(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 669 749 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
04.12.2013 Bulletin 2013/49

(21) Application number: **12739854.3**

(22) Date of filing: **23.01.2012**

(51) Int Cl.:
G03G 15/11 *(2006.01)*

(86) International application number:
PCT/JP2012/051368

(87) International publication number:
WO 2012/102244 (02.08.2012 Gazette 2012/31)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **24.01.2011 JP 2011012400**

(71) Applicant: **Mitsubishi Heavy Industries Printing & Packaging Machinery, Ltd.**
Mihara-shi
Hiroshima 729-0393 (JP)

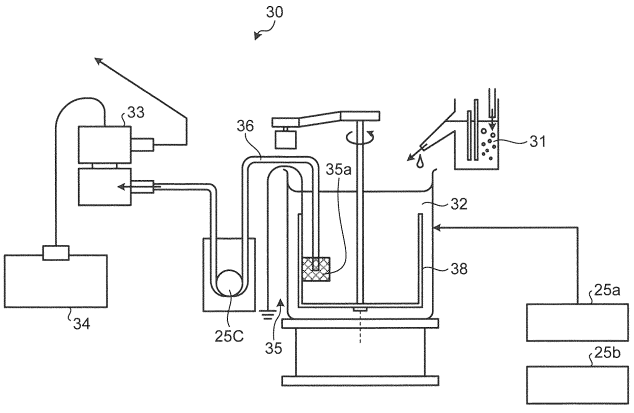
(72) Inventors:
- **SHIGEYAMA, Naoki**
  Mihara-shi
  Hiroshima 729-0393 (JP)
- **SENOO, Shinichiro**
  Mihara-shi
  Hiroshima 729-0393 (JP)
- **SATO, Minoru**
  Mihara-shi
  Hiroshima 729-0393 (JP)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) LIQUID TONER CONCENTRATION SENSOR DEVICE, ELECTROPHOTOGRAPHIC PRINTER, AND LIQUID TONER CONCENTRATION MEASUREMENT METHOD

(57) A liquid toner concentration sensor device 30 includes a dispersion tank 31, a stirring tank 32, a concentration sensor 33, a control device 34, and a charge adjustment unit 35. The stirring tank 32 is a container for storing a liquid toner T conveyed from the dispersion tank 31, a highly concentrated liquid toner T1 conveyed by a concentrated toner pump 25a, and a carrier conveyed from a carrier pump 25b. The concentration sensor 33 measures the concentration of the liquid toner T conveyed from the stirring tank 32 to a supply pan. The control device 34 controls the concentrated toner pump 25a and the carrier pump 25b based on the measurement results of the concentration sensor 33. The charge adjustment unit 35 is capable of removing the charge from the charged liquid toner.

FIG.2



EP 2 669 749 A1

Description

Field

[0001] The present invention relates to a liquid toner concentration sensor device, an electrophotographic printer, and a liquid toner concentration measurement method for measuring a liquid toner concentration.

Background

[0002] In the related art, a liquid toner concentration sensor can measure a liquid toner concentration by allowing a liquid toner to pass between an electrical conductive plate and a counterpart plate.

[0003] In Patent Literature 1, a liquid toner introduced to a developing unit is collected by a stirring tank, and a liquid toner concentration is measured by a capacitance-type concentration sensor. The liquid toner concentration is controlled to be maintained constant based on the measurement results of the liquid toner concentration.

Citation List

Patent Literature

[0004] Patent Literature 1: WO 2009/036504

Summary

Technical Problem

[0005] The liquid toner concentration sensor disclosed in Patent Literature 1 measures the amount of charge on a liquid toner to calculate the value of the liquid toner concentration from the relation between the liquid toner charge and the liquid toner concentration. However, the liquid toner is electrically charged when the liquid toner passes through a conveyance path or a collection path and is stirred by an impeller in a stirring tank. The charged liquid toner passes through a dispersion tank and is stirred in the stirring tank together with a new liquid toner. When the concentration of the charged liquid toner is measured by a capacitance-type liquid toner concentration sensor device, it may not be possible to accurately measure the liquid toner concentration due to the charge charged to the liquid toner.

[0006] In view of the above problem, an object of the present invention is to suppress a decrease in liquid toner concentration measurement accuracy.

Solution to Problem

[0007] According to an aspect of the present invention, a liquid toner concentration sensor device includes: a stirring tank to which a liquid toner collected from a developing unit and a new liquid toner are introduced and which is capable of stirring both of the liquid toners; a concentration sensor that measures a concentration of the liquid toner stirred in the stirring tank; and a charge adjustment unit that maintains an amount of charge on the stirred liquid toner at a predetermined value before the concentration sensor performs measurements.

[0008] Due to the above configuration, the liquid toner concentration sensor device according to the present invention can maintain the amount of charge on the liquid toner at a predetermined value. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

[0009] According to another aspect of the present invention, a liquid toner concentration sensor device includes: a dispersion tank to which a liquid toner collected from a developing unit is introduced; a stirring tank to which the liquid toner in the dispersion tank and a new liquid toner are introduced and which is capable of stirring both of the liquid toners; a concentration sensor that measures a concentration of the liquid toner stirred in the stirring tank; and a charge adjustment unit that maintains an amount of charge on the stirred liquid toner at a predetermined value before the concentration sensor performs measurements.

[0010] Due to the above configuration, the liquid toner concentration sensor device according to the present invention can maintain the amount of charge on the liquid toner at a predetermined value. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

[0011] Advantageously, in the liquid toner concentration sensor device, the charge adjustment unit includes a conductor that makes contact with the liquid toner.

[0012] Due to the above configuration, the liquid toner concentration sensor device according to the present invention can decrease the amount of charge on the charged liquid toner with high accuracy. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

[0013] Advantageously, in the liquid toner concentration sensor device, the charge adjustment unit includes a conductive wire for grounding the conductor.

[0014] Due to the above configuration, the liquid toner concentration sensor device according to the present invention can decrease the amount of charge on the charged liquid toner with high accuracy. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

[0015] Advantageously, in the liquid toner concentration sensor device, the charge adjustment unit has the conductor that is provided in a path of the liquid toner between the stirring tank and the concentration sensor.

[0016] Due to the above configuration, the liquid toner concentration sensor device according to the present invention can decrease the amount of charge on the charged liquid toner with high accuracy. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

[0017] Advantageously, in the liquid toner concentration sensor device, the charge adjustment unit has the conductor that is provided in the stirring tank.

[0018] Due to the above configuration, the liquid toner concentration sensor device according to the present invention can decrease the amount of charge on the charged liquid toner with high accuracy. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

[0019] Advantageously, in the liquid toner concentration sensor device, the charge adjustment unit has the conductor that is provided in an inlet of a conveying pump that conveys the liquid toner from the stirring tank.

[0020] Due to the above configuration, the liquid toner concentration sensor device according to the present invention can decrease the amount of charge on the charged liquid toner with high accuracy. Moreover, it is possible to reliably collect the charge on the charged liquid toner. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

[0021] Advantageously, in the liquid toner concentration sensor device, the charge adjustment unit has the conductor that is provided so as to cover the concentration sensor provided in the stirring tank.

[0022] Due to the above configuration, the liquid toner concentration sensor device according to the present invention can decrease the amount of charge on the charged liquid toner with high accuracy. Moreover, it is possible to reliably collect the charge on the charged liquid toner. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

[0023] Advantageously, in the liquid toner concentration sensor device, the charge adjustment unit includes the conductive wire for grounding a conductive portion of the circulation path of the liquid toner.

[0024] Due to the above configuration, the liquid toner concentration sensor device according to the present invention can remove the charge on the charged liquid toner even in a circulation path of the liquid toner. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

[0025] According to still another aspect of the present invention, an electrophotographic printer includes: a developing unit that transfers a liquid toner to a photosensitive member on which an electrostatic latent image is formed and develops the liquid toner; an intermediate transfer member that transfers the liquid toner developed by the developing unit; a pressing member that makes contact with the intermediate transfer member to form a nip portion and applies a voltage for transferring the liquid toner; and any one of the above liquid toner concentration sensor device.

[0026] Due to the above configuration, the electrophotographic printer according to the present invention can maintain the amount of charge on the liquid toner at a predetermined value. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

[0027] According to still another aspect of the present invention, a liquid toner concentration measurement method includes: stirring a liquid toner collected from a developing unit and a new liquid toner; maintaining an amount of charge on the stirred liquid toner at a predetermined value; and measuring a concentration of the liquid toner in which the amount of charge is maintained at the predetermined value.

[0028] Due to the above configuration, the liquid toner concentration measurement method according to the present invention can maintain the amount of charge on the liquid toner at a predetermined value. In this manner, when the concentration of a circulating liquid toner is measured, a decrease in the liquid toner concentration measurement accuracy can be suppressed.

Advantageous Effects of Invention

[0029] The present invention provides an advantageous effect of suppressing a decrease in liquid toner concentration measurement accuracy.

Brief Description of Drawings

[0030]

FIG. 1 is an explanatory diagram schematically illustrating an electrophotographic printer according to a first embodiment.
FIG. 2 is an explanatory diagram schematically illustrating a liquid toner concentration sensor device according to the first embodiment.
FIG. 3-1 is a diagram illustrating an output voltage of a concentration sensor when a liquid toner is circulated.
FIG. 3-2 is a diagram illustrating an adhering state of a charged liquid toner in a circulation path.
FIG. 4 is a diagram illustrating an output voltage of a concentration sensor when a charge adjustment unit is provided, and a liquid toner is circulated.
FIG. 5 is an explanatory diagram schematically illustrating a charge adjustment unit according to the first embodiment.
FIG. 6 is an explanatory diagram schematically illustrating a charge adjustment unit provided in a circulation path according to the first embodiment.
FIG. 7 is an explanatory diagram schematically illustrating a liquid toner concentration sensor device according to a second embodiment.
FIG. 8 is an explanatory diagram schematically illustrating a liquid toner concentration sensor device according to a third embodiment.
FIG. 9 is an explanatory diagram schematically illustrating a modification of the liquid toner concentration sensor device according to the third embodiment.

Description of Embodiments

[0031] Hereinafter, the present invention will be described in detail with reference to the drawings. However, the present invention is not limited to the following description. Components in the following description include those easily contemplated by a person skilled in the art, those substantially similar thereto, and those falling within the scope of equivalents. The components described herein can be appropriately combined with each other.

(First Embodiment)

[0032] FIG. 1 is an explanatory diagram schematically illustrating an electrophotographic printer according to a first embodiment. Hereinafter, an electrophotographic printer 10 according to the first embodiment will be described. The electrophotographic printer 10 is a liquid development electrophotographic printer. The electrophotographic printer 10 includes a feeder unit, a printing unit 11, and a delivery unit. For example, the feeder unit can feed printing sheets, which are cut papers, from a feeder tray to the printing unit one by one. The printing unit 11 can perform printing on one side or both sides of each supplied printing sheet. The delivery unit can deliver, to an delivery tray, the printing sheets simplex- or duplex-printed by the printing unit.

[0033] The electrophotographic printer 10 is configured to include the printing unit 11, an intermediate transfer member 12, a backup roller 13, developing units 14a, 14b, 14c, and 14d, a liquid toner supplying device 20, a cleaning device 40, a liquid toner collecting unit 50, and a solid content separation device 60. The developing units 14a, 14b, 14c, and 14d correspond to respective ink colors C (cyan), M (magenta), Y (yellow), and K (black).

[0034] The printing unit 11 performs printing using a liquid toner. The liquid toner T contains a carrier liquid, toner particles, and a small amount of charge accelerator. The toner particles are particles that contain a thermoplastic material and a coloring material (a pigment or a dye). The carrier liquid is a petroleum-based solvent. In the liquid toner, toner particles having an average diameter of approximately 1 μm to approximately 2 μm are contained in the carrier in a concentration of approximately 10% to approximately 40% by the weight ratio. Moreover, a viscosity (toner viscosity) of the liquid toner T is 10 cp (centipoise) to 120 cp, and particularly preferably, is 80 cp or smaller.

[0035] The intermediate transfer member 12 has a bias voltage difference in relation to a photosensitive drum 15 and faces the backup roller 13 at a nip portion N1. A blanket 12a is wound around an outer circumferential surface of the intermediate transfer member 12. In the first embodiment, the blanket 12a is a urethane-based conductive rubber.

[0036] The backup roller 13 is configured to apply predetermined pressure to the intermediate transfer member 12. A printing sheet S is conveyed between the backup roller 13 and the intermediate transfer member 12, and predetermined

nip pressure is applied to the printing sheet S. Since a bias voltage is applied to the backup roller 13, the voltage difference between the intermediate transfer member 12 and the backup roller 13 causes force to be applied to the liquid toner T in such a direction that the liquid toner is attracted from the intermediate transfer member 12 to the backup roller 13. In this manner, the liquid toner T is transferred from the intermediate transfer member 12 to the printing sheet S.

[0037] The developing units 14a, 14b, 14c, and 14d are arranged along the intermediate transfer member 12. In this embodiment, the developing unit 14a will be described in detail.

[0038] The developing unit 14a includes a photosensitive drum 15, a supply pan 16a, and liquid toner conveying rollers 16b. The photosensitive drum 15 has a photosensitive layer on an outer circumferential surface thereof and forms a nip portion N2 between the photosensitive drum 15 and the intermediate transfer member 12. The supply pan 16a is a container that stores the liquid toner T. The liquid toner conveying rollers 16b convey the liquid toner T from the supply pan 16a to the photosensitive drum 15.

[0039] The liquid toner supplying device 20 includes a concentrated toner tank 21, a concentrated toner pump 25a, a carrier tank 22, a carrier pump 25b, a liquid toner concentration sensor device 30, collecting blades 26, a liquid toner pump 25c, a collecting pump 25d, and a collecting pump 25e.

[0040] The concentrated toner tank 21 is a container that stores a liquid toner T1 having a higher concentration than a normal liquid toner T. When the high concentration liquid toner T1 becomes short, the concentrated toner tank 21 is supplied with the high concentration liquid toner T1 from a toner bottle 21a. The carrier tank 22 is a container for storing the carrier. When the volume of the carrier becomes short, the carrier tank 22 is supplied with carrier from a carrier can 22a.

[0041] The liquid toner concentration sensor device 30 includes a dispersion tank 31, a stirring tank 32, and a concentration sensor 33. The dispersion tank 31 is a container for storing the liquid toner T collected from the liquid toner conveying rollers 16b. Since the collected liquid toner T is a surplus liquid toner T that is not transferred from the photosensitive drum 15 to the intermediate transfer member 12, the proportion of the carrier therein is decreased from that before it is collected. Moreover, the liquid toner concentration is increased to 130% to 140% from that before it is collected.

[0042] The dispersion tank 31 can disperse the collected liquid toner T with an impeller 31a in the dispersion tank 31. The liquid toner T in the dispersion tank 31 overflows from the dispersion tank 31 and is conveyed to the stirring tank 32, for example.

[0043] The stirring tank 32 is a container that stores the high concentration liquid toner T1 supplied from the concentrated toner tank 21, the carrier supplied from the carrier tank 22, the liquid toner T supplied from the dispersion tank 31, and the liquid toner T collected from the supply pan 16a. Moreover, the liquid toner T collected from the liquid toner conveying rollers 16b may be stored directly in the stirring tank 32, not via the dispersion tank 31.

[0044] The concentrated toner pump 25a is a pump that conveys the high concentration liquid toner T1 from the concentrated toner tank 21 to the stirring tank 32. The carrier pump 25b is a pump that conveys the carrier from the carrier tank 22 to the stirring tank 32. The collecting pump 25d is a pump that conveys the surplus liquid toner T from the supply pan 16a to the stirring tank 32. The liquid toner pump 25c is a pump that conveys the stirred liquid toner T from the stirring tank 32 to the supply pan 16a.

[0045] The collecting blade 26 collects the surplus liquid toner T on the outer periphery of the liquid toner conveying rollers 16b. The surplus liquid toner T is a toner that is not transferred to the outer periphery of the photosensitive drum 15. The collecting pump 25e is a pump that conveys the liquid toner T collected from the collecting blade 26 to the stirring tank 32.

[0046] The concentration sensor 33 is provided in a conveying path between the stirring tank 32 and the supply pan 16a, for example. The concentration sensor 33 measures the concentration of the liquid toner T conveyed from the stirring tank 32 to the supply pan 16a. A control device 34 controls the concentrated toner tank 21 and the carrier tank 22 based on the measurement results of the concentration sensor 33 so that the concentration of the liquid toner T reaches a predetermined target concentration.

[0047] The developing units 14a, 14b, 14c, and 14d each include the concentrated toner tank 21, the concentrated toner pump 25a, the dispersion tank 31, the stirring tank 32, the liquid toner pump 25c, the collecting pump 25d, and the collecting pump 25e. In the first embodiment, the developing units 14a, 14b, 14c, and 14d share the carrier tank 22 and the carrier pump 25b. The carrier tank 22 and the carrier pump 25b may be provided in each developing unit.

[0048] The cleaning device 40 includes a carrier nozzle 41, a carrier pump 42, a collecting blade 43a, a first cleaning roller 44b, a collecting blade 43b, a second cleaning roller 44c, and a collecting blade 43c. The carrier nozzle 41 is disposed between the backup roller 13 and the photosensitive drum 15. The carrier nozzle 41 ejects the carrier conveyed from the carrier tank 22 to the intermediate transfer member 12. The carrier pump 42 is a pump that conveys the carrier from the carrier tank 22 to the carrier nozzle 41.

[0049] The first cleaning roller 44b and the collecting blade 43b are arranged between the photosensitive drum 15 of the developing unit 14b and the photosensitive drum 15 of the developing unit 14c. The first cleaning roller 44b is arranged to make contact with the intermediate transfer member 12 and collects the liquid toner T on the outer circumferential surface of the intermediate transfer member 12. Moreover, the collecting blade 43b collects the liquid toner T on the

outer circumferential surface of the first cleaning roller 44b.

[0050] The second cleaning roller 44c and the collecting blade 43c are arranged between the backup roller 13 and the photosensitive drum 15 of the developing unit 14d. The second cleaning roller 44c is arranged to make contact with the intermediate transfer member 12 and collects the liquid toner T on the outer circumferential surface of the intermediate transfer member 12. Moreover, the collecting blade 43c collects the liquid toner T on the outer circumferential surface of the second cleaning roller 44c.

[0051] The collecting blade 43a is arranged to make contact with the intermediate transfer member 12. The collecting blade 43a collects the liquid toner T on the outer circumferential surface of the intermediate transfer member 12. This liquid toner T is diluted with the carrier discharged from the carrier nozzle 41 to the intermediate transfer member 12.

[0052] The liquid toner collecting unit 50 includes a liquid toner collecting pump 51a, a liquid toner collecting pump 51b, and a liquid toner collecting pump 51c. The liquid toner collecting pump 51a is arranged between the collecting blade 43a and the solid content separation device 60. The liquid toner collecting pump 51b is arranged between the collecting blade 43b and the solid content separation device 60. The liquid toner collecting pump 51c is arranged between the collecting blade 43c and the solid content separation device 60.

[0053] The liquid toner collecting pump 51a conveys the liquid toner T collected from the carrier nozzle 41 to the solid content separation device 60. The solid content separation device 60 is a device that is mainly configured to collect the surplus liquid toner T to separate the carrier from the liquid toner T. The solid content separation device 60 accelerates separation between the toner as a solid content included in the conveyed liquid toner T and the carrier as a liquid. The liquid toner collecting pump 51b conveys, to the solid content separation device 60, the liquid toner T that the collecting blade 43b collects from the first cleaning roller 44b.

[0054] The electrophotographic printer 10 illustrated in FIG. 1 recycles the carrier separated by the solid content separation device 60. In the first embodiment, a recycled carrier supply pump 17 is arranged between the solid content separation device 60 and the carrier tank 22. The recycled carrier supply pump 17 conveys the carrier separated by the solid content separation device 60 to the carrier tank 22. The liquid toner concentration sensor device 30 will be described in detail below.

[0055] FIG. 2 is an explanatory diagram schematically illustrating the liquid toner concentration sensor device according to the first embodiment. The liquid toner concentration sensor device 30 includes the dispersion tank 31, the stirring tank 32, the concentration sensor 33, the control device 34, and a charge adjustment unit 35. The charge adjustment unit 35 is configured to maintain the amount of charge on the liquid toner T at a predetermined value.

[0056] As described above, the stirring tank 32 is a container that stores the liquid toner T conveyed from the dispersion tank 31, the high concentration liquid toner T1 conveyed by the concentrated toner pump 25a, and the carrier conveyed from the carrier pump 25b. Moreover, a stirring plate 38 is arranged in the stirring tank 32 so as to stir the liquid stored in the stirring tank 32.

[0057] The liquid toner pump 25c conveys the liquid toner T stirred in the stirring tank 32 to the supply pan 16a. The concentration sensor 33 is arranged, for example, between the liquid toner pump 25c and the supply pan 16a so as to measure the concentration of the conveyed liquid toner T. The concentration sensor 33 may be arranged between the liquid toner pump 25c and the stirring tank 32. In the first embodiment, the concentration sensor 33 is a capacitance-type concentration sensor.

[0058] The capacitance-type concentration sensor measures a capacitance between two mutually insulated plates facing each other with a fixed gap by allowing a measurement target liquid toner to pass between the plates. For example, the liquid toner concentration can be obtained from the measurement results of the capacitance using a calibration curve.

[0059] The control device 34 controls the concentrated toner pump 25a and the carrier pump 25b based on the measurement results of the concentration sensor 33. The control device 34 causes the concentrated toner pump 25a to convey the high concentration liquid toner T1 from the concentrated toner tank 21 to the stirring tank 32. Moreover, the control device 34 also causes the carrier pump 25b to convey the carrier from the carrier tank 22 to the stirring tank 32.

[0060] The liquid toner T is electrically charged due to friction or the like when it passes through the circulation path of the liquid toner T. Moreover, the liquid toner T is also electrically charged due to friction with the stirring plate 38 when it is stirred by the stirring plate 38 arranged in the stirring tank 32.

[0061] FIG. 3-1 is a diagram illustrating an output voltage of the concentration sensor when the liquid toner T is circulated. The output results indicated by the concentration sensor 33 are obtained by circulating the liquid toner T along a circulation path formed by the stirring tank 32, the concentration sensor 33, the liquid toner pump 25c, the concentrated toner pump 25a, and the carrier pump 25b. The concentration sensor 33 converts the measured capacitance of the liquid toner T into a voltage V and outputs the voltage V. Since the circulating liquid toner T is negatively charged with time due to friction in the circulation path, the output voltage V of the concentration sensor 33 decreases with time.

[0062] Here, the voltage V output by the concentration sensor 33 increases as the capacitance of the liquid toner T increases. Moreover, the capacitance of the liquid toner T increases as the liquid toner concentration of the liquid toner T increases. Thus, the voltage V output by the concentration sensor 33 increases when the liquid toner concentration of the liquid toner T increases, and the voltage V output by the concentration sensor 33 decreases when the liquid toner

concentration of the liquid toner T decreases. When the liquid toner T is charged (in this example, with negative charge), the capacitance thereof detected by the capacitance concentration sensor 33 is lower than its actual capacitance. As a result, even if the liquid toner T has the same liquid toner concentration, the liquid toner concentration measured by the concentration sensor 33 when the liquid toner T is charged is lower than that measured when the liquid toner T is not charged.

[0063] The liquid toner concentration of the liquid toner T may not change generally just because it circulates in the circulation path. However, if the liquid toner T is charged after circulating in the circulation path, the liquid toner concentration of the liquid toner T measured by the concentration sensor 33 is lower than the actual value. Thus, the control device 34 that has acquired the liquid toner concentration of the liquid toner T measured by the concentration sensor 33 may perform control so as to increase the liquid toner concentration of the circulating liquid toner T.

[0064] The voltage V output by the concentration sensor 33 begins to approach a certain value after it decreases with time. Since the amount of charge that can be charged on the liquid toner T itself has an upper limit, the amount of charge on the liquid toner T enters a saturation state with time.

[0065] FIG. 3-2 is a diagram illustrating an adhering state of the charged liquid toner in the circulation path. The charged liquid toner T adheres to the circulation path due to electrostatic force. In particular, as in FIG. 3-2, portions of the circulation path to which the liquid toner T adheres include an inner circumferential surface of the stirring tank 32 and an inlet of a liquid toner conveying tube 36 that conveys the liquid toner T from the stirring tank 32 to the concentration sensor 33. Since a solid content Ta of the charged liquid toner T adheres to the conveying path, the solid content included in the liquid toner T decreases.

[0066] FIG. 4 is a diagram illustrating the output voltage of the concentration sensor when a charge adjustment unit is provided, and the liquid toner T is circulated. The output results indicated by the concentration sensor 33 are obtained by circulating the liquid toner T through a circulation path formed by the stirring tank 32, the concentration sensor 33, the liquid toner pump 25c, the concentrated toner pump 25a, the carrier pump 25b, and the charge adjustment unit 35. The charge adjustment unit 35 of the first embodiment is configured to remove the charge (negative charge in the present embodiment) on the charged liquid toner T.

[0067] In this example, the negative charge on the charged liquid toner T is removed by the charge adjustment unit 35. Thus, the output voltage V of the concentration sensor 33 becomes approximately constant regardless of time. By providing the charge adjustment unit 35 in a region upstream of a region where the liquid toner concentration is measured by the concentration sensor 33, the concentration sensor 33 can measure the capacitance of the liquid toner T without being affected by charge. Therefore, it is possible to prevent the measured liquid toner concentration of the liquid toner T from becoming lower than the actual value. As a result, the concentration sensor 33 can suppress a decrease in the liquid toner concentration measurement accuracy due to the influence of the charge charged to the liquid toner T. Moreover, in the present embodiment, it is possible to suppress the control device 34 that has acquired the liquid toner concentration of the liquid toner T measured by the concentration sensor 33 from performing control so as to excessively increase the liquid toner concentration.

[0068] FIG. 5 is an explanatory diagram schematically illustrating a charge adjustment unit according to the first embodiment. The charge adjustment unit 35 includes a conductor 35a that makes contact with the charged liquid toner T and a conductive wire 35b for grounding the conductor 35a. In the first embodiment, grounding of the conductor 35a means that the conductor 35a is electrically connected to a reference potential point (for example, a metallic housing or a metallic frame of the electrophotographic printer 10) in the electrophotographic printer 10 by the conductive wire 35b and that the conductor 35a is electrically connected to the ground by the conductive wire 35b. The conductor 35a making contact with the charged liquid toner T is a metal or a conductive plastic, for example.

[0069] The conductor 35a can be wound to cover the inlet of the liquid toner pump 25c that conveys the liquid toner T from the stirring tank 32 to the concentration sensor 33, for example. When the conductor 35a is a metal mesh, if the metal mesh is wound to cover the inlet of the liquid toner conveying tube 36, the area in which the charge on the charged liquid toner T is collected increases. Therefore, the charge can be efficiently removed from the liquid toner T. By connecting the conductive wire 35b to the conductor 35a to realize grounding, the charge charged to the liquid toner T can be removed. For example, when the conductive wire 35b is connected to the ground, the charge charged to the liquid toner T is allowed to escape to the ground, whereby the charge can be removed from the liquid toner T. The charge adjustment unit 35 is not limited to the above-described configuration as long as the conductor 35a is provided in the path of the liquid toner T between the stirring tank 32 and the concentration sensor 33.

[0070] FIG. 6 is an explanatory diagram schematically illustrating a charge adjustment unit provided in a circulation path according to the first embodiment. A charge adjustment unit 35A includes a conductive wire 35b for grounding conductive portions in the circulation path in which the liquid toner T circulates. The conductive wire 35b that constitutes the charge adjustment unit 35A may be provided in any conductive portion in the circulation path. For example, in the example illustrated in FIG. 6, the conductive wire 35b is connected to the dispersion tank 31, the impeller 31a of the dispersion tank 31, the stirring tank 32, the liquid toner conveying tube 36, and the stirring plate 38 that have conductive properties, to thereby realize grounding. By connecting a conductive portion in the circulation path and the ground or a

reference potential point of the electrophotographic printer 10 by the conductive wire 35b, the charge charged to the liquid toner T can be removed from the liquid toner T. Moreover, by connecting a plurality of conductive portions in the circulation path and the ground or the reference potential point of the electrophotographic printer 10 by the conductive wire 35b, the charge charged to the liquid toner T can be allowed to escape to the ground or the like from the plurality of portions. As a result, a state where the liquid toner T is not charged in the entire circulation path can be created. Moreover, the grounding may be realized by winding the conductor 35a to cover the inlet of the liquid toner conveying tube 36 to be electrically connected to the conductive portion in the circulation path.

[0071] A liquid toner concentration measurement method according to the present embodiment is executed in the following steps. First, the stirring plate 38 executes a step of stirring the liquid toner T conveyed from the dispersion tank 31 and the high concentration liquid toner T1 conveyed by the concentrated toner pump 25a in the stirring tank 32. Subsequently, the charge adjustment unit 35 in the circulation path executes a step of maintaining the amount of charge on the stirred liquid toner T to a predetermined value. Moreover, the concentration sensor 33 executes a step of measuring the concentration of the liquid toner T maintained at a predetermined value. The control device 34 controls the concentration of the circulating liquid toner T based on the concentration of the liquid toner T measured by the concentration sensor 33.

[0072] In the present embodiment, before the concentration sensor 33 performs measurements, the amount of charge on the stirred liquid toner is maintained at a predetermined value (0 in the present embodiment). By doing so, since the amount of charge on the liquid toner circulating in the circulation path becomes 0, it is possible to suppress a decrease in the liquid toner concentration measurement accuracy due to the influence of the charge charged to the liquid toner even when a capacitance-type concentration sensor is used. The configuration according to the first embodiment can be appropriately applied to the following embodiments.

(Second Embodiment)

[0073] FIG. 7 is an explanatory diagram schematically illustrating a liquid toner concentration sensor device according to a second embodiment. A liquid toner concentration sensor device 30 includes a dispersion tank 31, a stirring tank 32, a concentration sensor 33, a control device 34, and a charge adjustment unit 35B. The stirring tank 32 may directly store the liquid toner T collected from the liquid toner conveying rollers 16b, not via the dispersion tank 31. Moreover, the charge adjustment unit 35B applies charge so that the amount of charge on the charged liquid toner T is equalized. The charge adjustment unit 35B uses a constant voltage power source 37, for example. The constant voltage power source 37 is configured to apply charge to the liquid toner T so that the amount of charge on the liquid toner T is maintained at a predetermined value.

[0074] The constant voltage power source 37 includes a power source 37a that applies a voltage and electrodes 37b electrically connected to the power source 37a. The constant voltage power source 37 is a device that generates a constant DC voltage. The charge adjustment unit 35B has the electrodes 37b and 37b that are disposed in the stirring tank 32 so as to be connected to positive and negative electrodes of the power source 37a, respectively. Moreover, the electrodes 37b and 37b are brought into contact with the charged liquid toner T in the stirring tank 32 so that a DC voltage is applied to the liquid toner T present between the electrodes 37b and 37b. In this manner, charge is applied to the liquid toner T in the stirring tank 32.

[0075] Since the constant voltage power source 37 of the charge adjustment unit 35B generates a constant DC voltage, when the electrodes 37b and 37b are brought into contact with the liquid toner T in the stirring tank 32, the same amount of charge can be charged to the liquid toner T present between the electrodes 37b and 37b. Moreover, since the liquid toner T is stirred in the stirring tank 32 and is applied with the charge from the power source 37a of the charge adjustment unit 35B, the amount (that is, an electric charge amount) of charge charged to the liquid toner T in the stirring tank 32 can be maintained at a predetermined value regardless of time.

[0076] In the second embodiment, the concentration sensor 33 measures the concentration of the charged liquid toner T. Thus, it is preferable to obtain the liquid toner concentration by obtaining the relation between the amount (for example, a saturation charge amount) of charge charged to the liquid toner T and the liquid toner concentration and correcting the liquid toner concentration measured by the concentration sensor 33 based on the relation. In the present embodiment, since charge is applied from the power source 37a of the charge adjustment unit 35B to the liquid toner T, the concentration sensor 33 can measure the capacitance of the liquid toner T in a state where the amount of charge charged to the liquid toner T is constant regardless of time. By doing so, it is possible to prevent the liquid toner concentration of the liquid toner T measured by the concentration sensor 33 from becoming lower than the actual value. As a result, in the present embodiment, it is possible to suppress the control device 34 that has acquired the liquid toner concentration of the liquid toner T measured by the concentration sensor 33 from performing control so as to excessively increase the liquid toner concentration.

[0077] In the present embodiment, before the concentration sensor performs measurements, the amount of charge on the stirred liquid toner is maintained at a predetermined value (a value other than 0 in the present embodiment). By

doing so, since the amount of charge charged to the liquid toner circulating in the circulation path can be maintained to be constant regardless of time, it is possible to maintain the influence of the charge charged to the liquid toner to be constant regardless of time even when a capacitance-type concentration sensor is used. As a result, in the present embodiment, it is possible to suppress a decrease in the liquid toner concentration measurement accuracy. The configuration according to the second embodiment can be appropriately applied to the following embodiments.

(Third Embodiment)

[0078] FIG. 8 is an explanatory diagram schematically illustrating a liquid toner concentration sensor device according to a third embodiment. A liquid toner concentration sensor device 30 includes a dispersion tank 31, a stirring tank 32, a concentration sensor 33, a control device 34, and charge adjustment units 35 and 35B. The stirring tank 32 may directly store the liquid toner T collected from the liquid toner conveying rollers 16b, not via the dispersion tank 31. The concentration sensor 33 is provided in the stirring tank 32. For example, the concentration sensor 33 is provided between the stirring plate 38 and a central rotating shaft of the stirring plate 38 when the stirring plate 38 stirs the inside of the stirring tank 32. The liquid toner T in the stirring tank 32 is conveyed to the liquid toner conveying tube 36 through the concentration sensor 33.

[0079] FIG. 9 is an explanatory diagram schematically illustrating a modification of the liquid toner concentration sensor device according to the third embodiment. The configuration of the liquid toner concentration sensor device 30 is the same as that of FIG. 8. The concentration sensor 33 is provided in the stirring tank 32, but is not provided in the circulation path of the liquid toner T. The liquid toner T in the stirring tank 32 is conveyed from the stirring tank 32 to the liquid toner pump 25C through the liquid toner conveying tube 36. For example, the concentration sensor 33 is provided between the stirring plate 38 and a central rotating shaft of the stirring plate 38 when the stirring plate 38 stirs the inside of the stirring tank 32. The concentration sensor 33 measures the concentration of the liquid toner T using the flow of the liquid toner T generated along the central shaft of the stirring tank 32.

[0080] Similarly to the first embodiment, the charge adjustment unit 35 includes a conductor 35a that makes contact with the charged liquid toner T and a conductive wire 35b for grounding the conductor 35a. In this modification, the conductor 35a is provided in the stirring tank 32. More specifically, the conductor 35a is wound to cover the concentration sensor 33 provided in the stirring tank 32, for example. That is, the conductor 35a surrounds the concentration sensor 33 provided in the stirring tank 32. When the concentration sensor 33 is not provided in the circulation path of the liquid toner T, the conductor 35a may be wound (surround) to cover the concentration sensor 33 provided in the stirring tank 32 and the inlet of the liquid toner pump 25c that conveys the liquid toner T from the stirring tank 32 to the concentration sensor 33. When the conductor 35a is a metal mesh, since the area in which the charge on the charged liquid toner T is collected increases, the charge can be efficiently removed from the liquid toner T. By connecting the conductive wire 35b to the conductor 35a to realize grounding, the charge charged to the liquid toner T can be removed. For example, when the conductive wire 35b is connected to the ground, the charge charged to the liquid toner T is allowed to escape to the ground, whereby the charge can be removed from the liquid toner T.

[0081] Similarly to the second embodiment, the charge adjustment unit 35B applies charge so that the amount of charge on the charged liquid toner T is equalized. The charge adjustment unit 35B uses a constant voltage power source 37, for example. The constant voltage power source 37 is configured to apply charge to the liquid toner T so that the amount of charge on the liquid toner T is maintained at a predetermined value. The constant voltage power source 37 includes a power source 37a that applies a voltage and electrodes 37b electrically connected to the power source 37a.

[0082] The electrodes 37b are provided in the stirring tank 32. For example, similarly to the concentration sensor 33, the electrodes 37b are provided between the stirring plate 38 and a central rotating shaft of the stirring plate 38 when the stirring plate 38 stirs the inside of the stirring tank 32. The electrodes 37b may be provided at a position opposite to the concentration sensor 33 about the central rotating shaft of the stirring plate 38 and may be provided at the same position as the concentration sensor 33.

[0083] In the third embodiment, even when the concentration sensor 33 is provided in the stirring tank 32, the amount of charge on the stirred liquid toner T can be maintained at a predetermined value (a value other than 0 in the present embodiment) before the liquid toner concentration of the charged liquid toner T is measured. Either one of the charge adjustment units 35 and 35B may be provided, and a new charge adjustment unit 35A may be provided in the circulation path.

Reference Signs List

[0084]

10	ELECTROPHOTOGRAPHIC PRINTER
11	PRINTING UNIT

12	INTERMEDIATE TRANSFER MEMBER
12a	BLANKET
13	BACKUP ROLLER
14a, 14b, 14c, 14d	DEVELOPING UNIT
15	PHOTOSENSITIVE DRUM
16a	SUPPLY PAN
16b	LIQUID TONER CONVEYING ROLLER
17	RECYCLED CARRIER SUPPLY PUMP
20	LIQUID TONER SUPPLYING DEVICE
21	CONCENTRATED TONER TANK
21a	TONER BOTTLE
22	CARRIER TANK
22a	CARRIER CAN
25a	CONCENTRATED TONER PUMP
25b	CARRIER PUMP
25c	LIQUID TONER PUMP
25d	COLLECTING PUMP
25e	COLLECTING PUMP
26	COLLECTING BLADE
30	LIQUID TONER CONCENTRATION SENSOR DEVICE
31	DISPERSION TANK
31a	IMPELLER
32	STIRRING TANK
33	CONCENTRATION SENSOR
34	CONTROL DEVICE
35	CHARGE ADJUSTMENT UNIT
35a	CONDUCTOR
35b	CONDUCTIVE WIRE
36	LIQUID TONER CONVEYING TUBE
37	CONSTANT VOLTAGE POWER SOURCE
37a	POWER SOURCE
37b	ELECTRODE
38	STIRRING PLATE
41	CARRIER NOZZLE
42	CARRIER PUMP
43a, 43b, 43c	COLLECTING BLADE
44b	FIRST CLEANING ROLLER
44c	SECOND CLEANING ROLLER
50	LIQUID TONER COLLECTING UNIT
51a, 51b, 51c	LIQUID TONER COLLECTING PUMP
60	SOLID CONTENT SEPARATION DEVICE

Claims

1. A liquid toner concentration sensor device comprising:

a stirring tank to which a liquid toner collected from a developing unit and a new liquid toner are introduced and which is capable of stirring both of the liquid toners;
a concentration sensor that measures a concentration of the liquid toner stirred in the stirring tank; and
a charge adjustment unit that maintains an amount of charge on the stirred liquid toner at a predetermined value before the concentration sensor performs measurements.

2. A liquid toner concentration sensor device comprising:

a dispersion tank to which a liquid toner collected from a developing unit is introduced;
a stirring tank to which the liquid toner in the dispersion tank and a new liquid toner are introduced and which is capable of stirring both of the liquid toners;

a concentration sensor that measures a concentration of the liquid toner stirred in the stirring tank; and
a charge adjustment unit that maintains an amount of charge on the stirred liquid toner at a predetermined value before the concentration sensor performs measurements.

3. The liquid toner concentration sensor device according to claim 1 or 2, wherein
the charge adjustment unit includes a conductor that makes contact with the liquid toner.

4. The liquid toner concentration sensor device according to claim 3, wherein
the charge adjustment unit includes a conductive wire for grounding the conductor.

5. The liquid toner concentration sensor device according to claim 3 or 4, wherein
the charge adjustment unit has the conductor that is provided in a path of the liquid toner between the stirring tank and the concentration sensor.

6. The liquid toner concentration sensor device according to claim 5, wherein
the charge adjustment unit has the conductor that is provided in the stirring tank.

7. The liquid toner concentration sensor device according to claim 5, wherein
the charge adjustment unit has the conductor that is provided in an inlet of a conveying pump that conveys the liquid toner from the stirring tank.

8. The liquid toner concentration sensor device according to claim 5, wherein
the charge adjustment unit has the conductor that is provided so as to cover the concentration sensor provided in the stirring tank.

9. The liquid toner concentration sensor device according to claim 1 or 2, wherein
the charge adjustment unit includes a conductive wire for grounding a conductive portion of the circulation path of the liquid toner.

10. An electrophotographic printer comprising:

a developing unit that transfers a liquid toner to a photosensitive member on which an electrostatic latent image is formed and develops the liquid toner;
an intermediate transfer member that transfers the liquid toner developed by the developing unit;
a pressing member that makes contact with the intermediate transfer member to form a nip portion and applies a voltage for transferring the liquid toner; and
the liquid toner concentration sensor device according to any one of claims 1 to 9.

11. A liquid toner concentration measurement method comprising:

stirring a liquid toner collected from a developing unit and a new liquid toner;
maintaining an amount of charge on the stirred liquid toner at a predetermined value; and
measuring a concentration of the liquid toner in which the amount of charge is maintained at the predetermined value.

FIG.1

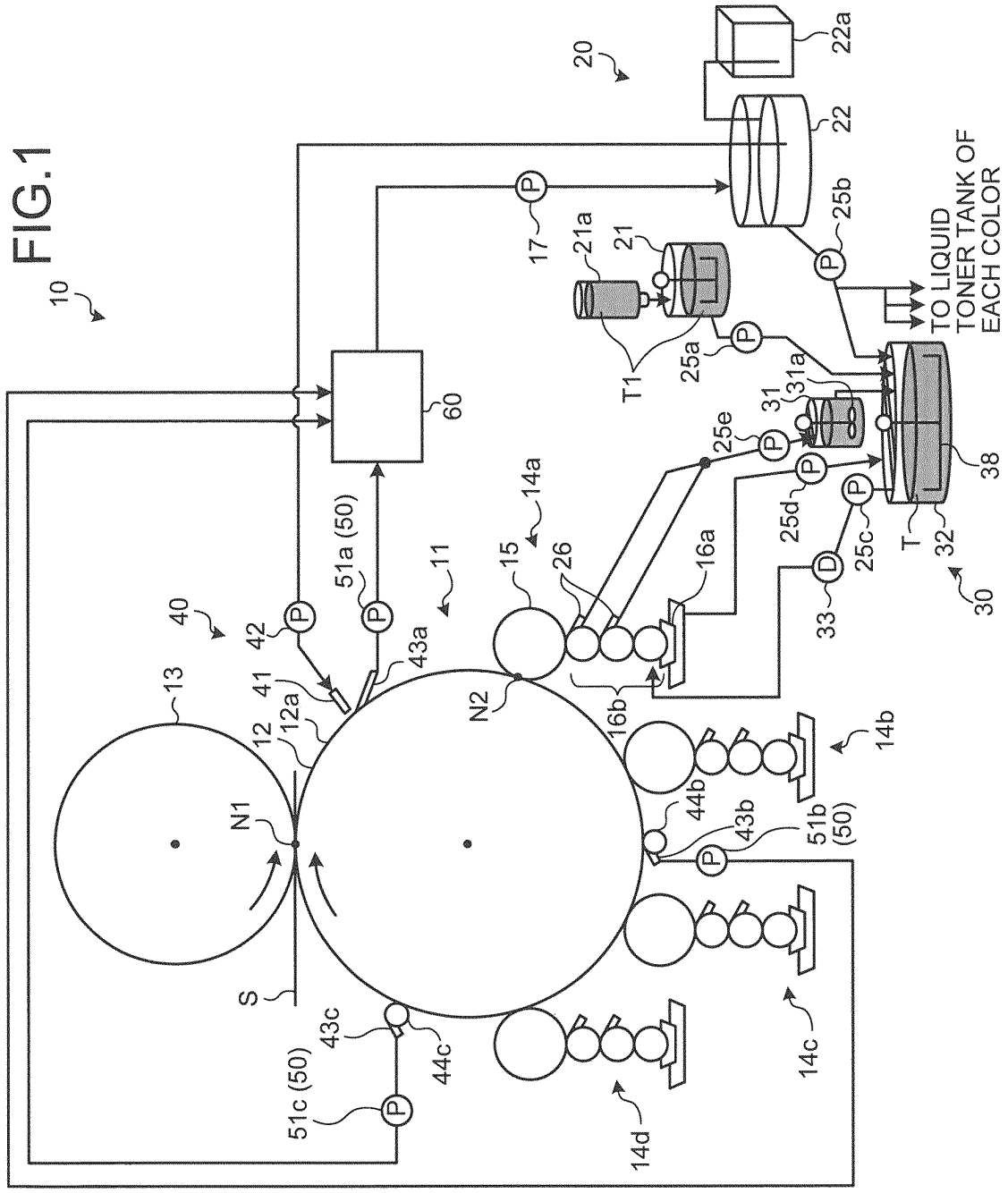

10
20
22a
22
25b
TO LIQUID TONER TANK OF EACH COLOR
17
21a
21
T1
25a
31a
31
25e
38
60
14a
15
26
16a
25d
25c
T
32
30
33
51a (50)
11
40
42
43a
41
12a
12
13
N2
16b
14b
44b
43b
51b (50)
N1
S
43c
44c
51c (50)
14d
14c

FIG.2

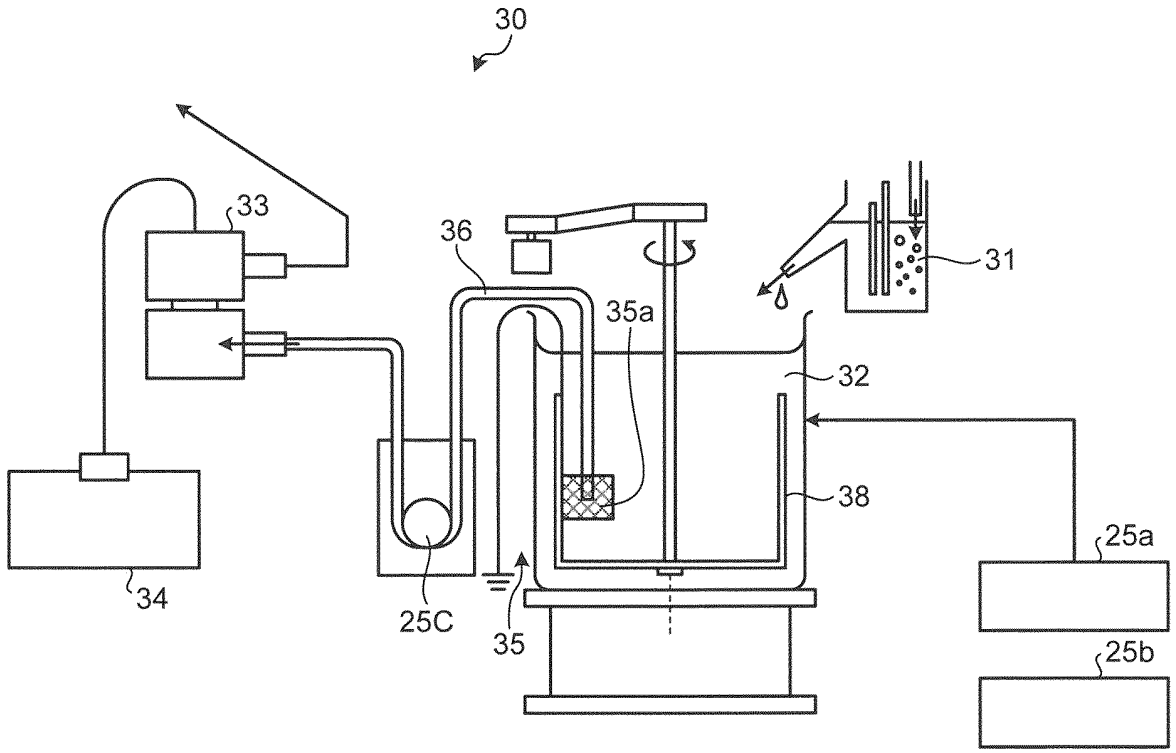


FIG.3A

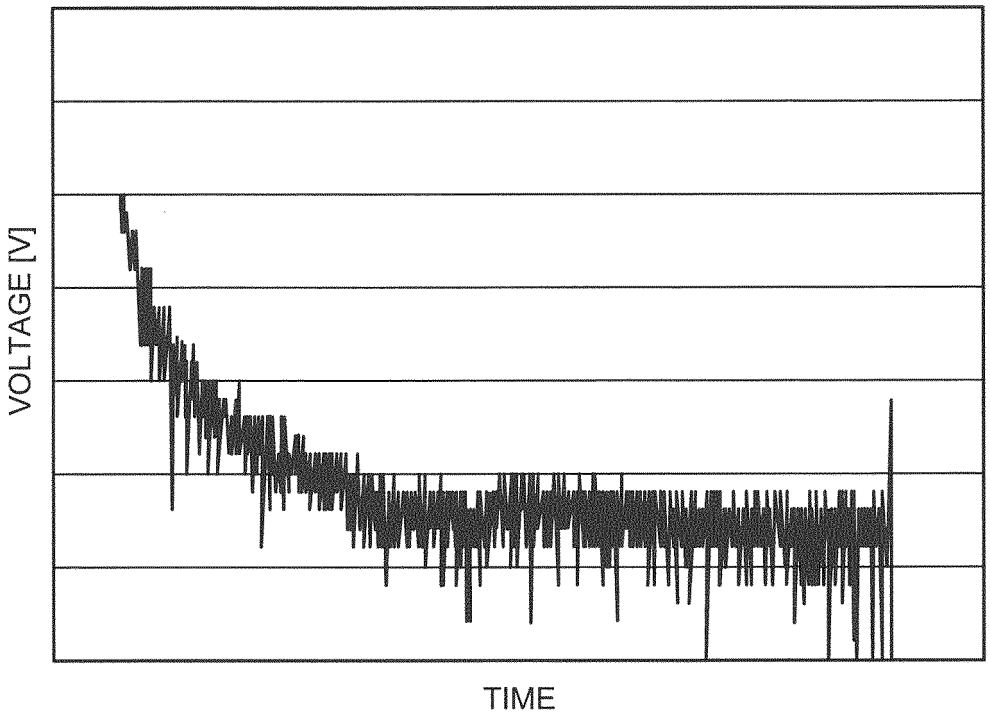


FIG.3B

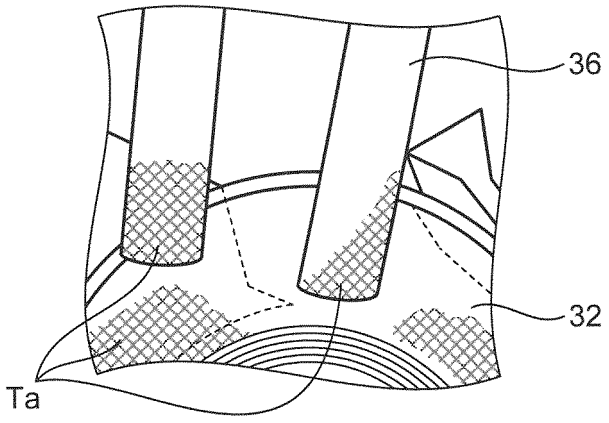


FIG.4

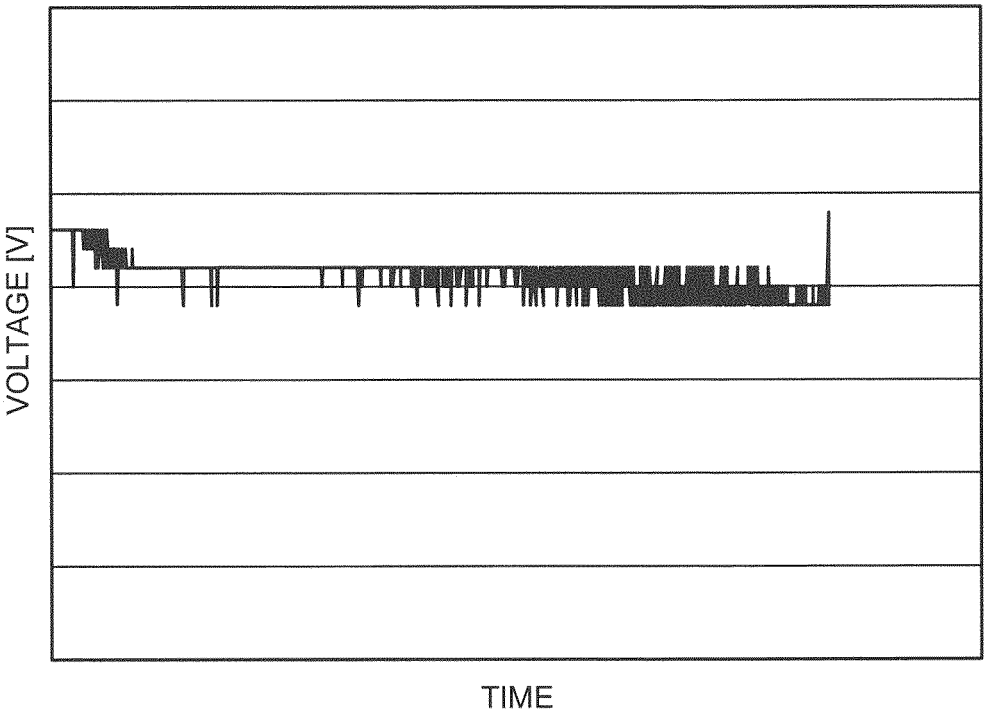


FIG.5

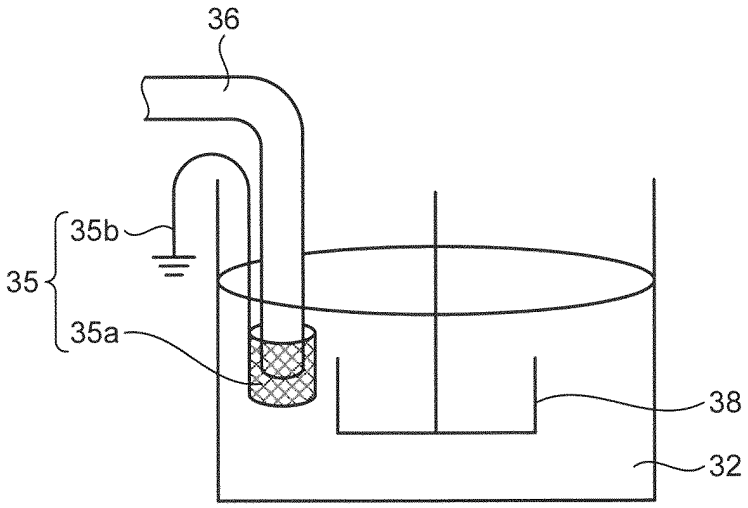


FIG.6

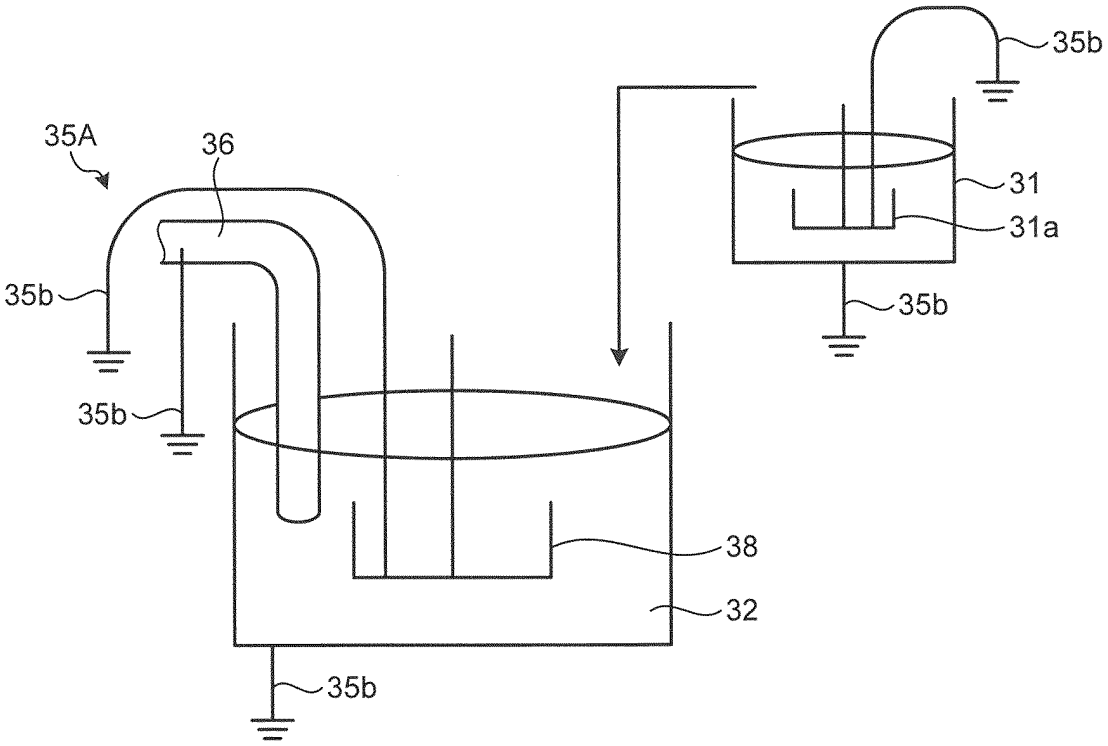


FIG.7

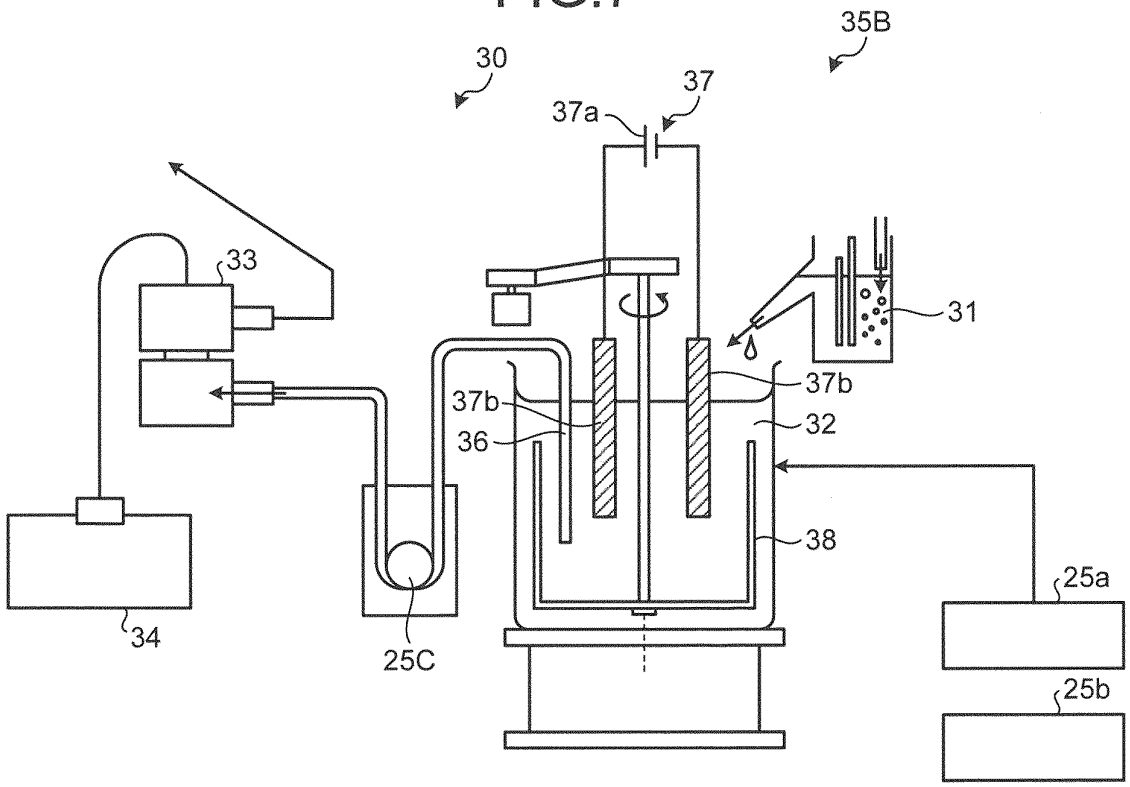

35B
30
37
37a
33
31
37b
37b
36
32
38
34
25C
25a
25b

FIG.8

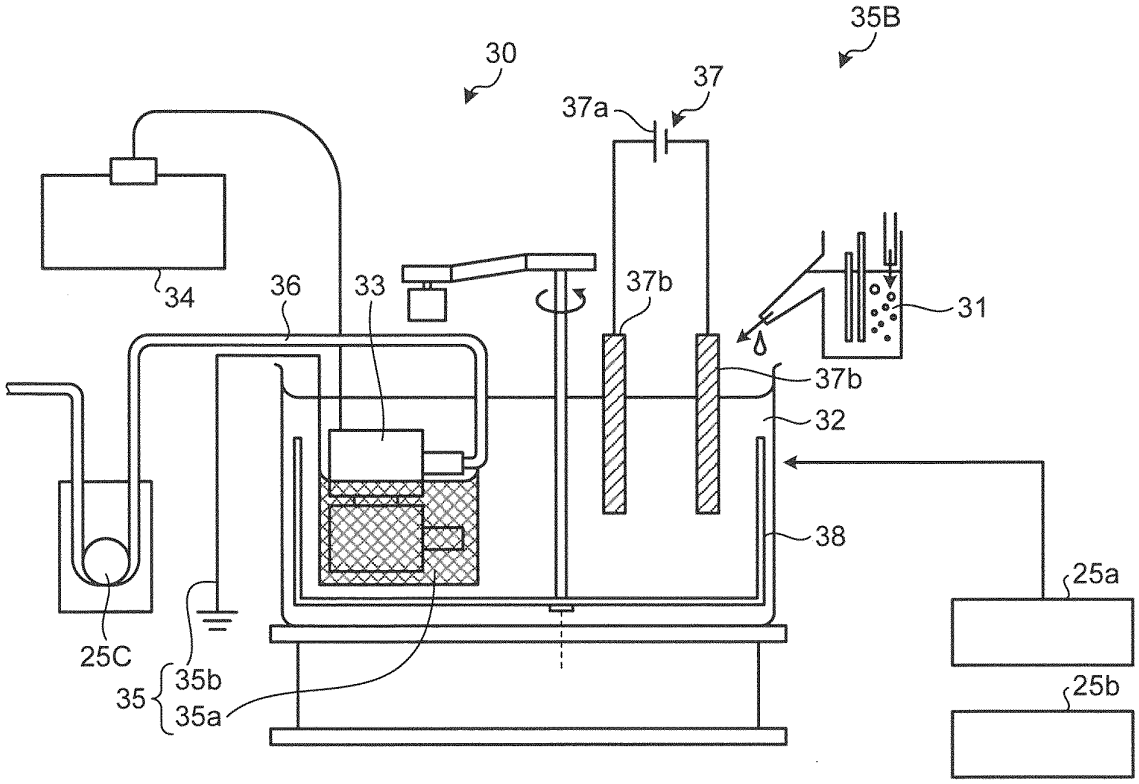
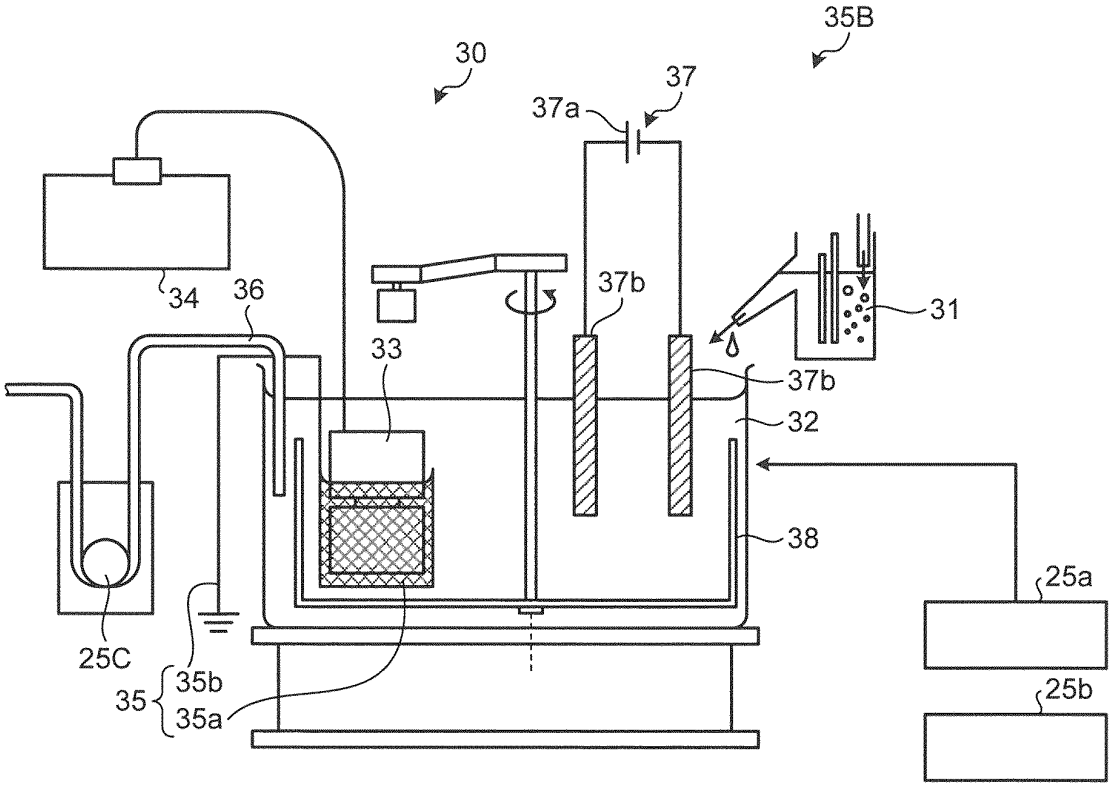

35B
30
37
37a
34
36
33
37b
31
37b
32
38
25C
35
35b
35a
25a
25b

FIG.9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/051368

A. CLASSIFICATION OF SUBJECT MATTER
G03G15/11(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G03G15/10-15/11, G01N27/22, G01R27/26

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006-099047 A (Kyocera Mita Corp.), 13 April 2006 (13.04.2006), paragraphs [0048], [0055] to [0057], [0064] (Family: none)	1-11
A	WO 2009/036504 A1 (RESEARCH LABORATORIES OF AUSTRALIA PTY LTD.), 26 March 2009 (26.03.2009), page 6, lines 16 to 24; page 8, lines 1 to 21 (Family: none)	1-11
A	JP 2003-050511 A (Ricoh Co., Ltd.), 21 February 2003 (21.02.2003), paragraphs [0015] to [0017], [0031] to [0038] & US 2003/0016962 A1	1-11

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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
04 April, 2012 (04.04.12)	17 April, 2012 (17.04.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/051368

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 05-188785 A (Mitsubishi Heavy Industries, Ltd.), 30 July 1993 (30.07.1993), paragraphs [0006] to [0008] (Family: none)	1-11
A	JP 11-326254 A (NEC Niigata, Ltd.), 26 November 1999 (26.11.1999), paragraph [0004] & US 6128450 A1	1-11

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2009036504 A **[0004]**