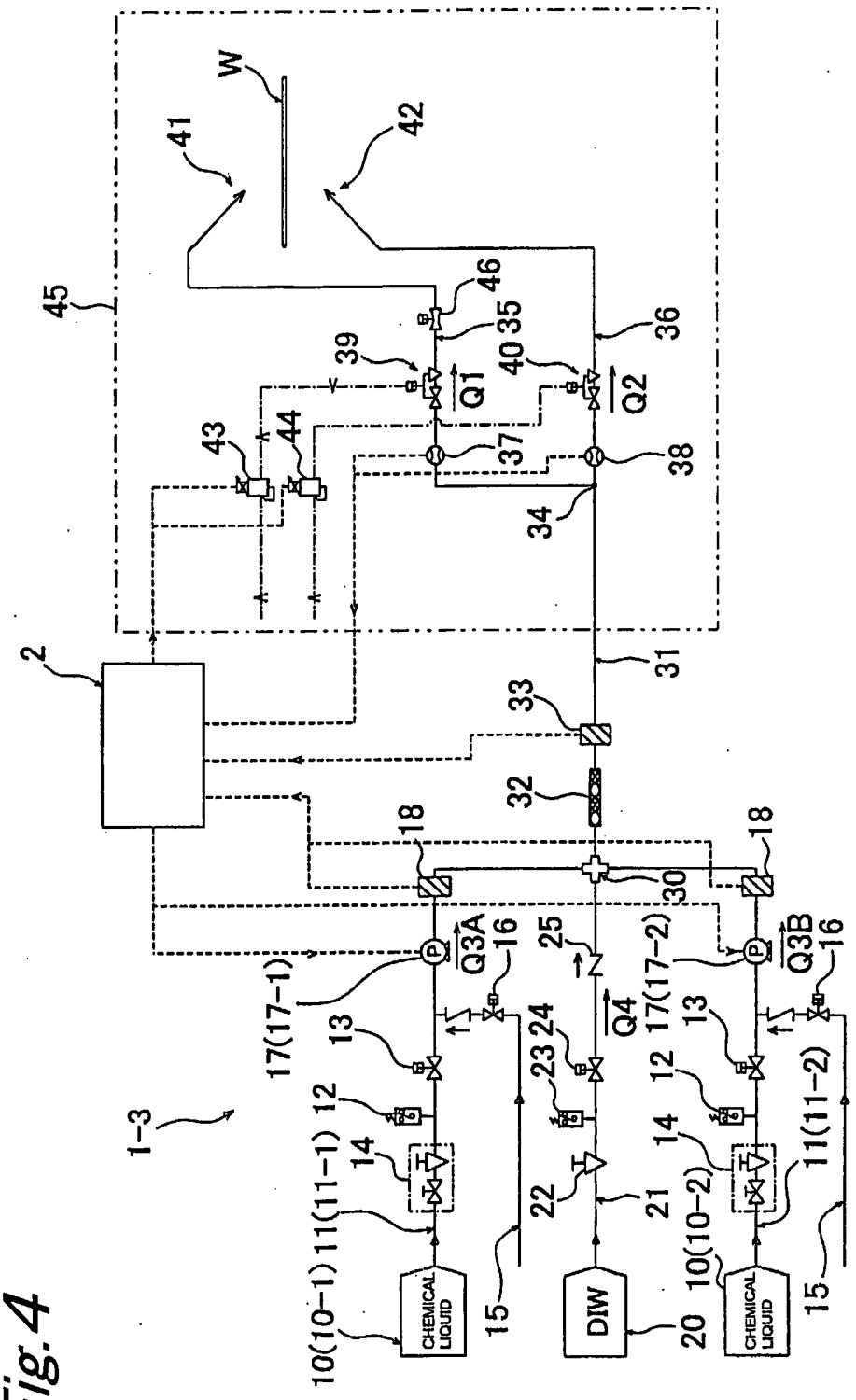

W
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46
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36
39
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Q1
Q2
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44
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38
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2
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33
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18
30
17
Q3
16
25
Q4
13
24
12
23
1-2
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11
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21
10
15
20
CHEMICAL LIQUID
DIW

Fig.3

Fig. 4


W
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45
46
35
36
39
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Q1
Q2
43
44
37
38
34
2
31
33
32
18
18
30
Q3A
Q3B
16
16
25
Q4
17(17-1)
17(17-2)
13
13
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CHEMICAL LIQUID
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CHEMICAL LIQUID

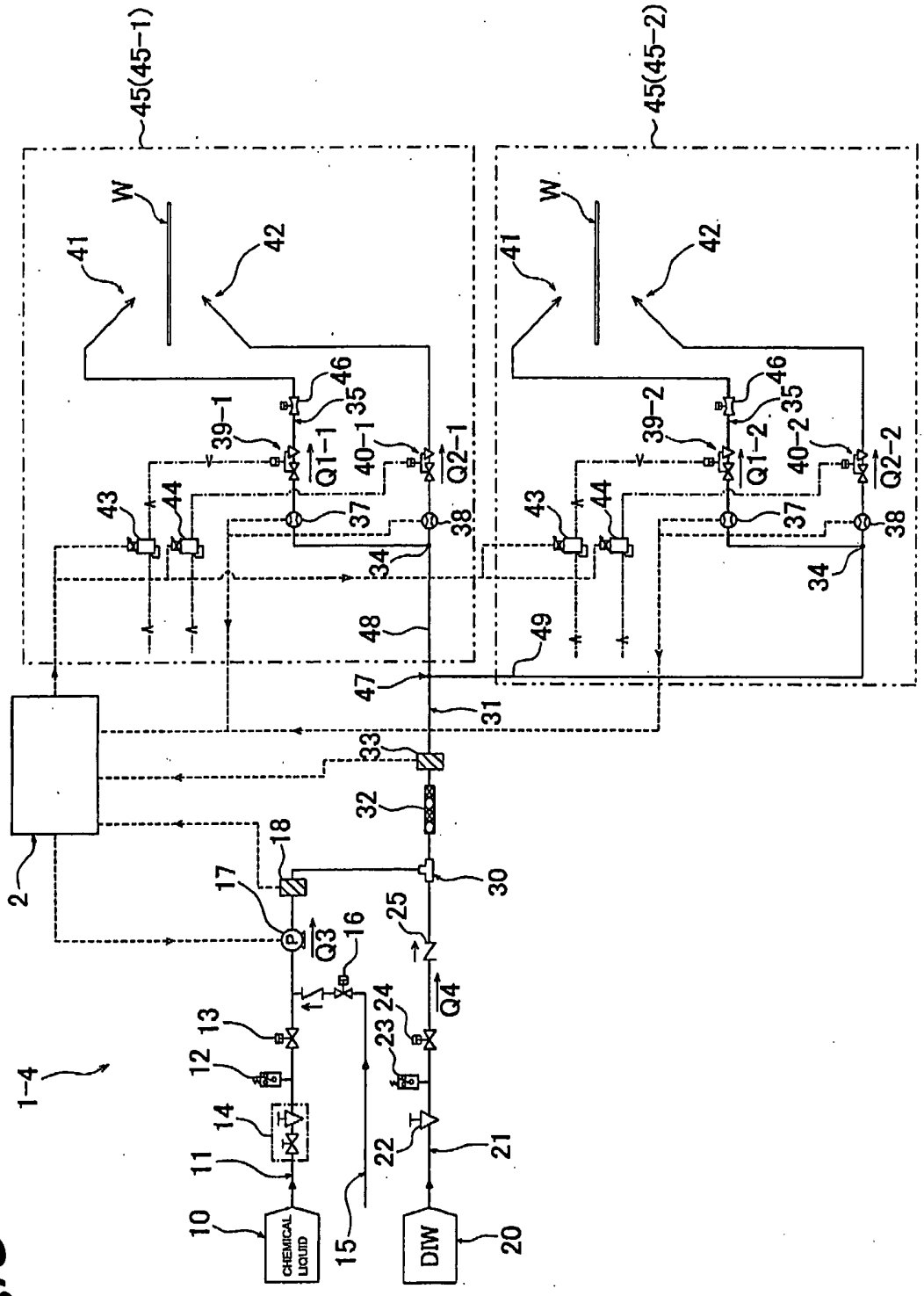

45(45-1)
45(45-2)
W
41
42
46
35
39-1
Q1-1
40-1
Q2-1
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34
48
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47
31
33
32
18
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Q3
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Q4
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CHEMICAL LIQUID
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40-2
Q2-2

Fig.5

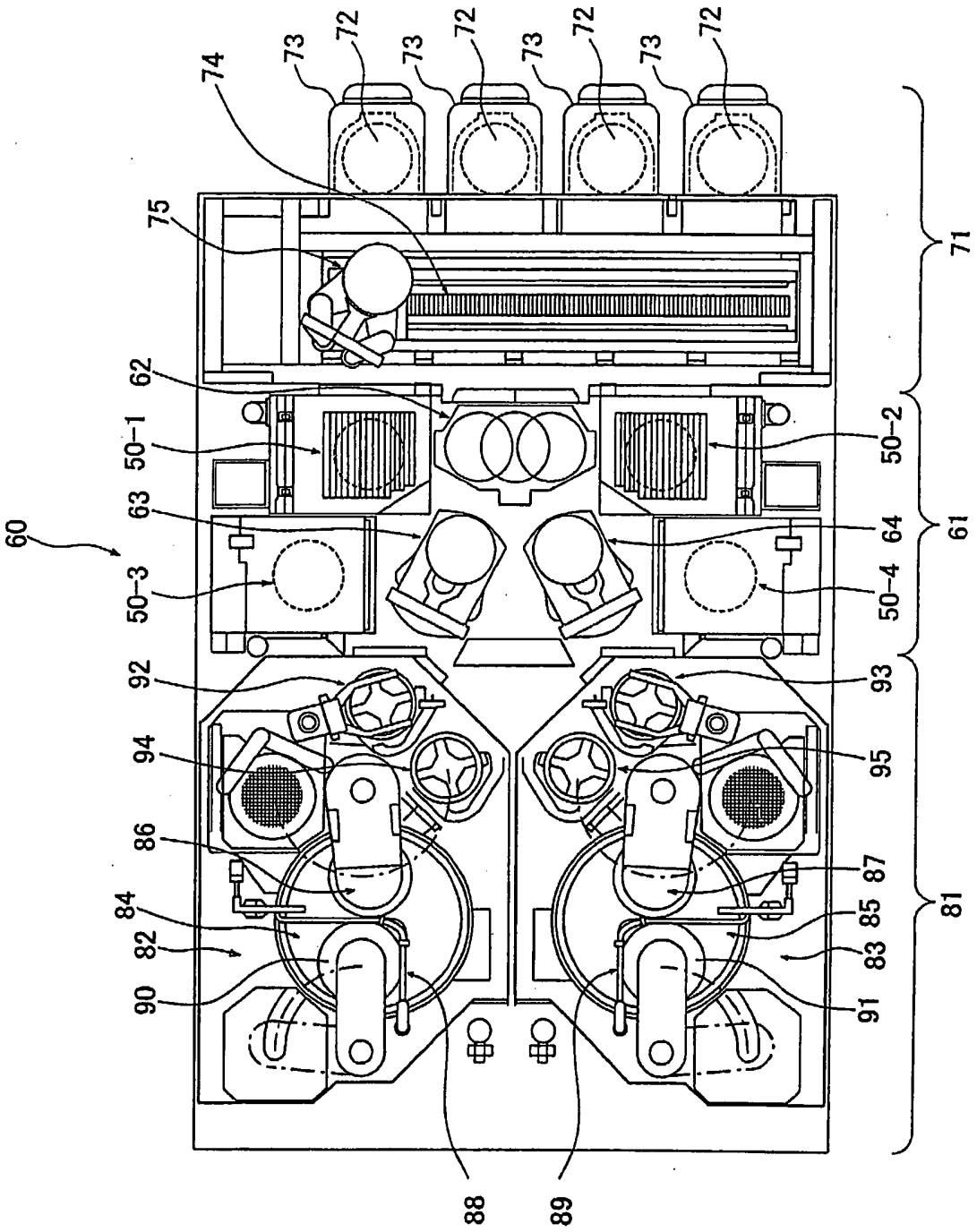

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Fig. 6

INTERNATIONALSEARCHREPORT

International application No.
PCT/JP2005/021174

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. *B01F15/04* (2006.01), *B01J4/00* (2006.01), *H01L21/304* (2006.01)

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)

Int.Cl. *B01F15/04* (2006.01), *B01J4/00* (2006.01), *H01L21/304* (2006.01)

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 1971-2006
Registered utility model specifications of Japan 1996-2006
Published registered utility model applications of Japan 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.
X Y	JP 2000-265945 A (UCT Corporation) 2000.09.26, para[0073]-[0082],[0118]-[0121],Fig.1 & US 6764212 B1	1-4,7,9,10 5,6,8
Y	JP 2004-111668 A (CITIZEN WATCH Co.,Ltd.) 2004.04.08, para[0010]-[0011],Fig.5 (no family)	5
Y	JP 2003-142448 A (TOKYO ELECTRON Limited.) 2003.05.16, all pages (no family)	6
Y	JP 2001-291697 A (DAINIPPON SCREEN MFG.Co.,Ltd.) 2001.10.19, para[0017]-[0026],Fig.2 (no family)	8

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

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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27.01.2006	07.02.2006

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