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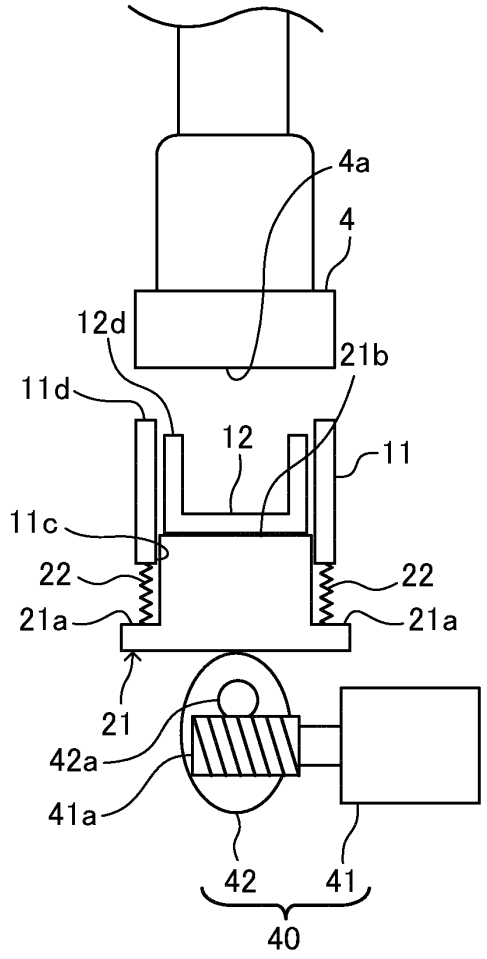
(54) MAINTENANCE DEVICE, LIQUID DISCHARGE DEVICE, AND LIQUID DISCHARGE APPARATUS

(57) A maintenance device (10) includes a moisturizing cap (11) and a suction cap (12). The moisturizing cap (11) contacts a discharge face (4a) of a liquid discharge head (4) with a first capping end (11d). The suction cap (12) is disposed inside the moisturizing cap (11). The suction cap (12) contacts the discharge face (4a) with a second capping end (12d) to suck a liquid from a discharge port (4c) in the discharge face (4a).

FIG. 3



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Description

BACKGROUND

Technical Field

[0001] Embodiments of the present disclosure relate to a maintenance device, a liquid discharge device, and a liquid discharge apparatus.

Related Art

[0002] As known in the art, a maintenance device includes a moisturizing cap and a suction cap. The moisturizing cap contacts a discharge face in which a discharge port is disposed to retain moisture of a liquid in the discharge port. The liquid is discharged from the discharge port. The suction cap is disposed in the moisturizing cap and contacts the discharge face to suck the liquid from the discharge port. When the moisturizing cap retains the moisture of the liquid in the discharge port, the suction cap is moved to a separated position away from the discharge face to be on standby. When the suction cap sucks the liquid from the discharge port, the suction cap is moved relative to the moisturizing cap so that the suction cap is in contact with the discharge face.

[0003] Japanese Unexamined Patent Application Publication No. 2010-058268 discloses a maintenance device including the moisturizing cap that contacts the discharge face facing downward to retain moisture of a liquid in the discharge port, and the suction cap disposed in the moisturizing cap. A suction cam as a mover for suction that raises and lowers the suction cap relative to the moisturizing cap is disposed in the moisturizing cap. A moisture-retention cam as a mover for moisture-retention raises the moisturizing cap to cap the discharge face with the moisturizing cap and retain the moisture of the liquid in the discharge port. The suction cam raises the suction cap relative to the moisturizing cap to cap the discharge face with the suction cap and suck the liquid from the discharge port.

[0004] However, the maintenance device described above may increase the number of components and the mechanical complexity, causing the device cost to increase.

SUMMARY

[0005] Embodiments of the present disclosure describe an improved maintenance device that includes a moisturizing cap and a suction cap. The moisturizing cap contacts a discharge face of a liquid discharge head with a first capping end. The suction cap is disposed inside the moisturizing cap. The suction cap contacts the discharge face with a second capping end to suck a liquid from a discharge port in the discharge face.

[0006] As a result, according to the present disclosure, the number of components of the maintenance device can be reduced, and the configuration of the maintenance device can be simplified, thereby reducing the device cost.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0007] A more complete appreciation of the disclosure and many of the attendant advantages and features thereof can be readily obtained and understood from the following detailed description with reference to the accompanying drawings, wherein:

FIG. 1 is a schematic side view of a part of an inkjet recording apparatus according to an embodiment of the present disclosure;
FIG. 2 is a schematic view of the inkjet recording apparatus as viewed in the direction indicated by arrow A in FIG. 1;
FIG. 3 is a schematic view of a suction cap and a moisturizing cap according to an embodiment of the present disclosure;
FIGS. 4A to 4C are schematic views of the suction cap and the moisturizing cap that move up and down;
FIGS. 5A and 5B are schematic views of the suction cap and the moisturizing cap, illustrating a dimensional relation between capping ends thereof;
FIG. 6 is a schematic view of a suction cap and a moisturizing cap according to another embodiment of the present disclosure;
FIG. 7 is a flowchart of a capping operation according to embodiments of the present disclosure;
FIG. 8 is a schematic view of a bioprinter according to an embodiment of the present disclosure;
FIG. 9 is a schematic view of a maintenance device of the bioprinter.
FIG. 10 is a schematic view of a liquid discharge device according to an embodiment of the present disclosure; and
FIG. 11 is a schematic view of a liquid discharge device according to another embodiment of the present disclosure.

[0008] The accompanying drawings are intended to depict embodiments of the present invention and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted. Also, identical or similar reference numerals designate identical or similar components throughout the several views.

DETAILED DESCRIPTION

[0009] In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific

element includes all technical equivalents that have a similar function, operate in a similar manner, and achieve a similar result.

[0010] Referring now to the drawings, embodiments of the present disclosure are described below. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0011] An embodiment of the present disclosure is described below. In this embodiment, an inkjet recording apparatus serves as a liquid discharge apparatus including a maintenance device. The present disclosure is not limited to the embodiments described below.

[0012] A basic configuration of an inkjet recording apparatus 100 according to the present embodiment is described. FIG. 1 is a schematic side view of a part of the inkjet recording apparatus 100 according to the present embodiment. FIG. 2 is a schematic view of the inkjet recording apparatus 100 as viewed in the direction indicated by arrow A in FIG. 1.

[0013] The inkjet recording apparatus 100 according to the present embodiment is a serial type apparatus, and includes a sheet feeding device 7 that feeds a rolled sheet 6, which is a recording medium, and a liquid discharge device 8 that discharges a liquid onto the rolled sheet 6. A cut sheet may be used as the recording medium.

[0014] As illustrated in FIG. 1, heaters 30A and 30B are disposed upstream and downstream from the liquid discharge device 8 in a conveyance direction of the rolled sheet 6 indicated by arrow CD in FIG. 1 to heat the rolled sheet 6, respectively. A drying fan heater 31 faces the heater 30B disposed downstream from the liquid discharge device 8 in the conveyance direction to blow hot air onto the rolled sheet 6 so as to quickly dry ink as a liquid on the rolled sheet 6.

[0015] The liquid discharge device 8 includes a carriage 3 and a plurality of liquid discharge heads 4 mounted on the carriage 3. The liquid discharge head 4 discharges ink as a liquid. The carriage 3 is reciprocally movable in a main scanning direction (i.e., the width direction of the rolled sheet 6). The liquid discharge head 4 discharges liquid droplets toward the rolled sheet 6 in the direction indicated by dotted arrows 55 in FIG. 1. A platen 32 as a guide faces the carriage 3. The platen 32 may also include a heater to heat the rolled sheet 6.

[0016] As illustrated in FIG. 2, the carriage 3 is held movably in the main scanning direction by a guide rod 5 which laterally bridges between side plates of the inkjet recording apparatus 100. The carriage 3 reciprocates in the main scanning direction when a main scanning motor as a driving source is driven.

[0017] The plurality of liquid discharge heads 4 mounted on the carriage 3 includes a nozzle row including a plurality of nozzles arranged in the sub-scanning direction (i.e., the conveyance direction of the rolled sheet 6) perpendicular to the main scanning direction. The liquid discharge head 4 discharges a liquid downward from the nozzles as a plurality of discharge ports.

[0018] Ink is supplied to a head tank of the liquid discharge head 4 via a supply tube from ink cartridges 20 which are replaceably installed on one side (left side in FIG. 2) of an apparatus body of the inkjet recording apparatus 100 in the main scanning direction. A maintenance device 10 is disposed on the other side (right side in FIG. 2) of the apparatus body in the main scanning direction. The maintenance device 10 maintains and recovers the state of the nozzles of the liquid discharge head 4.

[0019] The maintenance device 10 is provided corresponding to each liquid discharge head 4, and includes a moisturizing cap 11 that caps a nozzle face 4a (see FIG. 3) serving as a discharge face of the liquid discharge head 4 to prevent moisture evaporation of ink in the liquid discharge head 4. The maintenance device 10 further includes, e.g., a dummy discharge receptacle 15 to receive ink discharged in dummy discharge in which ink not contributing to image formation is discharged to discharge thickened ink. A suction cap 12 is disposed in each moisturizing cap 11. A suction pump 13 as a suction device is connected to each suction cap 12. While the nozzle face 4a of the liquid discharge head 4 is capped by the suction cap 12, the nozzle face 4a is sucked by the suction pump 13 to remove the thickened ink adhering to a wall surface of the nozzle and adhering around a discharge opening of the nozzle. The ink sucked by the suction pump 13 is stored in a waste liquid tank 14.

[0020] The inkjet recording apparatus 100 drives the liquid discharge head 4 in response to an image signal while moving the carriage 3 in the main scanning direction to discharge ink droplets onto the rolled sheet 6 fed from the sheet feeding device 7, thus forming an image. In the present embodiment, the heaters 30A and 30B heat the rolled sheet 6 to quickly dry the ink adhering to the rolled sheet 6, thereby preventing the image from deteriorating. Further, in the present embodiment, the drying fan heater 31 blows hot air to the ink on the rolled sheet 6, thereby quickly drying the ink on the rolled sheet 6 and sufficiently preventing the image from deteriorating.

[0021] FIG. 3 is a schematic view of the suction cap 12 and the moisturizing cap 11. As illustrated in FIG. 3, the moisturizing cap 11 has a frame shape in which the entire bottom and top are open, and a holder 21 that holds the suction cap 12 is disposed so as to pass through a bottom opening 11c of the moisturizing cap 11.

[0022] The holder 21 has a shape slightly narrower than the bottom opening 11c of the moisturizing cap 11, and substantially closes the bottom opening 11c of the moisturizing cap 11. The holder 21 includes a first holding portion 21a that faces the moisturizing cap 11 from below and holds the moisturizing cap 11 via a spring 22 as an elastic member so as to raise and lower the moisturizing cap 11. The suction cap 12 is held so as to be placed on an upper face of the holder 21 (i.e., a second holding portion 21b).

[0023] A cam 42 as a mover is in contact with a bottom

surface of the holder 21. A worm 41a of a worm gear is formed on a motor shaft of a cam motor 41 that rotates the cam 42. A worm wheel 42a formed on a cam shaft of the cam 42 meshes with the worm 41a. In the present embodiment, the cam 42 and the cam motor 41 construct an elevator 40 to raise and lower the moisturizing cap 11 and the suction cap 12.

[0024] In the present embodiment, since the suction cap 12 is disposed inside the moisturizing cap 11, the maintenance device 10 can be downsized as compared with a case in which a suction cap is disposed outside the moisturizing cap 11, thereby downsizing the entire inkjet recording apparatus 100.

[0025] FIGS. 4A to 4C are schematic views of the moisturizing cap 11 and the suction cap 12 that move up and down. FIG. 4A illustrates a decapping state in which neither the moisturizing cap 11 nor the suction cap 12 caps the nozzle face 4a. FIG. 4B illustrate a moisture-retentive capping state in which the moisturizing cap 11 caps the nozzle face 4a, and FIG. 4C illustrates a suction capping state in which the suction cap 12 caps the nozzle face 4a.

[0026] As illustrated in FIG. 4A, in the decapping state, a capping end 11d (i.e., a first capping end) of the moisturizing cap 11 that contacts the nozzle face 4a is positioned higher than a capping end 12d (i.e., a second capping end) of the suction cap 12. When the cam motor 41 is driven to rotate the cam 42 from the decapping state, the moisturizing cap 11 and the suction cap 12 are raised.

[0027] As described above, the capping end 11d of the moisturizing cap 11 that contacts the nozzle face 4a is positioned higher (closer to the nozzle face 4a) than the capping end 12d of the suction cap 12. Accordingly, as illustrated in FIG. 4B, the capping end 11d of the moisturizing cap 11 comes into contact with the nozzle face 4a before the capping end 12d of the suction cap 12. When the cam motor 41 is stopped in the state illustrated in FIG. 4B, the moisturizing cap 11 retains moisture of ink in the nozzles with the suction cap 12 separated from the nozzle face 4a. Since the bottom opening 11c of the moisturizing cap 11 is closed by the holder 21 with almost no clearance, ink in the nozzles can be prevented from drying. A slider such as a rubber material that slides on the inner wall surface of the moisturizing cap 11 may be disposed at the rim of the second holding portion 21b of the holder 21 to seal the clearance of the bottom opening 11c between the moisturizing cap 11 and the holder 21.

[0028] In the suction cap 12, ink discharged from the nozzles during the ink suction may adhere to the inside or the capping end 12d of the suction cap 12. If the suction cap 12 is in contact with the nozzle face 4a in the moisture-retentive capping state, the ink adhering to the capping end 12d may be transferred to the nozzle face 4a to stain the nozzle face 4a. In particular, if the suction cap 12 keeps contact with the nozzle face 4a for a long time, the ink adhering to the capping end 12d evaporates on the nozzle face 4a. As a result, a mark of the suction cap 12 so-called cap mark may be formed on the nozzle face 4a.

[0029] In the present embodiment, as illustrated in FIG. 4B, only the moisturizing cap 11 is in contact with the nozzle face 4a, and the suction cap 12 is separated from the nozzle face 4a to retain the moisture of the ink in the nozzles. Accordingly, ink adhering to the suction cap 12 does not adhere to the nozzle face 4a during the moisture retention, thereby preventing the nozzle face 4a from being stained with the ink.

[0030] When the suction cap 12 sucks ink from the nozzles, the cam motor 41 is driven from the state illustrated in FIG. 4B, and the holder 21 is raised by the cam 42. As a result, the spring 22 is compressed and deformed, and the suction cap 12 held by the holder 21 is raised relative to the moisturizing cap 11 (specifically, relative to the side wall of the moisturizing cap 11). Then, as illustrated in FIG. 4C, the capping end 12d of the suction cap 12 comes into contact with the nozzle face 4a, thereby establishing the suction capping state.

[0031] As described above, in the present embodiment, the single elevator 40 raises and lowers the moisturizing cap 11, and raises and lowers the suction cap 12 relative to the moisturizing cap 11. Thus, the maintenance device 10 has fewer components than a maintenance device including an elevator that raises and lowers the moisturizing cap 11 and another elevator that raises and lowers the suction cap 12 relative to the moisturizing cap 11. Further, the maintenance device 10 has a simpler configuration than a maintenance device including an elevator that raises and lowers the moisturizing cap 11 and another elevator that raises and lowers the suction cap 12 relative to the moisturizing cap 11. As a result, the cost of the maintenance device 10 can be reduced.

[0032] FIGS. 5A and 5B are schematic views of the suction cap 12 and the moisturizing cap 11, illustrating a dimensional relation between the capping end 11d of the moisturizing cap 11 and the capping end 12d of the suction cap 12. In FIG. 5A, the liquid discharge head 4 is viewed in the sub-scanning direction, and in FIG. 5B, the liquid discharge head 4 is viewed in the main scanning direction.

[0033] As illustrated in FIGS. 5A and 5B, the moisturizing cap 11 is in contact with the vicinity of the edge of the nozzle face 4a. As illustrated in FIG. 5A, the capping end 11d of the moisturizing cap 11 and the capping end 12d of the suction cap 12 is separated from each other by a gap D2 in the transverse direction of the liquid discharge head 4. As illustrated in FIG. 5B, the capping end 11d of the moisturizing cap 11 and the capping end 12d of the suction cap 12 is separated from each other by a gap d2 in the longitudinal direction of the liquid discharge head 4. As described above, the gaps are disposed between the capping end 11d of the moisturizing cap 11 and the capping end 12d of the suction cap 12 in both the transverse direction and the longitudinal direction of the liquid discharge head 4.

[0034] In the present embodiment, even when ink is sucked from nozzles 4c by the suction cap 12, the capping end 11d of the moisturizing cap 11 is in contact with

the nozzle face 4a. When the maintenance device 10 transitions to the decapping state illustrated in FIG. 4A after a suction operation, the suction cap 12 is separated from the nozzle face 4a, and then the moisturizing cap 11 is separated from the nozzle face 4a. When the suction cap 12 is separated from the nozzle face 4a, ink adhering to the capping end 12d of the suction cap 12 may be transferred to the nozzle face 4a. If there is no gap between the capping end 11d of the moisturizing cap 11 and the capping end 12d of the suction cap 12, the ink transferred to the nozzle face 4a may adhere to the capping end 11d of the moisturizing cap 11. However, in the present embodiment, there are the gaps (i.e., the gaps D2 and d2) between the capping end 11d of the moisturizing cap 11 and the capping end 12d of the suction cap 12. Accordingly, the ink transferred from the capping end 12d of the suction cap 12 to the nozzle face 4a is prevented from adhering to the moisturizing cap 11, thereby preventing the moisturizing cap 11 from being stained with the ink.

[0035] As illustrated in FIGS. 5A and 5B, the gaps D2 and d2 between the capping end 12d of the suction cap 12 and the capping end 11d of the moisturizing cap 11 are shorter than distances D1 and d1 from the nozzle 4c to the edge of the nozzle face 4a, respectively. With such a dimensional relation, the suction cap 12 can cap all the nozzles 4c.

[0036] In the above embodiment, the entire bottom portion of the moisturizing cap 11 is open. Alternatively, in another embodiment, a part of the bottom portion of the moisturizing cap 11 may be open, and the holder 21 may pass through the bottom opening 11c as illustrated in FIG. 6. Even with such a configuration, the moisturizing cap 11 and the suction cap 12 can be raised and lowered by the same operation as the operation described with reference to FIGS. 4A to 4C. Preferably, a slider that slides on the outer wall surface of the holder 21 is disposed at the rim of the bottom opening 11c of the moisturizing cap 11 to seal the clearance of the bottom opening 11c between the moisturizing cap 11 and the holder 21.

[0037] In the above embodiment, the first holding portion 21a that holds the moisturizing cap 11 is disposed outside the moisturizing cap 11. Alternatively, in another embodiment, the first holding portion 21a may be disposed inside the moisturizing cap 11. In such a case, for example, the moisturizing cap 11 has a held portion projecting from the inner wall surface of the moisturizing cap 11, and the spring 22 is disposed between the held portion of the moisturizing cap 11 and the first holding portion 21a of the holder 21 disposed inside the moisturizing cap 11.

[0038] In the above embodiment, the cam 42 is disposed outside the moisturizing cap 11, and the holder 21 penetrates the moisturizing cap 11 and contacts the cam 42 disposed outside the moisturizing cap 11. The moisturizing cap 11 having such a configuration can be prevented from being upsized, and the maintenance device 10 including the moisturizing cap 11 can be prevented from being complicated as compared with a case in which a cam is disposed inside the moisturizing cap 11.

[0039] FIG. 7 is a flowchart of a capping operation. When an image forming operation ends and the capping operation starts (step S1), a controller of the inkjet recording apparatus 100 determines whether to perform the suction operation (step S2). When the suction operation is not performed (No in step S2), the controller causes the maintenance device 10 to raise the holder 21 so that the moisturizing cap 11 contacts the nozzle face 4a, and to stop raising the holder 21 in the moisture-retentive capping state illustrated in FIG. 4B (step S7).

[0040] On the other hand, for example, when a user sets the maintenance device 10 to perform the suction operation at the end of the image forming operation via the control panel or the like of the inkjet recording apparatus 100 (Yes in step S2), the controller causes the maintenance device 10 to raise the holder 21 from the decapping state illustrated in FIG. 4A until the suction cap 12 comes into contact with the nozzle face 4a (step S3) to transition to the suction capping state illustrated in FIG. 4C.

[0041] When the maintenance device 10 reaches the suction capping state, the controller causes the maintenance device 10 to drive the suction pump 13 to perform the suction operation (step S4). When the suction operation ends, the controller causes the maintenance device 10 to perform a predetermined maintenance operation (step S5). Examples of the maintenance operation include a cleaning operation in which ink adhering to the nozzle face 4a is removed with a cleaning blade and a recovery operation in which ink meniscus is recovered. The maintenance device 10 performs the cleaning operation while the carriage 3 moves from a capping position (home position) to a position where the liquid discharge head 4 faces the dummy discharge receptacle 15. That is, the controller causes the maintenance device 10 to lower the holder 21 to transition from the suction capping state illustrated in FIG. 4C to the decapping state illustrated in FIG. 4A, and then causes the carriage 3 to move to a position where the liquid discharge head 4 faces the dummy discharge receptacle 15. At this time, the controller causes the maintenance device 10 to raise a cleaning blade disposed between the dummy discharge receptacle 15 and the moisturizing cap 11 and bring the cleaning blade into contact with the nozzle face 4a of the liquid discharge head 4 moving toward the dummy discharge receptacle 15 to remove ink adhering to the nozzle face 4a, thus performing the cleaning operation.

[0042] After the predetermined maintenance operation such as the cleaning operation is performed, the controller causes the liquid discharge head 4 to perform dummy discharge in which ink is discharged to the dummy discharge receptacle 15 (step S6). When the carriage 3 returns to the capping position (home position) again after the dummy discharge, the controller causes the maintenance device 10 to raise the holder 21. When the mois-

turizing cap 11 comes into contact with the nozzle face 4a to transition to the moisture-retentive capping state illustrated in FIG. 4B, the controller causes the maintenance device 10 to stop raising the holder 21 (step S7). Thus, the maintenance device 10 completes the capping operation (step S8).

[0043] In the above-described embodiments, the "liquid discharge apparatus" includes the liquid discharge head or the liquid discharge device and drives the liquid discharge head to discharge liquid. The liquid discharge apparatus may be, for example, an apparatus capable of discharging liquid to a material onto which liquid can adhere or an apparatus to discharge liquid toward gas or into liquid.

[0044] The "liquid discharge apparatus" may further include devices relating to feeding, conveying, and ejecting of the material onto which liquid can adhere and also include a pretreatment device and an aftertreatment device.

[0045] The "liquid discharge apparatus" may be, for example, an image forming apparatus to form an image on a sheet by discharging ink, or a three-dimensional fabrication apparatus to discharge fabrication liquid to a powder layer in which powder material is formed in layers so as to form a three-dimensional object.

[0046] The "liquid discharge apparatus" is not limited to an apparatus that discharges liquid to visualize meaningful images such as letters or figures. For example, the liquid discharge apparatus may be an apparatus that forms meaningless images such as meaningless patterns or an apparatus that fabricates three-dimensional images.

[0047] The above-described term "material onto which liquid can adhere" represents a material on which liquid is at least temporarily adhered, a material on which liquid is adhered and fixed, or a material into which liquid is adhered to permeate. Specific examples of the "material onto which liquid can adhere" include, but are not limited to, a recording medium such as a paper sheet, recording paper, a recording sheet of paper, a film, or cloth, an electronic component such as an electronic substrate or a piezoelectric element, and a medium such as layered powder, an organ model, or a testing cell. The "material onto which liquid can adhere" includes any material to which liquid adheres, unless particularly limited.

[0048] Examples of the "material onto which liquid can adhere" include any materials onto which liquid can adhere even temporarily, such as paper, thread, fiber, fabric, leather, metal, plastic, glass, wood, ceramic, construction materials (e.g., wall paper or floor material), and cloth textile.

[0049] Examples of the "liquid" include ink, treatment liquid, DNA sample, resist, pattern material, binder, fabrication liquid, and solution or liquid dispersion containing amino acid, protein, or calcium.

[0050] The liquid discharge apparatus may be an apparatus to relatively move the liquid discharge head and the material onto which liquid can adhere. However, the liquid discharge apparatus is not limited to such an apparatus. For example, the liquid discharge apparatus may be a serial head apparatus that moves the liquid discharge head or a line head apparatus that does not move the liquid discharge head.

[0051] Examples of the liquid discharge apparatus further include: a treatment liquid applying apparatus that discharges a treatment liquid onto a paper sheet to apply the treatment liquid to the surface of the paper sheet, for reforming the surface of the paper sheet; and an injection granulation apparatus that injects a composition liquid, in which a raw material is dispersed in a solution, through a nozzle to granulate fine particle of the raw material.

[0052] FIG. 8 is a schematic view of a bioprinter 200 as an example of the liquid discharge apparatus. The bioprinter 200 includes a loading table 230 on which a culture vessel such as a glass substrate is placed. The loading table 230 is supported by an elevator 231 so as to move in the vertical direction (i.e., the Z-axis direction). A liquid discharge head 204 is disposed above the loading table 230 to discharge liquid containing living tissues and cells. A carriage 203 holding the liquid discharge head 204 is held by a guide shaft 205 extending in the left-right direction of the bioprinter 200 in FIG. 8 (i.e., the X-axis direction) so as to be movable in the left-right direction. Both ends of the guide shaft 205 are held by front-rear guides 221 extending in the front-rear direction of the bioprinter 200 in FIG. 8 (i.e., the Y-axis direction which is perpendicular to the surface of the paper on which FIG. 8 is drawn) so as to be movable in the front-rear direction.

[0053] The bioprinter 200 includes a Y-axis moving mechanism that moves the guide shaft 205 in the front-rear direction of the bioprinter 200 and an X-axis moving mechanism that moves the carriage 203 in the left-right direction of the bioprinter 200 in FIG. 8. While controlling the elevator 231, the Y-axis moving mechanism, and the X-axis moving mechanism, the controller causes the liquid discharge head 204 to discharge liquid containing living tissues and cells from a nozzle 204c to fabricate a biological composition, an organ, or the like. A maintenance device 210 is disposed at the home position where the carriage 203 stands by.

[0054] FIG. 9 is a schematic view of the maintenance device 210 of the bioprinter 200. As illustrated in FIG. 9, the liquid discharge head 204 used in the bioprinter 200 has a cylindrical shape, and a moisturizing cap 211 and a suction cap 212 also have a cylindrical shape. Since a discharge face 204a of the liquid discharge head 204 is a substantially conical inclined surface that tapers toward the nozzle 204c, a capping end 211d of the moisturizing cap 211 is a funnel-shaped inclined surface. As a result, the capping end 211d of the moisturizing cap 211 contacts the discharge face 204a of the liquid discharge head 204 without any clearance, thereby retaining moisture of the liquid in the nozzle 204c.

[0055] The "liquid discharge device" refers to a liquid discharge head integrated with functional components

or mechanisms, i.e., an assembly of components related to liquid discharge. For example, the "liquid discharge device" includes a combination of the liquid discharge head with at least one of a head tank, a carriage, a supply mechanism, a maintenance device, and a main-scanning moving mechanism.

[0056] Here, the integrated unit may be, for example, a combination in which the liquid discharge head and a functional part(s) are secured to each other through, e.g., fastening, bonding, or engaging, and a combination in which one of the liquid discharge head and a functional part(s) is movably held by another. The liquid discharge head may be detachably attached to the functional part(s) or unit(s) each other.

[0057] Examples of the liquid discharge device include a liquid discharge device 440 in which a liquid discharge head 404 and a head tank 441 are integrated as a single unit, which is mounted on a carriage 403, as illustrated in FIG. 10. Alternatively, the liquid discharge head 404 and the head tank 441 coupled (connected) with a tube or the like may construct the liquid discharge device 440 as a single unit. Here, a unit including a filter may further be added to a portion between the head tank 441 and the liquid discharge head 404 of the liquid discharge device 440. In another example, the liquid discharge device may be an integrated unit in which a liquid discharge head is integrated with a carriage.

[0058] As yet another example, the liquid discharge device is a unit in which the liquid discharge head and the main-scanning moving mechanism are combined into a single unit. The liquid discharge head is movably held by a guide that is a part of the main-scanning moving mechanism. The liquid discharge device may be an integrated unit in which the liquid discharge head, the carriage, and the main-scanning moving mechanism are integrated as a single unit.

[0059] In another example, the cap that forms a part of the maintenance device is secured to the carriage mounting the liquid discharge head so that the liquid discharge head, the carriage, and the maintenance device are integrated as a single unit to form the liquid discharge device.

[0060] Further, in still another example, as illustrated in FIG. 11, the liquid discharge head 404 is coupled to tubes 456 so that the liquid discharge head 404 and the supply mechanism are integrated as a single liquid discharge device, as illustrated in FIG. 11.

[0061] The main-scanning moving mechanism may be a guide only. The supply mechanism may be a tube(s) only or a loading device only.

[0062] The liquid discharge head is not limited in the type of pressure generator used. The pressure generator is not limited to the piezoelectric actuator (or a laminated piezoelectric element) described in the above-described embodiments, and may be, for example, a thermal actuator that employs an electrothermal transducer element, such as a thermal resistor, or an electrostatic actuator including a diaphragm and opposed electrodes.

[0063] In the present specification, the terms "image formation," "recording," "printing," "image printing," and "fabricating" used herein may be used synonymously with each other.

[0064] The embodiments described above are just examples, and the various aspects of the present disclosure attain respective effects as follows.

Aspect 1

[0065] A maintenance device such as the maintenance device 10 includes a moisturizing cap such as the moisturizing cap 11 and a suction cap such as the suction cap 12. The moisturizing cap 11 contacts a discharge face such as the nozzle face 4a with a first capping end such as the capping end 11d. The suction cap 12 is disposed inside the moisturizing cap 11. The suction cap 12 contacts the discharge face with a second capping end such as the capping end 12d to suck a liquid from a discharge port such as the nozzle 4c in the discharge face.

Aspect 2

[0066] In Aspect 1, the maintenance device 10 further includes a holder such as the holder 21. The holder 21 includes a first holding portion such as the first holding portion 21a connected to the moisturizing cap 11 with an elastic member such as the spring 22 and a second holding portion such as the second holding portion 21b contacting a base of the suction cap 12 to support the suction cap 12.

Aspect 3

[0067] In Aspect 2, the maintenance device 10 further includes a holder such as the cam 42 that moves the holder 21 to move the moisturizing cap 11 and the suction cap 12 toward and away from the discharge face in a contact-separation direction. The cam 42 moves the moisturizing cap 11 to a first contact position at which the capping end 11d is in contact with the discharge face while the capping end 12d of the suction cap 12 is separated from the discharge face, and the cam 42 moves the suction cap 12 to a second contact position at which the capping end 12d is in contact with the discharge face while the capping end 11d of the moisturizing cap 11 is in contact with the discharge face.

Aspect 4

[0068] In Aspect 3, the moisturizing cap 11 at the first contact position retains a moisture of the liquid in the discharge port, and the suction cap 12 at the second contact position sucks the liquid from the discharge port.

Aspect 5

[0069] In Aspect 3, the capping end 11d of the mois-

turizing cap 11 separated from the discharge face is closer to the discharge face than the capping end 12d of the suction cap 12 separated from the discharge face.

[0070] With this configuration according to Aspects 1 to 5, for example, when the discharge face such as the nozzle face 4a faces downward and a direction perpendicular to the discharge face is a vertical direction, the mover such as the cam 42 raises the holder 21 from a separated position at which the suction cap 12 and the moisturizing cap 11 are separated from the discharge face, thereby raising the moisturizing cap 11 held by the holder 21 via the elastic member such as the spring 22 together with the suction cap 12. Since the capping end 11d of the moisturizing cap 11 to contact the discharge face is higher than the capping end 12d of the suction cap 12 to contact the discharge face, the capping end 11d of the moisturizing cap 11 comes into contact with the discharge face first to retain moisture in the discharge port such as the nozzle 4c when the mover continues to raise the holder 21. When the capping end 11d of the moisturizing cap 11 comes into contact with the discharge face, the mover stops raising the holder 21. As a result, the suction cap 12 is on standby at the separated position away from the discharge face while the moisturizing cap 11 retains the moisture of the liquid in the discharge port. Thus, the suction cap 12 stained with the liquid can be prevented from contacting the discharge face while the moisturizing cap 11 retains the moisture of the liquid in the discharge port, and the mark of the suction cap 12 can be prevented from being formed on the discharge face.

[0071] According to Aspect 2, the moisturizing cap 11 is held via the elastic member by the holder 21 that holds the suction cap 12. Accordingly, when the mover further raises the holder 21 from the state in which only the capping end 11d of the moisturizing cap 11 is in contact with the discharge face, the elastic member is elastically deformed, the suction cap 12 is raised relative to the moisturizing cap 11, and the capping end 12d of the suction cap 12 comes into contact with the discharge face. Thus, the suction cap 12 can suck the liquid from the discharge port.

[0072] As described above, according to Aspects 1 to 5, the single mover can move the moisturizing cap 11 so that the moisturizing cap 11 contacts and separates from the discharge face, and can move the suction cap 12 relative to the moisturizing cap 11. Thus, the maintenance device according to Aspects 1 to 5 has fewer components and a simpler configuration than a maintenance device including a mover for moisture retention that moves the moisturizing cap 11 and another mover for suction that moves the suction cap 12 relative to the moisturizing cap 11 as disclosed in Japanese Unexamined Patent Application Publication No. 2010-058268.

Aspect 6

[0073] In Aspect 3, the cam 42 moves the suction cap 12 and the moisturizing cap 11 toward or away from the discharge face such as the nozzle face 4a facing downward in a vertical direction as the contact-separation direction. The moisturizing cap 11 has a bottom opening 11c through which the second holding portion 21b of the holder 21 passes. The second holding portion 21b is disposed higher than the first holding portion 21a.

[0074] With this configuration, as described in the above embodiment, the suction cap 12 can be brought into contact with and separated from the discharge face such as the nozzle face 4a while the moisturizing cap 11 is in contact with the discharge face.

Aspect 7

[0075] In Aspect 6, the first capping end such as the capping end 11d of the moisturizing cap 11 and the second capping end such as the capping end 12d of the suction cap 12 are separated from each other by a gap in a lateral direction orthogonal to the vertical direction.

[0076] With this configuration, as described in the above embodiment, the suction cap 12 is raised and lowered while the moisturizing cap 11 is in contact with the discharge face such as the nozzle face 4a. That is, when the suction cap 12 is separated from the discharge face after the suction operation, the moisturizing cap 11 is in contact with the discharge face. When liquid (e.g., ink) is sucked from the discharge port such as the nozzle 4c while the suction cap 12 is in contact with the discharge face, the liquid may adhere to the capping end 12d of the suction cap 12. In this case, when the suction cap is separated from the discharge face after the suction operation, the liquid adhering to the capping end 12d may be transferred to the discharge face. However, even if the liquid is transferred from the capping end 12d of the suction cap 12 to the discharge face, since the predetermined gap is disposed between the capping end 11d of the moisturizing cap 11 and the capping end 12d of the suction cap 12, the liquid transferred to the discharge face can be prevented from being transferred and adhered to the capping end 11d of the moisturizing cap 11. Accordingly, the moisturizing cap can be prevented from being stained with the liquid.

Aspect 8

[0077] In Aspect 7, the gap is shorter than a distance from the discharge port such as the nozzle 4c to an edge of the discharge face such as the nozzle face 4a in the lateral direction.

[0078] With this configuration, as described in the above embodiment, the discharge port such as the nozzle 4c can be capped with the suction cap 12, and the moisturizing cap 11 can be brought into contact with the discharge face such as the nozzle face 4a.

Aspect 9

[0079] In Aspect 3, the mover includes the cam 42 contacting with a bottom surface of the holder 21.
[0080] With this configuration, as described in the above embodiment, the cam 42 can move the holder 21 to moves the moisturizing cap 11 and the suction cap 12.

Aspect 10

[0081] A liquid discharge device such as the liquid discharge device 8 includes the liquid discharge head such as the liquid discharge head 4 to discharge the liquid and the maintenance device such as the maintenance device 10 according to any one of Aspects 1 to 9.
[0082] With this configuration, the size and cost of the liquid discharge device can be reduced.

Aspect 11

[0083] A liquid discharge apparatus such as the inkjet recording apparatus 100 includes the liquid discharge device such as liquid discharge device 8 according to Aspect 10.
[0084] With this configuration, the size and cost of the liquid discharge device can be reduced.

Aspect 12

[0085] In Aspect 11, the liquid includes an ink.
[0086] As a result, the liquid discharge apparatus can form an image with the ink.

Aspect 13

[0087] In Aspect 11, the liquid contains living tissues and living cells.
[0088] As a result, the liquid discharge apparatus can fabricate a biological composition, an organ, or the like.
[0089] Any one of the above-described operations may be performed in various other ways, for example, in an order different from the one described above.

Claims

1. A maintenance device (10) comprising:

a moisturizing cap (11) configured to contact a discharge face (4a) of a liquid discharge head (4) with a first capping end (11d);
a suction cap (12) inside the moisturizing cap (11), the suction cap (12) configured to contact the discharge face (4a) with a second capping end (12d) to suck a liquid from a discharge port (4c) in the discharge face (4a).

2. The maintenance device (10) according to claim 1, further comprising:
a holder (21) including:

a first holding portion (21a) connected to the moisturizing cap (11) with an elastic member (22); and
a second holding portion (21b) contacting a base of the suction cap (12) to support the suction cap (12).

3. The maintenance device (10) according to claim 2, further comprising a mover (42) configured to move the holder (21) to move the moisturizing cap (11) and the suction cap (12) toward and away from the discharge face (4a) in a contact-separation direction,

wherein the mover (42) moves the moisturizing cap (11) to a first contact position at which the first capping end (11d) is in contact with the discharge face (4a) while the second capping end (12d) of the suction cap (12) is separated from the discharge face (4a), and
the mover (42) moves the suction cap (12) to a second contact position at which the second capping end (12d) is in contact with the discharge face (4a) while the first capping end (11d) of the moisturizing cap (11) is in contact with the discharge face (4a).

4. The maintenance device (10) according to claim 3,

wherein the moisturizing cap (11) at the first contact position retains a moisture of the liquid in the discharge port (4c);
the suction cap (12) at the second contact position sucks the liquid from the discharge port (4c).

5. The maintenance device (10) according to claim 3, wherein the first capping end (11d) of the moisturizing cap (11) separated from the discharge face (4a) is closer to the discharge face than the second capping end (12d) of the suction cap (12) separated from the discharge face (4a).

6. The maintenance device (10) according to claim 3,

wherein the mover (42) moves the suction cap (12) and the moisturizing cap (11) toward or away from the discharge face (4a) facing downward in a vertical direction as the contact-separation direction,
the moisturizing cap (11) has a bottom opening (11c) through which the second holding portion (21b) of the holder (21) passes, and
the second holding portion (21b) is disposed higher than the first holding portion (21a).

7. The maintenance device (10) according to claim 6,

wherein the first capping end (11d) and the second capping end (12d) are separated from each other by a gap (D2; d2) in a lateral direction orthogonal to the vertical direction.

8. The maintenance device (10) according to claim 7, wherein the gap (D2; d2) is shorter than a distance (D1; d1) from the discharge port (4c) to an edge of the discharge face (4a) in the lateral direction.

9. The maintenance device (10) according to claim 3, wherein the mover (42) includes a cam (42) contacting with a bottom surface of the holder (21).

10. A liquid discharge device (8) comprising:

the liquid discharge head (4) configured to discharge the liquid from the discharge port (4c); and
the maintenance device (10) according to any one of claims 1 to 9.

11. A liquid discharge apparatus (100) comprising the liquid discharge device (8) according to claim 10.

12. The liquid discharge apparatus (100) according to claim 11,
wherein the liquid includes an ink.

13. The liquid discharge apparatus (100) according to claim 11,
wherein the liquid contains living tissues or living cells.

FIG. 1

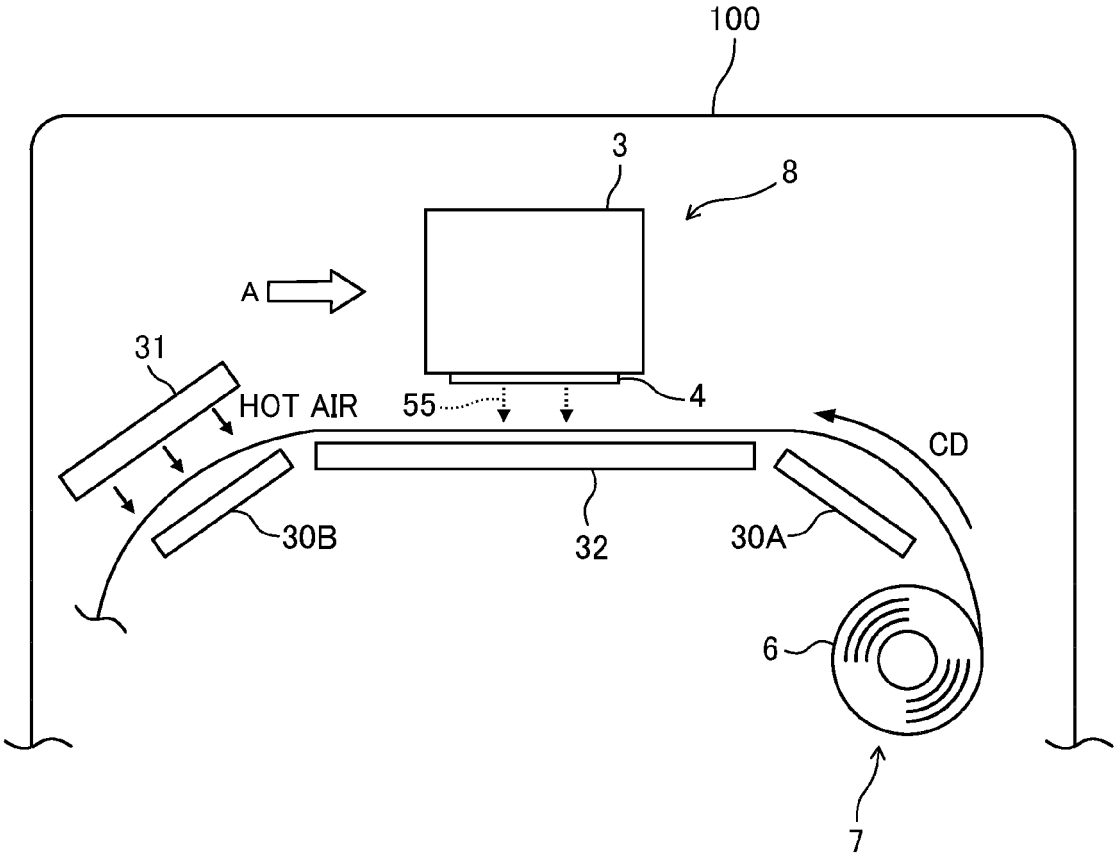

100
3
8
A
31
HOT AIR
55
4
CD
30B
32
30A
6
7

FIG. 2

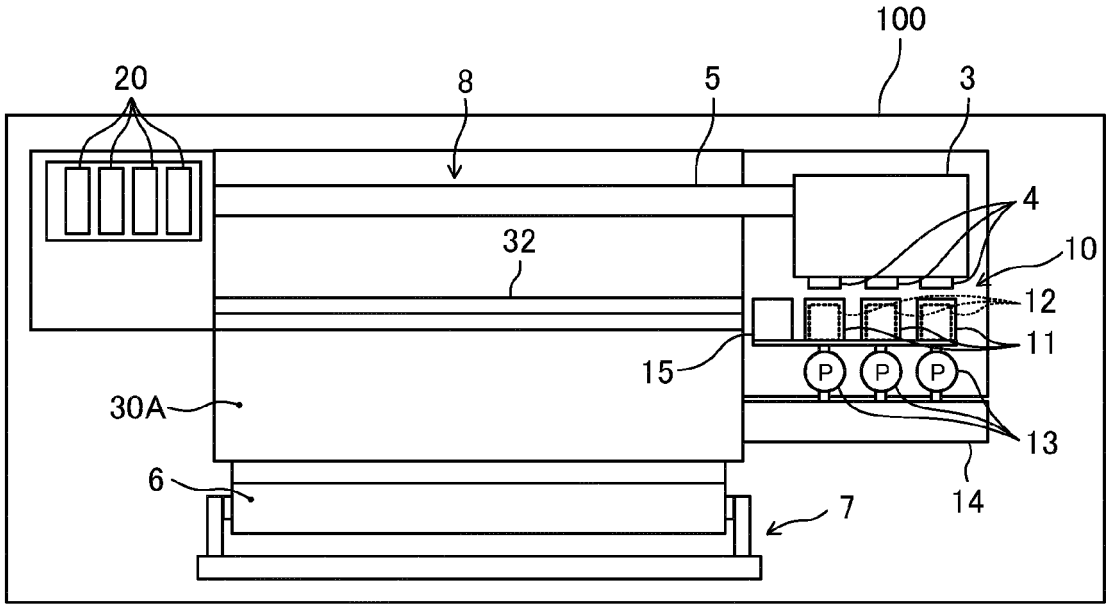

100
20
8
5
3
4
32
10
12
11
15
P
P
P
30A
13
6
14
7

FIG. 3

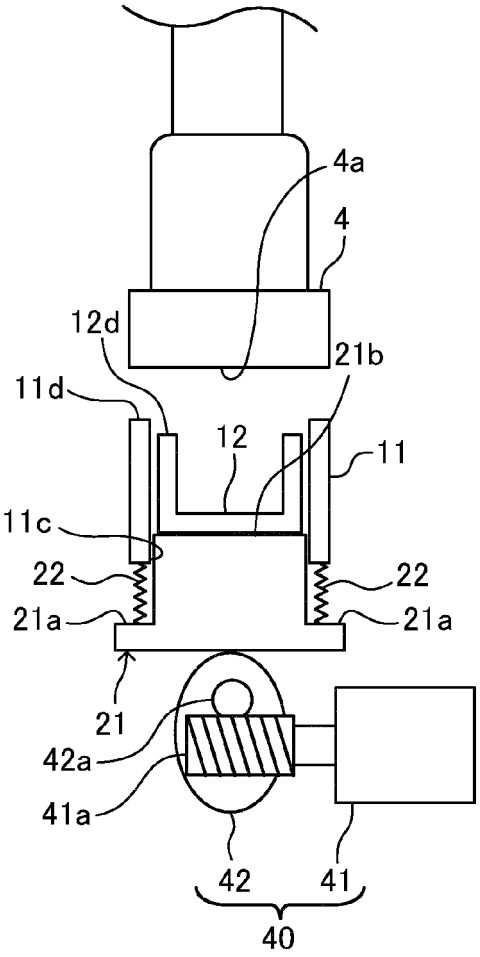


FIG. 4A

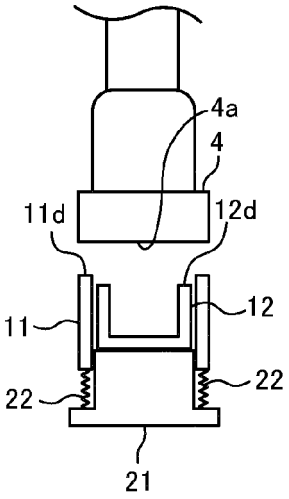


FIG. 4B

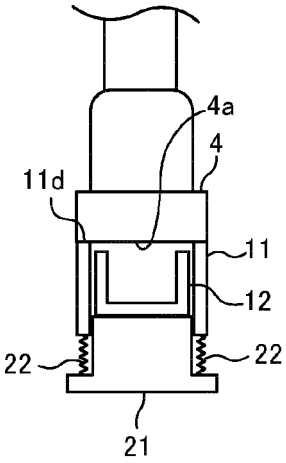


FIG. 4C

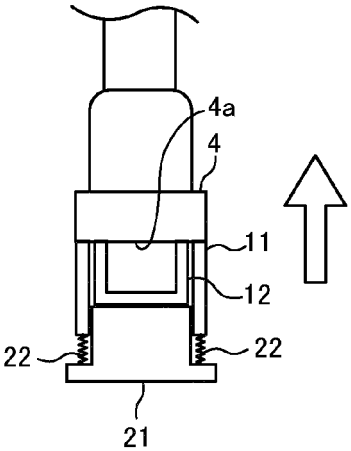


FIG. 5A

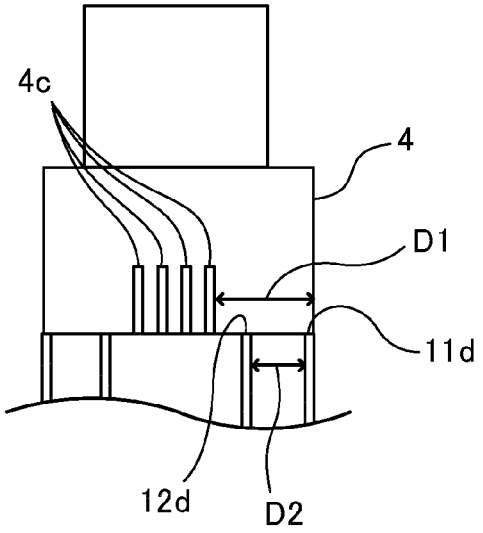


FIG. 5B

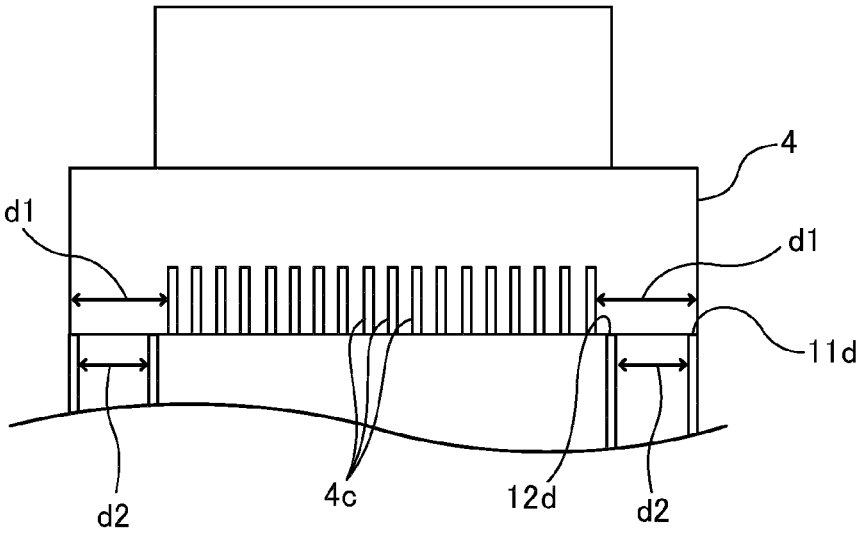


FIG. 6

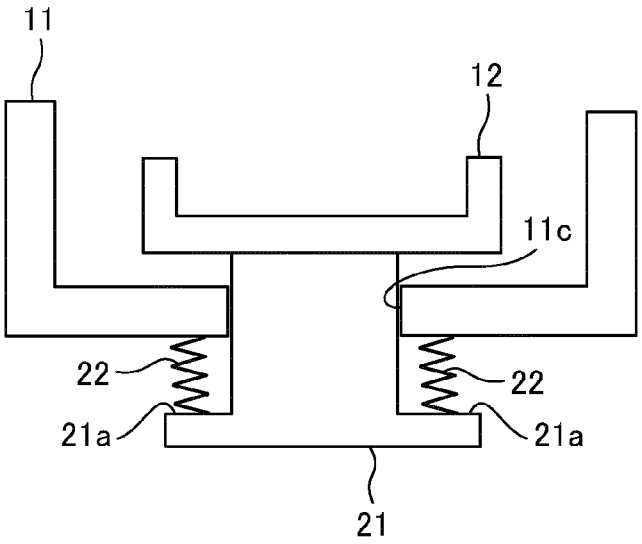


FIG. 7

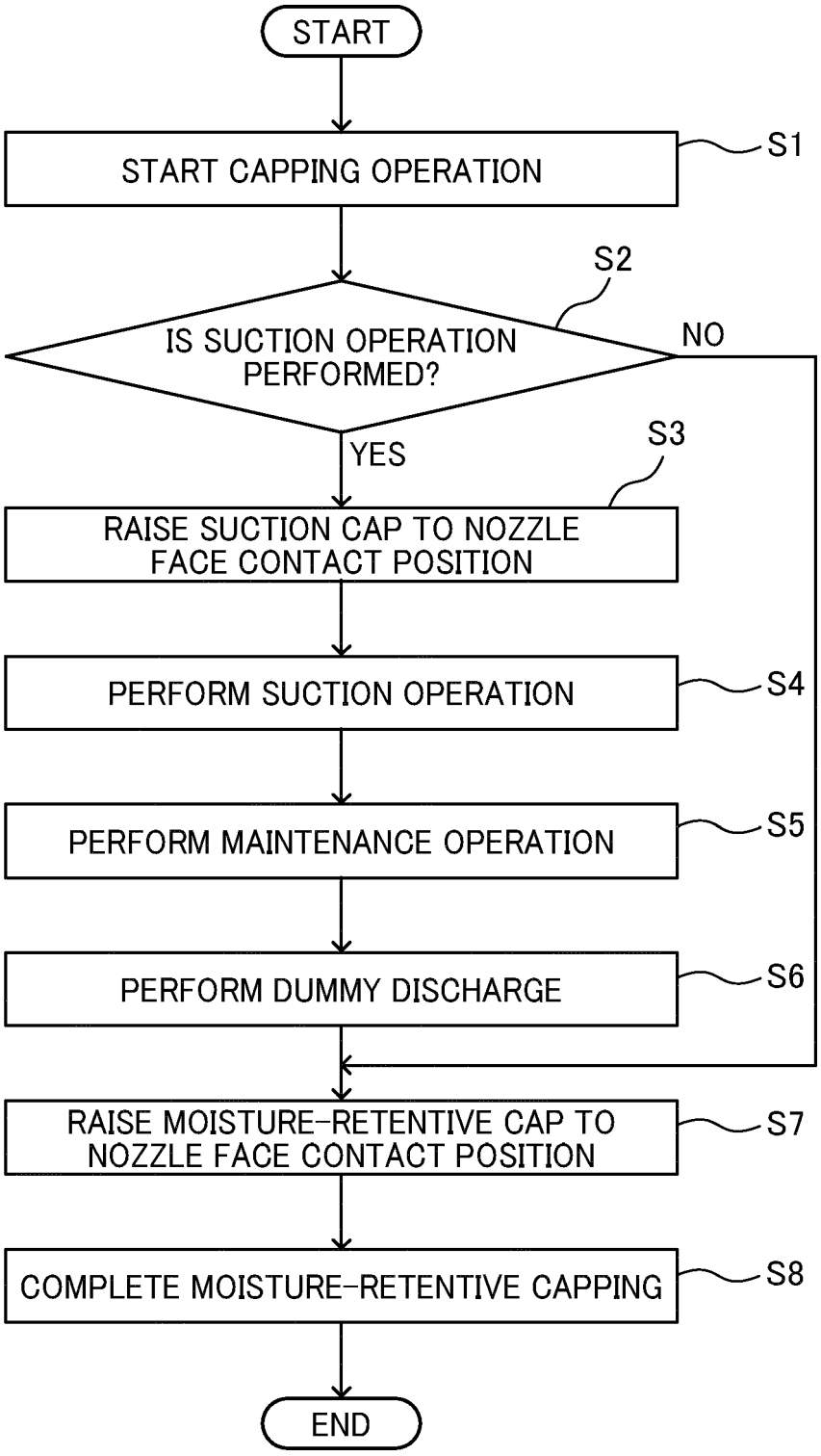

START
START CAPPING OPERATION
S1
S2
IS SUCTION OPERATION PERFORMED?
NO
YES
S3
RAISE SUCTION CAP TO NOZZLE FACE CONTACT POSITION
PERFORM SUCTION OPERATION
S4
PERFORM MAINTENANCE OPERATION
S5
PERFORM DUMMY DISCHARGE
S6
RAISE MOISTURE-RETENTIVE CAP TO NOZZLE FACE CONTACT POSITION
S7
COMPLETE MOISTURE-RETENTIVE CAPPING
S8
END

FIG. 8

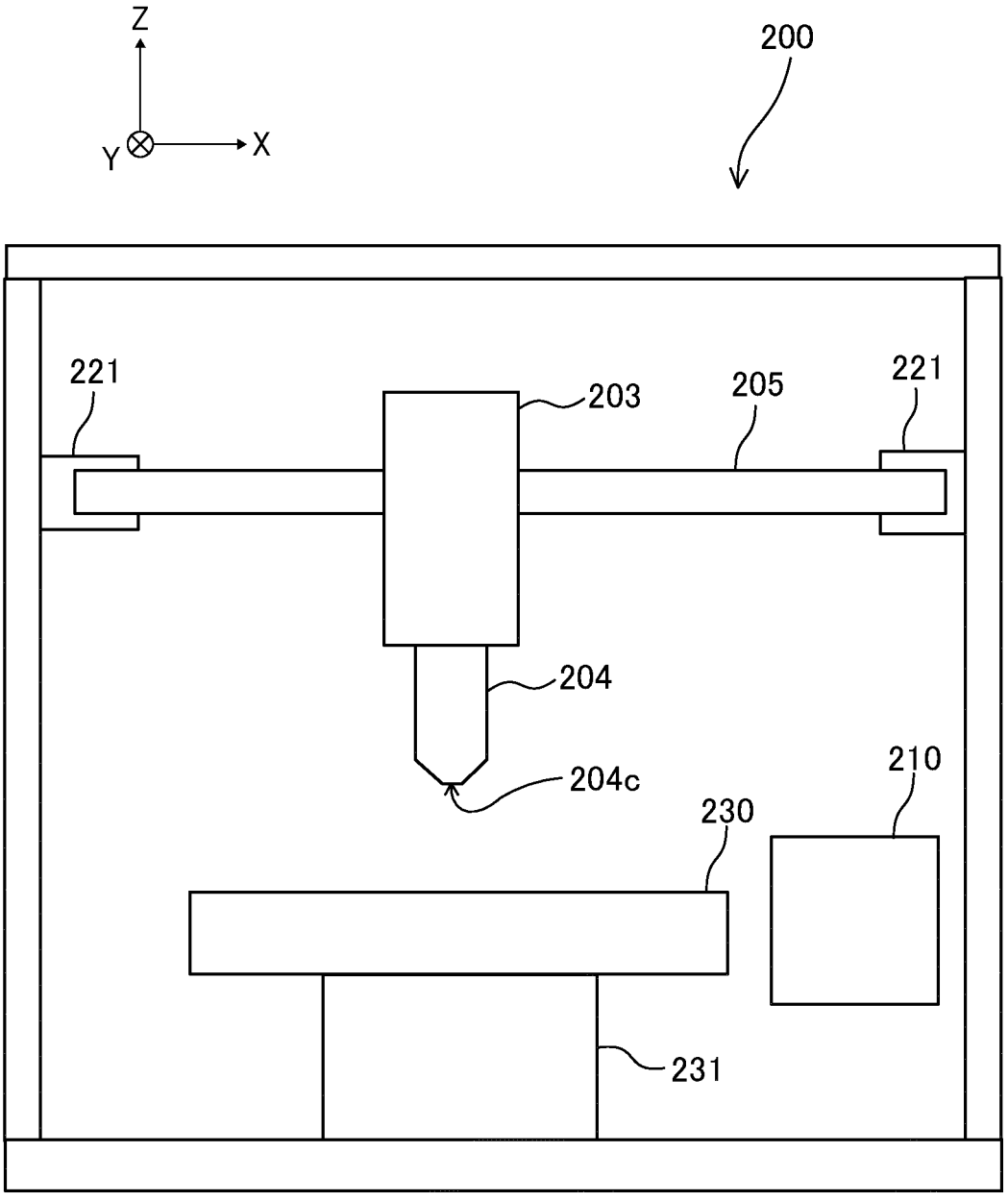


FIG. 9

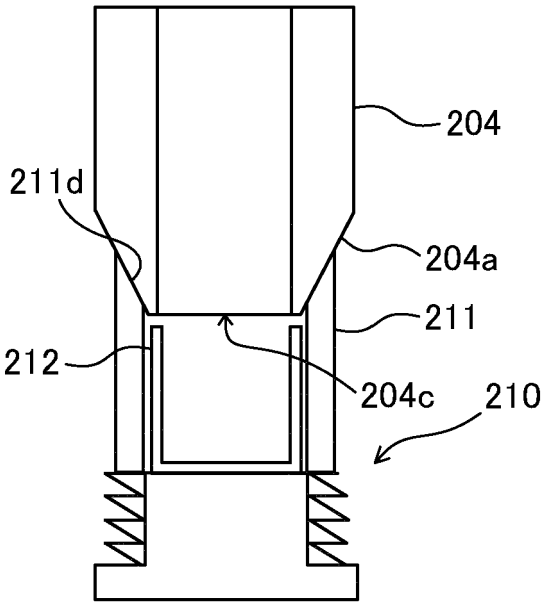


FIG. 10

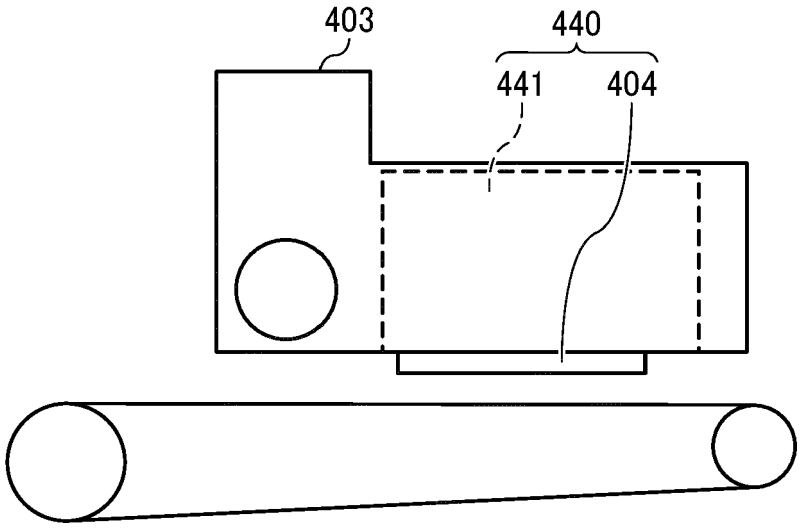
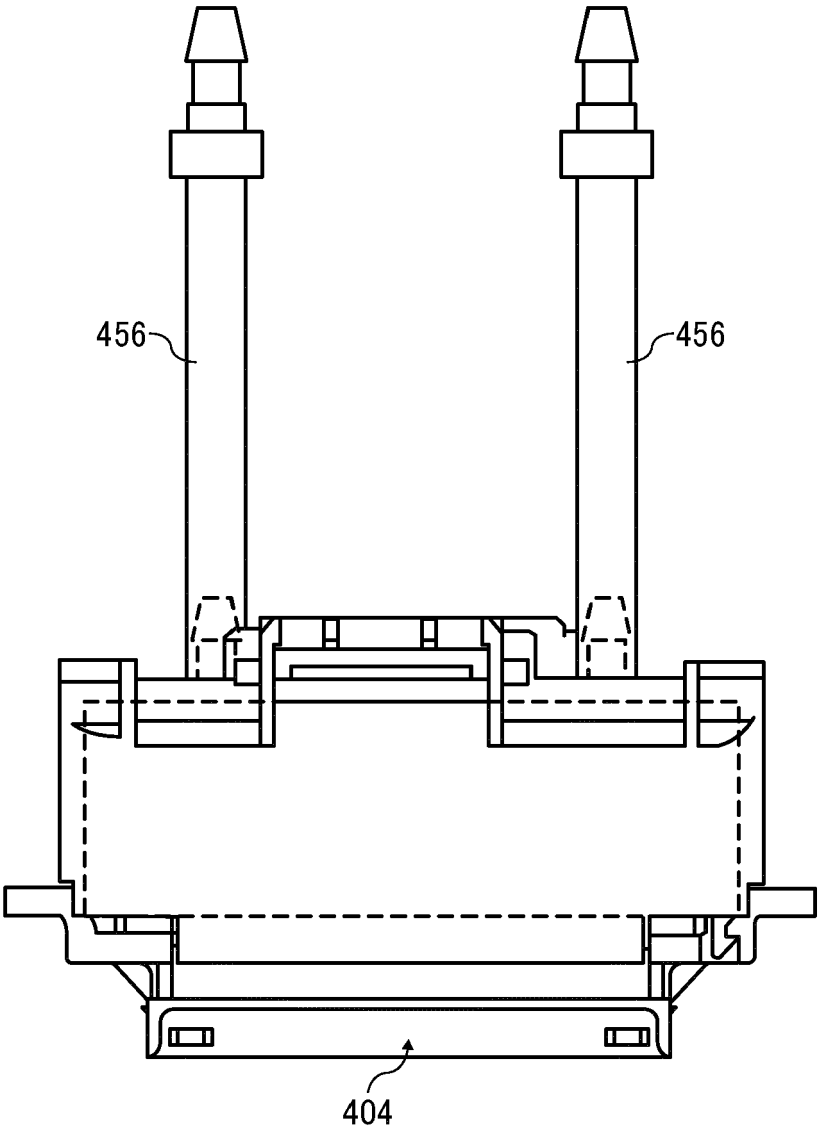


FIG. 11



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EUROPEAN SEARCH REPORT

Application Number
EP 22 21 0738

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2017/266974 A1 (HAMAGUCHI MASAYA [JP] ET AL) 21 September 2017 (2017-09-21)	1-8,13	INV. B41J2/165
Y	* figures 16, 18 * * paragraph [0089] * * paragraph [0123] * * paragraph [0126] *	9	
X	US 2013/106949 A1 (YOSHIHISA SUGATA [JP]) 2 May 2013 (2013-05-02)	1,10-12	
Y	* figures 1, 8, 10-14 * * paragraph [0083] *	9	
X	US 2021/394516 A1 (TAKAHASHI KENTA [JP]) 23 December 2021 (2021-12-23) * figure 3 * * paragraph [0045] *	1	

TECHNICAL FIELDS SEARCHED (IPC)

B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 April 2023	João, César

CATEGORY OF CITED DOCUMENTS

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20-04-2023

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