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

(11) EP 4 464 514 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
20.11.2024 Bulletin 2024/47

(21) Application number: **24176139.4**

(22) Date of filing: **15.05.2024**

(51) International Patent Classification (IPC):
B41J 3/407 *(2006.01)* ***B41J 11/00*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B41J 11/00214; B41J 3/4073; B41J 2203/01

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **18.05.2023 JP 2023082096**

(71) Applicant: **Seiko Epson Corporation**
Tokyo 160-8801 (JP)

(72) Inventors:
- **OGUCHI, Hideki**
  Suwa-shi, Nagano, 392-8502 (JP)
- **YAHIRO, Yuki**
  Suwa-shi, Nagano, 392-8502 (JP)

(74) Representative: **MERH-IP Matias Erny Reichl Hoffmann**
Patentanwälte PartG mbB
Paul-Heyse-Strasse 29
80336 München (DE)

(54) PRINTING METHOD, PRINT HEAD UNIT, AND ROBOT SYSTEM

(57) A printing method for performing printing on an object by using an ink ejection head and a robot including a robot arm that supports and moves the ink ejection head, in which the ink ejection head ejects curable ink and prints on the object while the robot scans the ink ejection head, the printing method includes a step of the ink ejection head ejecting the curable ink toward the object; a step of inspecting the curable ink ejected onto the object and outputting an inspection result; a step of determining whether the inspection result is pass or fail; and a step of curing the curable ink ejected onto the object when the inspection result is pass.

EP 4 464 514 A1

Description

[0001] The present application is based on, and claims priority from JP Application Serial Number 2023-082096, filed May 18, 2023, the disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

1. Technical Field

[0002] The present invention relates to a printing method, a print head unit, and a robot system.

2. Related Art

[0003] There is known a three dimensional object printing device that performs printing on a surface of a three dimensional object by moving an inkjet print head by combining operations of a plurality of movable sections.

[0004] For example, JP-A-2013-202781 discloses a system for inkjet printing on a three dimensional object including a joint arm robot, a print head, and a piezo actuator arranged therebetween. A robot is configured to move a print head along a surface of an object. This allows inkjet printing to be performed even on non-planar regions.

[0005] Curable ink can also be used in inkjet printing. Curable ink is cured by, for example, being irradiated with ultraviolet light or being heated after being ejected onto an object. Therefore, there is a problem that it is difficult to remove the ink that has been completely cured, and even when a print result is defective, it cannot be corrected. Therefore, it is required to realize a printing method capable of correcting a print result even when the printing result is defective in printing performed by a robot ejecting curable ink.

SUMMARY

[0006] A printing method according to an application example of the present disclosure is a printing method for performing printing on an object by using an ink ejection head and a robot including a robot arm that supports and moves the ink ejection head, in which the ink ejection head ejects curable ink and prints on the object while the robot scans the ink ejection head, the printing method including a step of the ink ejection head ejecting the curable ink toward the object; a step of inspecting the curable ink ejected onto the object and outputting an inspection result; a step of determining whether the inspection result is pass or fail; and a step of curing the curable ink ejected onto the object when the inspection result is pass.

[0007] A print head unit according to an application example of the present disclosure is a print head unit supported by a robot arm and configured to perform printing by being scanned with respect to an object, the print head unit including an attachment section configured to attach to a robot arm; an ink ejection head that ejects curable ink; an inspection device that inspects the ejected curable ink; and a curing device that cures the ejected curable ink.

[0008] A robot system according to an application example of the present disclosure is a robot system for performing printing onto an object, the robot system including an ink ejection head that ejects curable ink; a robot including a robot arm that supports and moves the ink ejection head; an inspection device that inspects the ejected curable ink; a curing device that cures the ejected curable ink; and a control device that performs the printing by controlling each operation of the ink ejection head, the robot, the inspection device, and the curing device, wherein the control device includes an inspection result acquisition section that acquires an inspection result output from the inspection device, a determination section that determines whether the inspection result is pass or fail, and a curing process section that causes the curing device to cure the curable ink when the inspection result is pass.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 is a perspective view showing the entire configuration of a robot system according to a first embodiment.

FIG. 2 is a functional block diagram of the robot system shown in FIG. 1.

FIG. 3 is a plan view showing a print head unit shown in FIG. 1.

FIG. 4 is a flowchart for explaining a printing method according to the first embodiment.

FIG. 5 is a diagram for explaining the printing method shown in FIG. 4, and is a diagram for explaining an operation of the robot system in each step shown in FIG. 4.

FIG. 6 is a diagram for explaining the printing method shown in FIG. 4, and is a diagram for explaining an operation of the robot system in each step shown in FIG. 4.

FIG. 7 is a diagram for explaining the printing method shown in FIG. 4, and is a diagram for explaining an operation of the robot system in each step shown in FIG. 4.

FIG. 8 is a diagram for explaining the printing method shown in FIG. 4, and is a diagram for explaining an operation of the robot system in each step shown in FIG. 4.

FIG. 9 is a diagram for explaining the printing method shown in FIG. 4, and is a diagram for explaining an operation of the robot system in each step shown in FIG. 4.

FIG. 10 is a side view showing a partial configuration of the robot system according to a second embodiment.

Fig. 11 is a side view showing a partial configuration of the robot system according to the second embodiment.

Fig. 12 is a side view showing a partial configuration of the robot system according to the second embodiment.

FIG. 13 is a flowchart for explaining a printing method according to a third embodiment.

FIG. 14 is a side view showing a partial configuration of the print head unit and the robot system used in a printing method shown in FIG. 13.

DESCRIPTION OF EMBODIMENTS

[0010] Hereinafter, preferred embodiments of a printing method, a print head unit and a robot system of the present disclosure will be described in detail with reference to the accompanying drawings.

1. FIRST EMBODIMENT

[0011] First, a printing method, a print head unit, and a robot system according to a first embodiment will be described.

1. 1. Robot system

[0012] FIG. 1 is a perspective view showing the entire configuration of a robot system 100 according to the first embodiment. FIG. 2 is a functional block diagram of the robot system 100 shown in FIG. 1. FIG. 3 is a plan view showing a print head unit 10 shown in FIG. 1.

[0013] The robot system 100 shown in FIG. 1 includes a robot 200, the print head unit 10 (print head unit according to the first embodiment), a fixing member 700 that supports and fixes an object Q, and a control device 900.

[0014] The robot 200 is a six axes vertical articulated robot including six drive axes. The robot 200 includes a base 210 fixed to a floor, a robot arm 220 connected to the base 210, and a movement stage 300 attached to the robot arm 220. The movement stage 300 may be provided as necessary, and may be omitted. In this case, the print head unit 10 may be directly attached to the robot arm 220. The number of drive axes of the robot 200 may be less than or more than six. The robot 200 may be a horizontal articulated robot or a multi-arm robot including a plurality of robot arms.

[0015] The robot arm 220 is a robotic arm in which a plurality of arms 221, 222, 223, 224, 225, and 226 are rotatably connected, and includes six joints J1 to J6. Among them, the joints J2, J3, and J5 are bending joints, and the joints J1, J4, and J6 are torsional joints. Further, the robot arm 220 is provided with an arm drive mechanism 230 shown in FIG. 2. The arm drive mechanism 230 includes motors M and encoders E provided in the joints J1, J2, J3, J4, J5, and J6 shown in FIG. 1. The motor M is a drive source for driving each of the joints J1, J2, J3, J4, J5, and J6. The encoder E detects a rotation amount of the motor M (a pivot angle of an arm).

[0016] As shown in FIG. 1, the print head unit 10 is attached to a tip end section of the arm 226 via the movement stage 300. The print head unit 10 shown in FIG. 1 includes an attachment section 11, an ink ejection head 400, an inspection device 500, and a curing device 800.

[0017] The attachment section 11 is connected to a tip end section of the arm 226 via the movement stage 300. The attachment section 11 supports the ink ejection head 400, the inspection device 500, and the curing device 800. Such an attachment section 11 is formed of, for example, a plate having sufficient rigidity. With this, it is possible to connect the ink ejection head 400, the inspection device 500, and the curing device 800 to the robot arm 220 while maintaining the mutual positional relationship. The configuration of the attachment section 11 is not limited thereto.

[0018] As shown in FIG. 3, the ink ejection head 400 includes an ink chamber (not shown), a diaphragm arranged on a wall surface of the ink chamber (not shown), and ink ejection apertures 411 connected to the ink chamber, and is configured such that ink in the ink chamber is ejected from the ink ejection apertures 411 by vibration of the diaphragm. However, the configuration of the ink ejection head 400 is not particularly limited.

[0019] Ink ejected from the ink ejection head 400 is curable ink. Curable ink is ink having a characteristic of, after being ejected in an uncured state, causing a curing reaction and being cured. Since the timing of a curing reaction can be selected, it is possible to appropriately fix ink to the object Q made of various materials. Examples of the curable ink include an ultraviolet curable ink (UV ink) and a thermosetting ink (resin type ink). Among these, since ultraviolet curable ink is ink which is cured in a short time by being irradiated with ultraviolet light, the range of wetting and spreading is particularly easily controlled, and the ultraviolet curable ink is useful as ink which is ejected from the ink ejection head 400. On the other hand, there are also thermosetting inks that are water-based inks. Water-based ink is useful as ink that generates little odor and is easy to handle.

[0020] The robot system 100 includes a print controller 420. As shown in FIG. 2, the ink ejection head 400 is connected to the print controller 420. In the example of FIG. 1, the print controller 420 is attached to a tip end section of the arm 226 via the movement stage 300 similarly to the ink ejection head 400. The print controller 420 controls operation of the ink ejection head 400 based on control signals output from the control device 900.

[0021] The print controller 420 includes, for example, a processor such as one or more central processing units (CPUs), a memory, an external interface, and the like. The print controller 420 may include a programmable logic device such as a field programmable gate array (FPGA) instead of the CPU or in addition to the CPU. The print controller 420 may be incorporated into the control device 900.

[0022] As shown in FIG. 3, the inspection device 500 includes an imaging section 510. The imaging section 510 images the ink ejected onto the object Q. The ejected ink can be inspected based on the image captured by the imaging section 510. In the present specification, "inspection" refers to capturing an image of an ink film formed with ejected ink.

[0023] In the present embodiment, the inspection device 500 is included in the print head unit 10, but may not necessarily be included. In this case, for example, the inspection device 500 may be provided at an arbitrary position of the robot arm 220, or may be provided at a position different from the robot arm 220. Example of a position different from the robot arm 220 are, for example, a ceiling or a wall of a space in which the robot 200 is arranged, a pillar erected on a floor, or the like.

[0024] The imaging section 510 is, for example, a camera. Examples of the camera include a black-and-white camera, a color camera, and a spectroscopic camera.

[0025] Among these cameras, the black-and-white camera and the color camera can acquire an image including at least luminance information distributed two dimensionally. The luminance information is a luminance value in two dimensional pixels. By using such an image, it is possible to inspect a position and a shape of the ink ejected onto the object Q.

[0026] A spectroscopic camera can acquire an image including at least two dimensional luminance information and color information. The color information is the chromaticity and brightness in pixels. By using an image with such color information, it is possible to inspect not only the position and the shape of the ink ejected onto the object Q, but also the color of the ink, that is, the type of the ink.

[0027] As shown in FIG. 3, the curing device 800 includes an ultraviolet light irradiation section 810. The ultraviolet light irradiation section 810 irradiates ultraviolet light toward the ink ejected onto the object Q. By this, ultraviolet curable ink can be cured and fixed.

[0028] The curing device 800 may include a device other than the ultraviolet light irradiation section 810. Such devices include, for example, a resistance heating heater, an infrared heater, and the like. When these devices are used, thermosetting ink may be used as the ink.

[0029] In the present embodiment, the curing device 800 is included in the print head unit 10, but may not necessarily be included. In this case, for example, the curing device 800 may be provided at an arbitrary position of the robot arm 220, or may be provided at a position different from the robot arm 220. Example of a position different from the robot arm 220 are, for example, a ceiling or a wall of a space in which the robot 200 is arranged, a pillar erected on a floor, or the like.

[0030] As shown in FIG. 3, the movement stage 300 includes a base section 310 connected to the arm 226, a stage 320 that moves with respect to the base section 310, and a movement mechanism 330 that moves the stage 320 with respect to the base section 310. As shown in FIG. 3, when three axes orthogonal to each other are defined as an X-axis, a Y-axis, and a Z-axis, the stage 320 includes a Y-stage 320Y movable in a direction along the Y-axis with respect to the base section 310 and an X-stage 320X movable in a direction along the X-axis with respect to the Y-stage 320Y. The X-stage 320X and the Y-stage 320Y are linearly guided in an X-axis direction and a Y-axis direction by a linear guide (not shown), and can smoothly move. The print head unit 10 is attached to the X-stage 320X. The stage 320 may include a rotation stage rotatable about the Z-axis with respect to the base section 310.

[0031] The movement mechanism 330 includes a Y-movement mechanism 330Y which moves the Y-stage 320Y in a direction along the Y-axis with respect to the base section 310 and an X-movement mechanism 330X which moves the X-stage 320X in a direction along the X-axis with respect to the Y-stage 320Y.

[0032] The Y-movement mechanism 330Y and the X-movement mechanism 330X each include a piezoelectric actuator 340 as a drive source. The piezoelectric actuators 340 vibrates using expansion and contraction of piezoelectric elements, and move the X-stage 320X and the Y-stage 320Y by transmitting the vibration to the X-stage 320X and the Y-stage 320Y. That is, the movement stage 300 is configured to move the print head unit 10 with respect to the robot arm 220 by piezo drive. This makes it possible to reduce the size and weight of the movement stage 300. Further, the drive accuracy of the movement stage 300 is improved. Furthermore, since the piezoelectric actuator 340 has a large holding torque at the time of stopping, it is also useful that there is no need to add a brake and that the positional stability of the stage 320 at the time of stoppin is high. The drive source may be an actuator other than the piezoelectric actuator 340.

[0033] As shown in FIGS. 1 and 2, the robot system 100 includes a robot controller 600. The motors M and the encoders E are connected to the robot controller 600. The robot controller 600 controls an operation of the robot 200 based on a control signal output from the control device 900.

[0034] The robot controller 600 includes, as functional sections, an arm control section 610, a movement stage controller 620, and a storage section 630.

[0035] The arm control section 610 controls the robot arm 220 to a target posture by outputting a control signal for controlling an operation of the arm drive mechanism 230.

[0036] The movement stage controller 620 moves the print head unit 10 to a target position with respect to the robot arm 220 by outputting a control signal for controlling an operation of the movement stage 300. The movement stage controller 620 may be independent of the robot controller 600.

[0037] The storage section 630 stores a program necessary for processing in the robot controller 600, data necessary for execution of the program, and the like.

[0038] The robot controller 600 includes, for example, a processor, such as one or more CPUs, a memory, an external interface, and the like. The robot controller 600 may include a programmable logic device such as an FPGA instead of the CPU or in addition to the CPU.

[0039] The control device 900 controls each operation of the robot controller 600, the print controller 420, the inspection device 500, and the curing device 800 to execute printing onto the object Q. As shown in FIG. 2, the control device 900 includes a print control section 910 and a storage section 930 as functional sections. The print control section 910 includes a print data generation section 912, an inspection result acquisition section 914, a determination section 916, and a curing process section 918.

[0040] The print data generation section 912 generates print data and outputs it to the robot controller 600 and the print controller 420. Print data is data constituting characters, images, and the like to be printed on the object Q.

[0041] The inspection result acquisition section 914 controls operation of the inspection device 500 and causes the inspection device 500 to image ink immediately after the ink is ejected onto a print surface Q1 of the object Q. Then, the obtained image is output as an inspection result and acquired.

[0042] The determination section 916 determines whether an inspection result acquired by the inspection result acquisition section 914 is acceptable or not. As a determination method for determining whether an inspection result is pass or fail, for example, in the case where an inspection result is an image including two dimensional luminance information, a method of determining whether or not a pattern constituted by position and shape of the ejected ink matches a pattern included in a template image registered in advance, that is, an acceptability criterion can be given. In this determination, whether an inspection result is acceptable or not is determined based on a known template matching technique.

[0043] When the inspection result is an image including color information, a method of determining whether or not the chromaticity and the brightness consisting of the hue and the saturation of the ejected ink satisfy an acceptability criterion registered in advance can be given. Specifically, for example, in an L*a*b* colorimetric system, a method of determining whether or not the difference (color difference ΔE) between color information included in an inspection result and a reference color is within a predetermined range can be given. Then, in a case where the color difference ΔE is within a predetermined range, the determination section 916 determines that an acceptability criterion is satisfied and that the inspection result is pass and, in a case where the color difference ΔE is not within the predetermined range, determines that the acceptability criterion is not satisfied and the inspection result is fail (is not pass). By using color information in this way, it is possible to perform a determination of whether an inspection result is pass or fail based on not only position and shape of the ejected ink but also on the color of the ink. As a result, it is possible to suppress the occurrence of color defects in a print result.

[0044] The curing process section 918 controls curing of an ink film by the curing device 800. Then, when the determination by the determination section 916 is pass, ultraviolet light is irradiated from the curing device 800 to cure the ink that was the target of inspection. On the other hand, when a determination by the determination section 916 is fail, the curing device 800 does not irradiate ultraviolet light.

[0045] The storage section 930 stores a program necessary for an operation of the control device 900, data necessary for the execution of the program, and the like.

[0046] The control device 900 is constituted by, for example, a computer, and includes a processor (CPU) that processes information, a memory that is communicably connected to the processor, and an external interface. Various programs that can be executed by the processor are stored in the memory, and the processor realizes the above-described functions by reading and executing the various programs and the like stored in the memory. The control device 900 may include a programmable logic device such as an FPGA instead of the CPU or in addition to the CPU.

[0047] The configuration of the robot system 100 according to the first embodiment has been described above, but the movement stage 300 may be attached to a position separated from the robot arm 220, for example, the fixing member 700, and may support the object Q. In this case, the movement stage 300 may be configured to finely adjust a position of the object Q in synchronization with an operation of the robot arm 220. The movement stage 300 may have a function of moving the print head unit 10 so as to cancel shaking of the robot arm 220 in an orthogonal direction D2 orthogonal to a printing direction D1 (to be described later), for example.

1. 2. Printing method

[0048] Next, a printing method according to the first embodiment will be described. In the following description, a method using the above-described robot system 100 will be described as an example.

[0049] FIG. 4 is a flowchart for explaining a printing method according to the first embodiment. FIGS. 5 to 9 are diagrams for explaining the printing method shown in FIG. 4, and are diagrams for explaining an operation of the robot system 100 in each step shown in FIG. 4.

[0050] The printing method according to the first embodiment is a method in which the ink ejection head 400 ejects ink 40 to perform printing on the object Q while the robot 200 causes the print head unit 10 to scan the object Q in the printing direction D1.

[0051] The printing method shown in FIG. 4 includes an ink ejecting step S102, an inspecting step S104, a determining step S106, an ink removing step S108, and a curing step S110. Hereinafter, each step will be described in order.

1. 2. 1. Ink ejecting step

[0052] In the ink ejecting step S102, the print data generation section 912 of the print control section 910 acquires the shape, size, and the like of the print surface Q1 of the object Q. Then, operating conditions of the robot 200 on the print surface Q1 are determined. The operating conditions are not particularly limited, and examples thereof include a posture, a movement path, acceleration, deceleration, the maximum speed, and the like of the robot arm 220 on the print surface Q1, and the movement amount, the movement speed, and the like of the movement stage 300. These operating conditions are set by the print data generation section 912 based on information previously input to the print control section 910, image data appropriately input thereto, and the like.

[0053] Next, in the ink ejecting step S102, print data generated by the print data generation section 912 is output to the robot controller 600 and the print controller 420. The robot controller 600 controls operation of the robot 200 based on print data. The print controller 420 controls operation of the ink ejection head 400 based on print data. Then, as shown in FIG. 5, the ink ejection head 400 ejects the ink 40 toward the print surface Q1 while the robot 200 causes the print head unit 10 to scan in the printing direction D1. The ejected ink 40 lands in a range (a predetermined range) set in print data to form an ink film 42. Here, the "predetermined range" refers to a minimum unit region in which inspection and curing are performed after formation of the ink film 42 in steps to be described later. By repeating formation of the ink film 42 and inspection and curing in the steps to be described later for each predetermined range, a target print result is finally obtained.

1.2.2. Inspecting step

[0054] In the inspecting step S104, the ink 40 ejected onto the print surface Q1, that is, the ink film 42 formed on the print surface Q1, is inspected. Specifically, as shown in FIG. 6, the ink film 42 is imaged by the inspection device 500. The inspection result acquisition section 914 of the control device 900 acquires the obtained image as an inspection result. Since the inspection device 500 is incorporated into the print head unit 10, inspection of the ink film 42 can be performed for each predetermined range. As a result, the size of an image for inspection can be small, and the inspection device 500 can be simplified. Therefore, it is possible to speed up the inspecting step S104 and the determining step S106. In addition, since it is possible to suppress the waiting time of inspection from becoming long, it is possible to suppress a change such as unintended wetting and spreading from occurring in the ink film 42.

[0055] Instead of performing inspection immediately after forming the ink film 42 in the predetermined range, the ink film 42 in the predetermined range may be formed in a plurality of units, and then the ink film 42 in a plurality of units may be collectively inspected. The predetermined range of the ink film 42 is not particularly limited, and is set in consideration of, for example, an inspection range of the inspection device 500, the drying time of the ink 40, and the like.

1.2.3. Determining step

[0056] In the determining step S106, the determination section 916 of the control device 900 determines whether or not an inspection result is pass in reference to the acceptability criterion.

[0057] When the inspection result is pass, the process proceeds to the curing step S110 . On the other hand, when the inspection result is fail, that is, is not pass, the process proceeds to the ink removing step S108. As a result, it is possible to prevent an ink film 42 of which the inspection result is fail (an ink film 42 with a printing failure) from being transferred to the curing step S110 to be described later. As a result, it is possible to ultimately obtain a print result with few failures while reducing the workload and costs for preparing a new object Q.

1.2.4. Ink removing step

[0058] In the ink removing step S108, the ink 40 ejected onto the print surface Q1, that is, the ink film 42, is removed. Thus, the object Q can be reused, and wasteful disposal of the object Q can be prevented. Since the ink film 42 is composed of uncured ink 40, it can be removed by various removing methods. As a method of removing the ink film 42, for example, wiping, blotting, washing, or the like can be given.

[0059] After the ink film 42 is removed, the process returns to the ink ejecting step S102, and printing is restarted. In this case, print data is set in the ink ejecting step S102 after printing is restarted so that printing is restarted from a portion removed in the ink removing step S108. 1.2.5. Curing step

[0060] In the curing step S110, when the inspection result is pass, then, as shown in FIG. 7, a curing process of irradiating ultraviolet light UV is performed on the ink film 42 that was the target of inspection. Thereby, the ink film 42 is cured, and the cured ink film 44 shown in FIG. 8 is obtained. As described above, the cured film 44 in which print data is faithfully reflected is obtained. According to the printing method as described above, it is possible to prevent the cured film 44, in which a printing failure occurred, from being generated. Therefore, it is possible to obtain a print result of a target shape.

[0061] Curing of the ink film 42 is performed for each predetermined range. Thus, since an irradiation range of ultraviolet light UV can be reduced, the curing device 800 can be reduced in size. In addition, since it is possible to suppress the waiting time of curing from becoming long, it is possible to suppress a change such as unintended wetting and spreading from occurring in the ink film 42.

[0062] Instead of performing curing immediately after inspecting the ink film 42 in a predetermined range, the ink film 42 in a predetermined range may be inspected in a plurality of units, and then the ink film 42 in a plurality of units may be cured collectively.

[0063] By repeating the formation of the cured film 44 by the printing method as described above, the cured film 44 can be continuously formed as shown in FIG. 9. Thereby, a cured film 46 in which print data is reflected can be obtained.

[0064] In the print head unit 10 shown in FIG. 3, the ink ejection head 400, the inspection device 500, and the curing device 800 are arranged in this order, and are integrally scanned by the robot 200. Therefore, when the print head unit 10 is scanned in the printing direction D1 immediately after the ink film 42 is formed by the ink ejection head 400, the inspection device 500 and the curing device 800 are sequentially moved onto the ink film 42. By this, ejection of the ink 40, inspection of the ink film 42, and curing of the ink film 42 can be continuously performed. As a result, it is possible to suppress the occurrence of printing failures one after another and to efficiently obtain highly accurate print results.

2. SECOND EMBODIMENT

[0065] Next, a print head unit and a robot system according to a second embodiment will be described.

[0066] FIGS. 10 to 12 are side views showing a partial configuration of the robot system 100 according to the second embodiment.

[0067] Hereinafter, the second embodiment will be described. In the following description, mainly differences from the first embodiment will be described and description of the same matters will be omitted. In FIGS. 10 to 12, the same components as those of the first embodiment are denoted by the same reference symbols.

[0068] The robot system 100 according to the second embodiment is the same as the robot system 100 according to the first embodiment except that the ink ejection head 400, the inspection device 500, and the curing device 800 are attached to a robot 200A, a robot 200B, and a robot 200C, which are different from each other.

[0069] In the second embodiment, first, as shown in FIG. 10, the ink 40 is ejected from the ink ejection head 400 attached to the robot 200A. Then, the ink film 42 is formed on the print surface Q1.

[0070] Next, the inspection device 500 attached to the robot 200B on the ink film 42 is moved. Then, as shown in FIG. 11, the inspection device 500 inspects the ink film 42.

[0071] Next, it is determined whether or not the inspection result is pass, and when the inspection result is pass, the curing device 800 attached to the robot 200C is moved over the ink film 42. Then, as shown in FIG. 12, the ink film 42 is cured by the curing device 800. Thereby, the same cured film 44 as in FIG. 8 is obtained.

[0072] Also in the second embodiment as described above, the same effects as those of the first embodiment can be obtained.

[0073] Further, in the second embodiment, the timing of inspection of the ink film 42 and the timing of curing the ink film 42 can be freely adjusted. Therefore, for example, it is also possible to perform inspection or curing after waiting for the ejected ink 40 to wet and spread. This makes it possible to perform inspection and curing according to the characteristics of the ink 40, thereby making it possible to form the cured film 44 of higher quality.

[0074] Any two of the ink ejection head 400, the inspection device 500, and the curing device 800 may be attached to one robot, and the remaining one may be attached to another robot.

3. THIRD EMBODIMENT

[0075] Next, a printing method, a print head unit, and a robot system according to a third embodiment will be described.

[0076] FIG. 13 is a flowchart for explaining a printing method according to the third embodiment. FIG. 14 is a side view showing a partial configuration of the print head unit 10 and the robot system 100 used in the printing method shown in FIG. 13.

[0077] Hereinafter, the third embodiment will be described. In the following description, mainly described differences from the first embodiment will be described and the description of the same matters will be omitted. In FIGS. 13 and 14, the same components as those of the first embodiment are denoted by the same reference symbols.

[0078] The printing method according to the third embodiment is the same as the printing method according to the first embodiment except that a provisional curing step S120 is included. The print head unit 10 and the robot system 100 according to the third embodiment are the same as the print head unit 10 and the robot system 100 according to the first embodiment except that a provisional curing device 850 is provided.

[0079] The printing method shown in FIG. 13 includes, in addition to the steps shown in FIG. 4, the provisional curing step S120 provided between the ink ejecting step S102 and the inspecting step S104. In the provisional curing step S120, the ink 40 ejected onto the print surface Q1, that is, the ink film 42 formed on the print surface Q1, is provisionally cured. The provisional curing is performed using the provisional curing device 850 shown in FIG. 14.

[0080] The provisional curing device 850 shown in FIG. 14 is the same as the curing device 800 shown in FIG. 3, except that the cumulative amount of ultraviolet light to be irradiated is set to be smaller than the cumulative amount of ultraviolet light irradiated by the curing device 800. Since the cumulative amount of ultraviolet light is set to be small, even when the ink film 42 is irradiated with ultraviolet light from the provisional curing device 850, the ink film 42 does not reach curing and remains in a state of provisional curing (semi-cured). The provisionally cured ink film 42 can be removed in the ink removing step S108. The provisionally cured ink film 42 is less likely to wet and spread as compared with the ink film 42 immediately after formation. Therefore, a landing position of the ink 40 is accurately reflected on the provisionally cured ink film 42, and the ink film 42 has a desired shape.

[0081] In the print head unit 10 shown in FIG. 14, the ink ejection head 400, the provisional curing device 850, the inspection device 500, and the curing device 800 are arranged in this order, and are integrally scanned by the robot 200. Therefore, when the print head unit 10 is scanned in the printing direction D1 immediately after the ink film 42 is formed by the ink ejection head 400, the provisional curing device 850, the inspection device 500, and the curing device 800 are sequentially moved over the ink film 42. Thereby, ejection of the ink 40, provisional curing of the ink film 42, inspection of the ink film 42, and curing of the ink film 42 can be continuously performed. As a result, the cured film 44 with high accuracy can be continuously formed, and a print result with high accuracy can be obtained.

[0082] Also in the third embodiment as described above, the same effect as in the first embodiment can be obtained.

4. Effects achieved by each embodiment

[0083] As described above, the printing method according to the embodiment is a printing method for performing printing on the object Q by using the ink ejection head 400 and the robot 200, in which the ink ejection head 400 ejects the ink 40 (curable ink) and prints on the object Q while the robot 200 scans the ink ejection head 400. The robot 200 includes the robot arm 220 that supports and moves the ink ejection head 400. The printing method includes the ink ejecting step S102, the inspecting step S104, the determining step S106, and the curing step S110. In the ink ejecting step S102, the ink ejection head 400 ejects the ink 40 toward the object Q. In the inspecting step S104, the ink 40 ejected onto the object Q is inspected, and an inspection result is output. In the determining step S106, it is determined whether or not the inspection result is pass. In the curing step S110, the ink 40 ejected onto the object Q is cured when the inspection result is pass.

[0084] According to such a configuration, even when a print result by the ink 40, which is a curable ink, is defective, it is possible to inspect the ink film 42 before curing and correct it as necessary. For this reason, it is possible to avoid discarding the object Q because of a printing failure, and it is possible to obtain print results with fewer failures while reducing workload and costs. As a result, it is possible to efficiently perform highly accurate printing on the object Q.

[0085] Further, it is desirable that the ink 40 (curable ink) is an ink which is cured by irradiation of ultraviolet light UV.

[0086] Since ultraviolet curable ink is ink which is cured in a short time by being irradiated with ultraviolet light UV, the range of wetting and spreading is particularly easily controlled.

[0087] The inspection result described above may include a two dimensional image obtained by imaging the ink 40 (curable ink) ejected onto the object Q. In this case, it is desirable that the determining step S106 (step of determining whether or not the inspection result is pass) includes a process of determining whether or not a two dimensional image satisfies an acceptability criterion, and when the two dimensional image satisfies the criterion, it is determined to pass.

[0088] A two dimensional image can be used for inspection of the position and shape of the ink 40 ejected onto the object Q. For this reason, template matching can be performed on a pattern formed by the position and shape of the ink 40. By this, a determination of whether the inspection result is pass or fail can be performed more easily and accurately.

[0089] The inspection result described above may include color information acquired from the ink 40 (curable ink) ejected onto the object Q. In this case, it is desirable that the determining step S106 (step of determining whether or not the inspection result is pass) includes a process of determining whether or not color information satisfies an acceptability criterion, and when the color information satisfies the criterion, it is determined to pass.

[0090] In the color information, the color of the ink 40 ejected onto the object Q can be included in the inspection result. As a result, it is possible to suppress the occurrence of color defects in a print result.

[0091] The printing method may include the ink removing step S108 of removing the ink 40 (curable ink) ejected onto the object Q in a case where the inspection result described above is negative.

[0092] According to such a configuration, it is possible to reuse the object Q by removing the ink 40 that was determined as fail. This makes it possible to prevent wasteful disposal of the object Q.

[0093] The printing method according to the embodiment includes a provisional curing step S120, if necessary. The provisional curing step S120 is provided before the inspecting step S104 (step of outputting an inspection result), and the ink 40 (curable ink) ejected onto the object Q is provisionally cured.

[0094] According to such a configuration, a provisionally cured ink film 42, is obtained that is in a state of being unlikely to wet and spread, as compared with the ink film 42 immediately after formation. The provisionally cured ink film 42 accurately reflects a landing position of the ink 40, and has an intended shape. The provisionally cured ink film 42 can be removed in the ink removing step S108.

[0095] The print head unit 10 according to the embodiment is supported by the robot arm 220, and performs printing by being scanned with respect to the object Q. The print head unit 10 includes the attachment section 11, the ink ejection head 400, the inspection device 500, and the curing device 800. The attachment section 11 is attached to the robot arm 220. The ink ejection head 400 ejects the ink 40 (curable ink). The inspection device 500 inspects the ejected ink 40. The curing device 800 cures the ejected ink 40.

[0096] According to such a configuration, even though a print result with the ink 40 is defective, it is possible to obtain a print head unit 10 that can be applied to a printing method of inspecting the ink film 42 before curing it and correcting it as necessary. For this reason, it is possible to avoid discarding the object Q because of a printing failure, and it is possible to obtain print results with fewer failures while reducing workload and costs. As a result, it is possible to efficiently perform highly accurate printing on the object Q.

[0097] It is desirable that the ink ejection head 400, the inspection device 500, and the curing device 800 are arranged in this order.

[0098] Since the print head unit 10 is integrally scanned, ejection of the ink 40, inspection of the ink film 42, and curing of the ink film 42 can be continuously performed. Thereby, the cured film 44 with high accuracy can be continuously formed, and a print result with high accuracy can be obtained.

[0099] The robot system 100 according to the embodiment is a robot system which performs printing on the object Q, and includes the ink ejection head 400, the robot 200, the inspection device 500, the curing device 800, and the control device 900. The ink ejection head 400 ejects the ink 40 (curable ink). The robot 200 includes the robot arm 220 that supports and moves the ink ejection head 400. The inspection device 500 inspects the ejected ink 40 . The curing device 800 cures the ejected ink 40. The control device 900 performs printing by controlling each operation of the ink ejection head 400, the robot 200, the inspection device 500, and the curing device 800. The control device 900 includes the inspection result acquisition section 914, the determination section 916, and the curing process section 918. The inspection result acquisition section 914 acquires an inspection result output from the inspection device 500. The determination section 916 determines whether or not the inspection result is pass. The curing process section 918 causes the curing device 800 to cure the ink 40 when the inspection result is pass.

[0100] According to such a configuration, even though a print result by the ink 40, which is curable ink, is defective, it is possible to realize the robot system 100 capable of inspecting the ink film 42 before curing the ink film 42 and correcting the ink film 42 as necessary. By using such a robot system 100, it is possible to avoid the discarding of the object Q due to a printing failure, and it is possible to obtain a print result with few defects while reducing the workload and costs. Thus, it is possible to efficiently perform highly accurate printing on the object Q.

[0101] Although the printing method, the print head unit, and the robot system of the present disclosure have been described based on the shown embodiments, the printing method, the print head unit, and the robot system of the present disclosure are not limited to the above embodiments. For example, the printing method of the present disclosure may be one in which any desired process or operation is added to the above-described embodiment. Further, the print head unit and the robot system of the present disclosure may be those in which each part of the above-described embodiment is replaced with an arbitrary configuration having a similar function, or may be those in which an arbitrary configuration is added to the above-described embodiment.

Claims

1. A printing method for performing printing on an object by using an ink ejection head and a robot including a robot arm that supports and moves the ink ejection head, in which the ink ejection head ejects curable ink and prints on the object while the robot scans the ink ejection head, the printing method comprising:

    a step of the ink ejection head ejecting the curable ink toward the object;
    a step of inspecting the curable ink ejected onto the object and outputting an inspection result;
    a step of determining whether the inspection result is pass or fail; and
    a step of curing the curable ink ejected onto the object when the inspection result is pass.

2. The printing method according to claim 1, wherein the curable ink is ink that is cured by irradiation of ultraviolet light.

3. The printing method according to claim 1, wherein

    the inspection result includes a two dimensional image obtained by imaging the curable ink ejected onto the object and
    the step of determining whether the inspection result is pass or fail includes a step of determining whether or not the two dimensional image satisfies an acceptability criterion, and determining that the inspection result is pass when the two dimensional image satisfies the acceptability criterion.

4. The printing method according to claim 1, wherein

    the inspection result includes color information acquired from the curable ink ejected onto the object and the step of determining whether the inspection result is pass or fail includes a step of determining whether or not the color information satisfies an acceptability criterion, and determining that the inspection result is pass when the two dimensional image satisfies the acceptability criterion.

5. The printing method according to claim 1, further comprising:
a step of removing the curable ink ejected to the object when the inspection result is negative.

6. The printing method according to claim 1, further comprising:
a step of provisional curing the curable ink ejected onto the object before the step of outputting the inspection result.

7. A print head unit supported by a robot arm and configured to perform printing by being scanned with respect to an object, the print head unit comprising:

an attachment section configured to attach to a robot arm;
an ink ejection head that ejects curable ink;
an inspection device that inspects the ejected curable ink; and
a curing device that cures the ejected curable ink.

8. The print head unit according to claim 7, wherein the ink ejection head, the inspection device, and the curing device are arranged in this order.

9. A robot system for performing printing onto an object, the robot system comprising:

an ink ejection head that ejects curable ink;
a robot including a robot arm that supports and moves the ink ejection head;
an inspection device that inspects the ejected curable ink;
a curing device that cures the ejected curable ink; and
a control device that performs the printing by controlling each operation of the ink ejection head, the robot, the inspection device, and the curing device, wherein
the control device includes

an inspection result acquisition section that acquires an inspection result output from the inspection device,
a determination section that determines whether the inspection result is pass or fail, and
a curing process section that causes the curing device to cure the curable ink when the inspection result is pass.

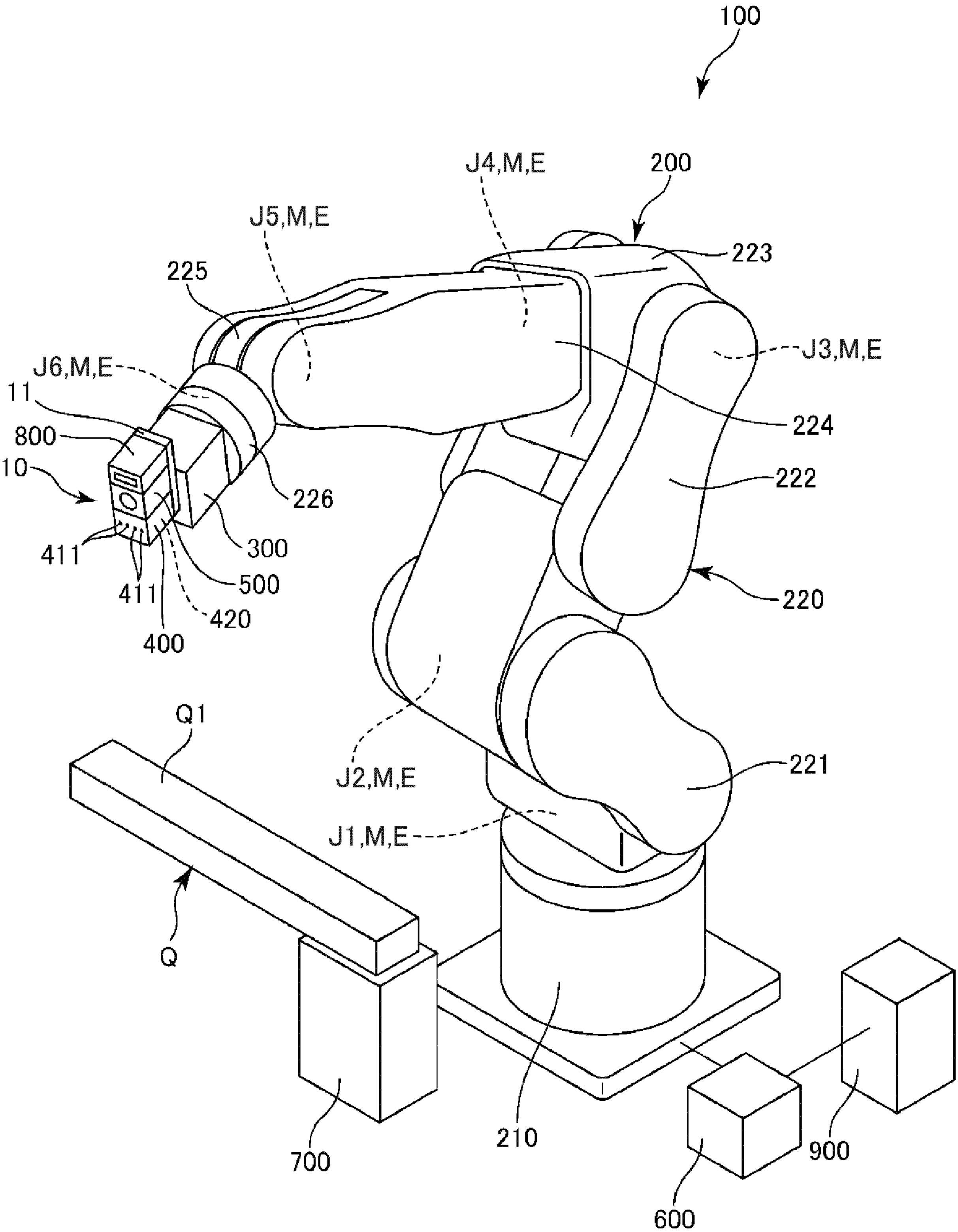
100
200
J4,M,E
J5,M,E
223
225
J3,M,E
J6,M,E
11
224
800
10
222
226
300
411
500
220
411
420
400
Q1
J2,M,E
221
J1,M,E
Q
700
210
900
600

FIG. 1

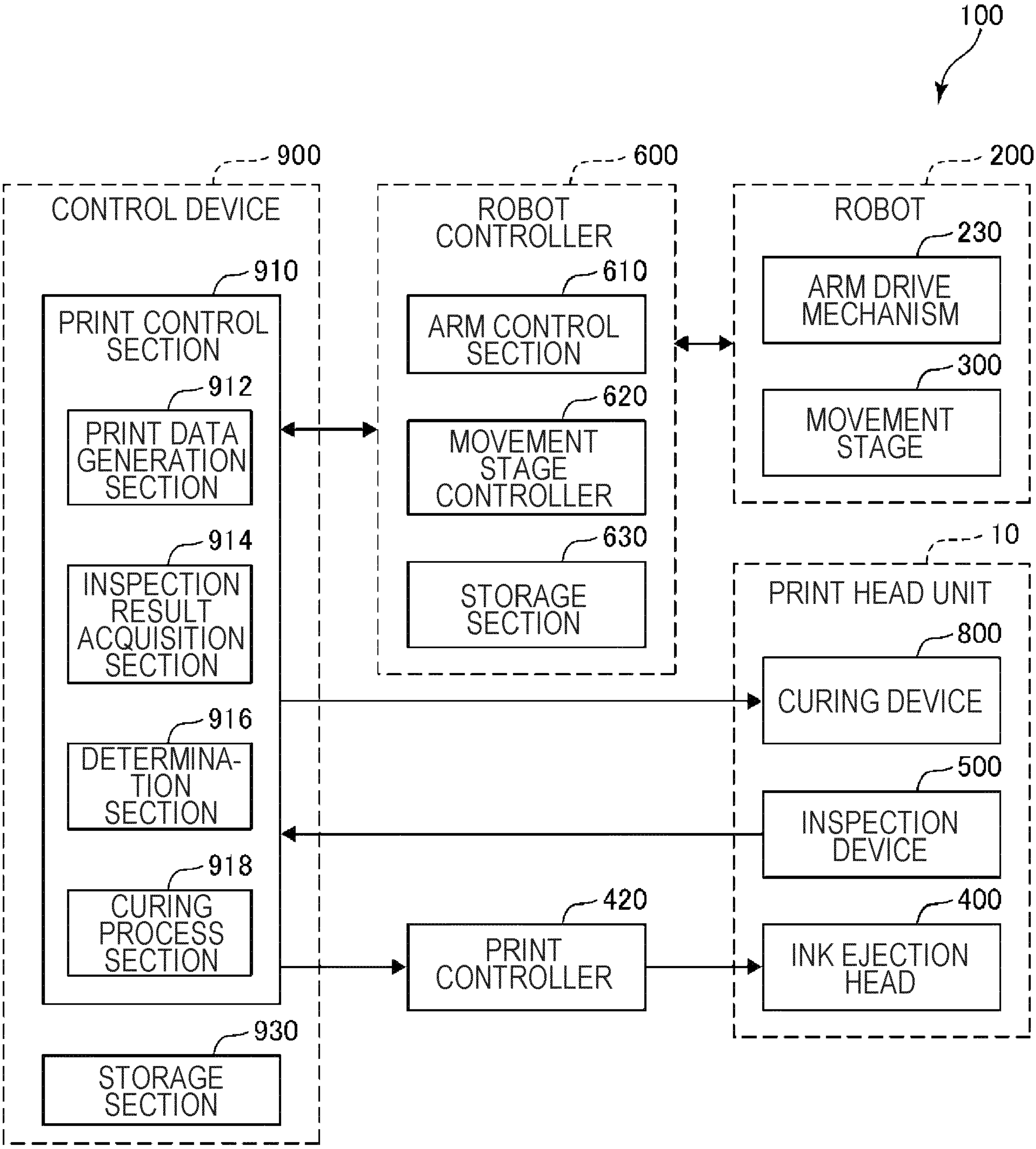
100
900
CONTROL DEVICE
910
PRINT CONTROL SECTION
912
PRINT DATA GENERATION SECTION
914
INSPECTION RESULT ACQUISITION SECTION
916
DETERMINATION SECTION
918
CURING PROCESS SECTION
930
STORAGE SECTION
600
ROBOT CONTROLLER
610
ARM CONTROL SECTION
620
MOVEMENT STAGE CONTROLLER
630
STORAGE SECTION
420
PRINT CONTROLLER
200
ROBOT
230
ARM DRIVE MECHANISM
300
MOVEMENT STAGE
10
PRINT HEAD UNIT
800
CURING DEVICE
500
INSPECTION DEVICE
400
INK EJECTION HEAD

FIG. 2

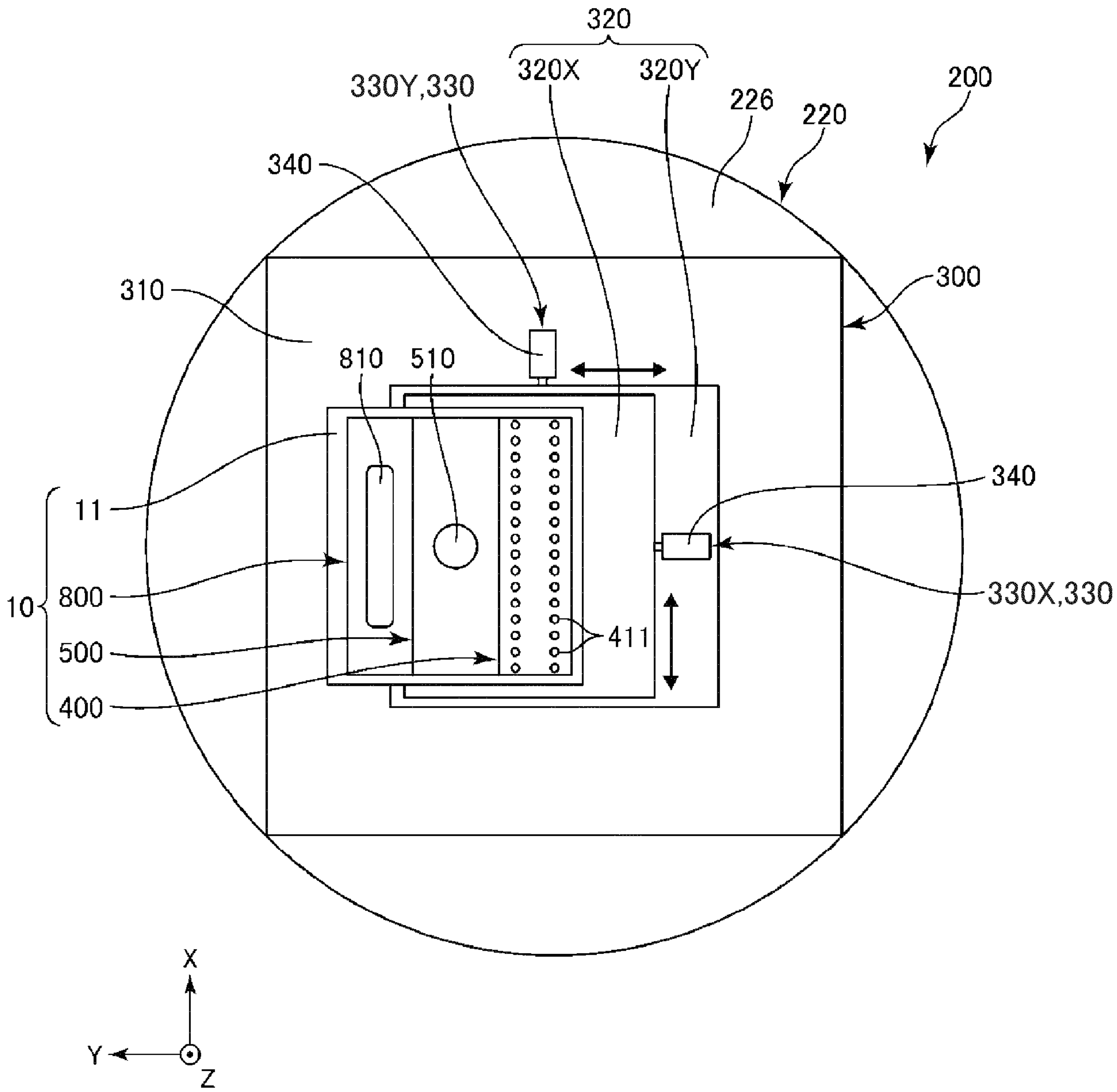
320
320X
320Y
330Y,330
200
226
220
340
300
310
810
510
340
11
10
800
330X,330
411
500
400
X
Y
Z

FIG. 3

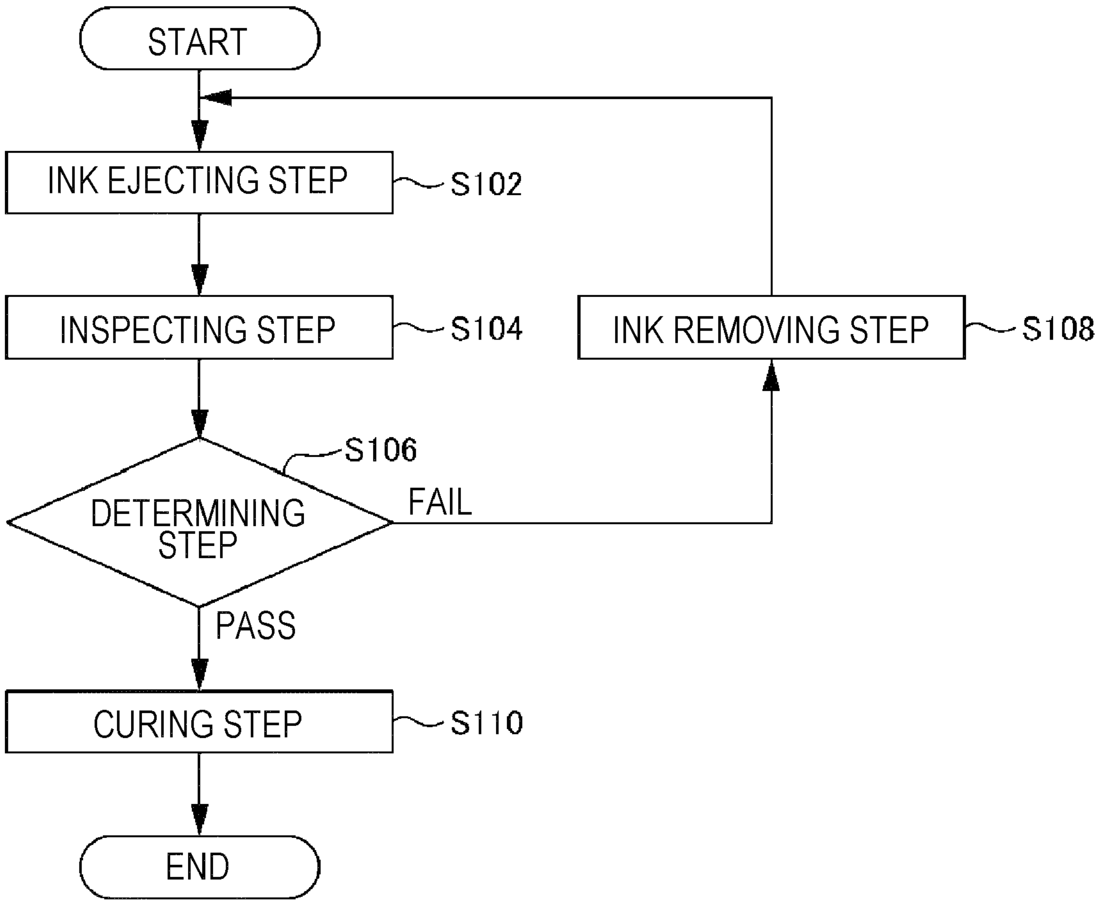
START
INK EJECTING STEP
S102
INSPECTING STEP
S104
INK REMOVING STEP
S108
S106
DETERMINING STEP
FAIL
PASS
CURING STEP
S110
END

FIG. 4

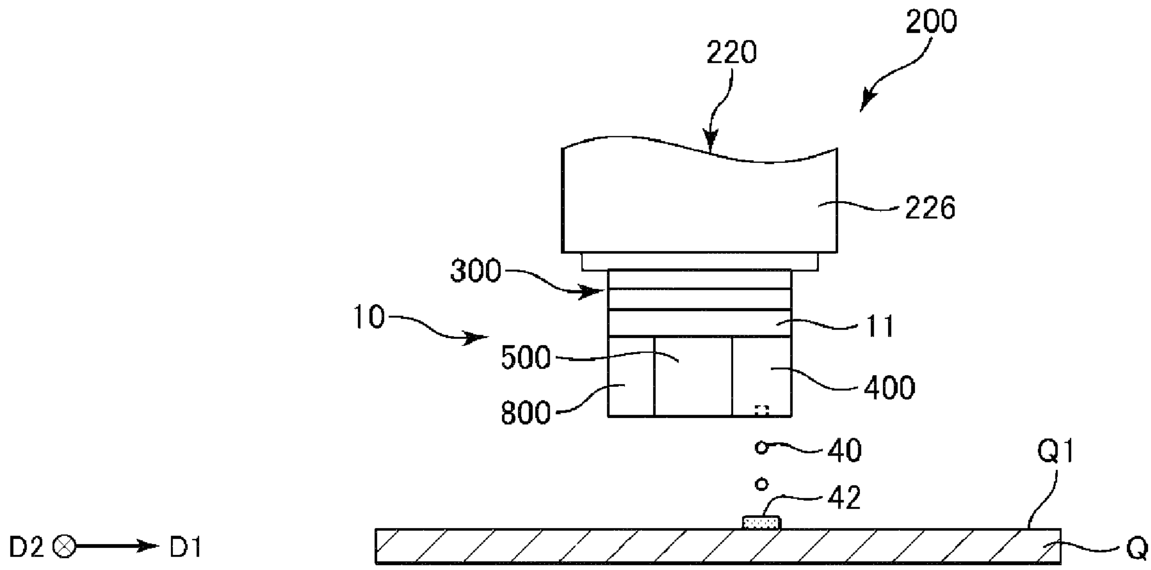
200
220
226
300
10
11
500
400
800
40
42
Q1
Q
D2
D1

FIG. 5

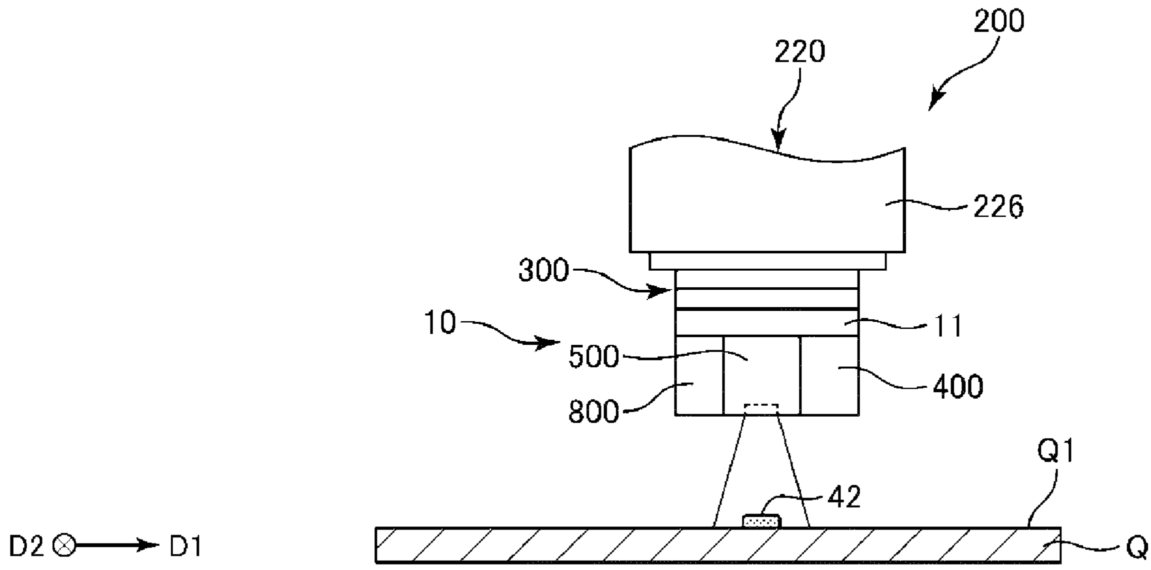

FIG. 6

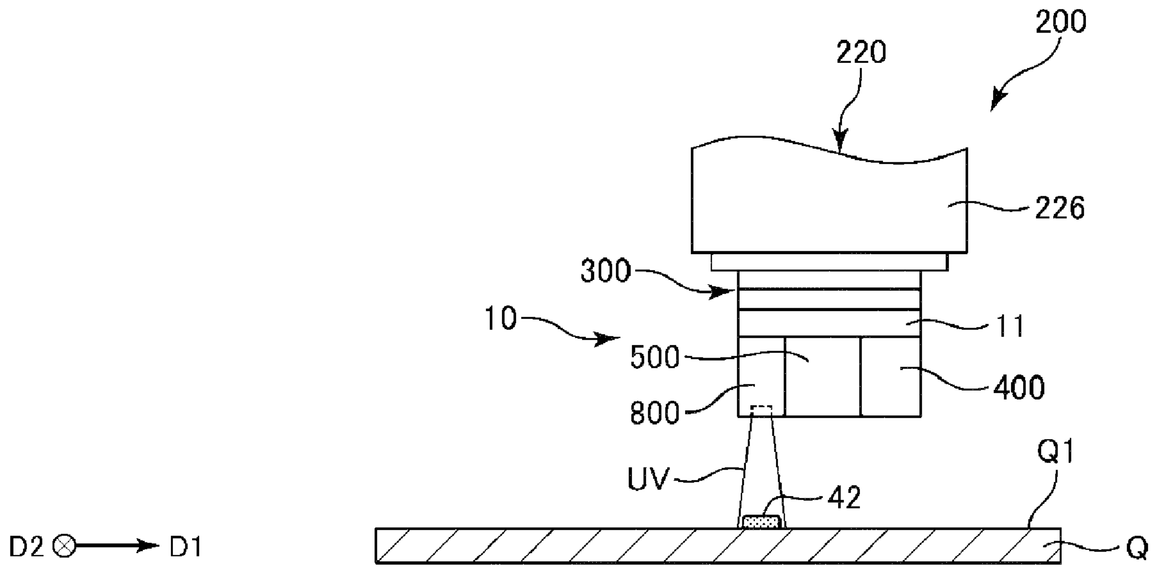

FIG. 7

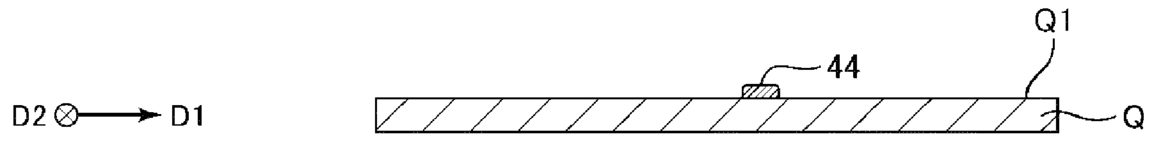

FIG. 8

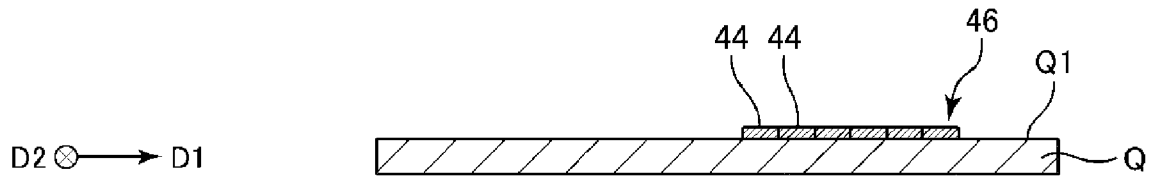

FIG. 9

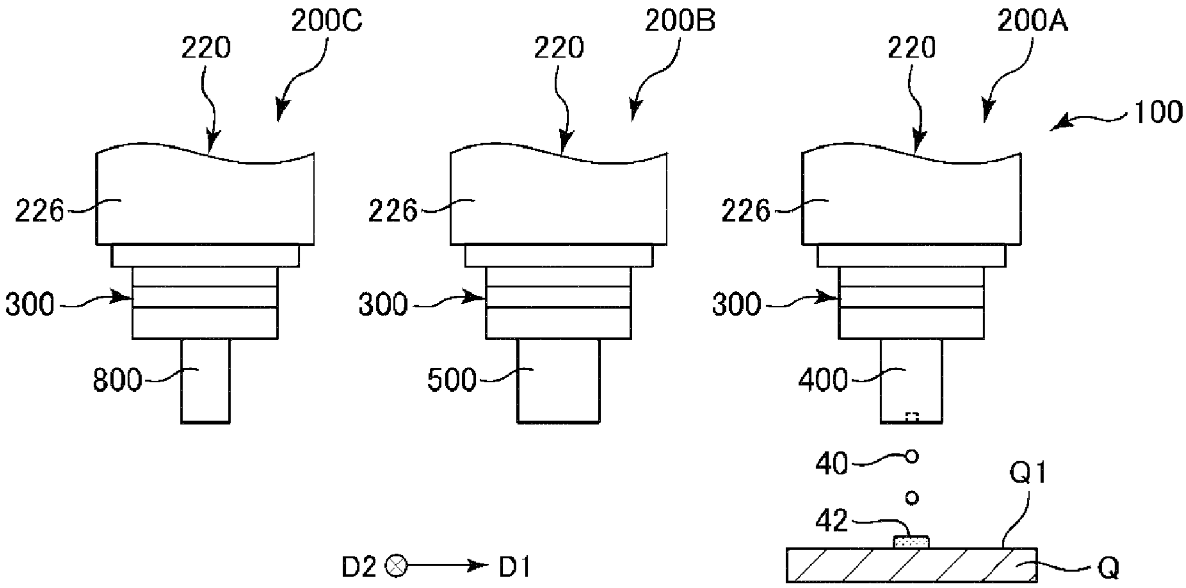

FIG. 10

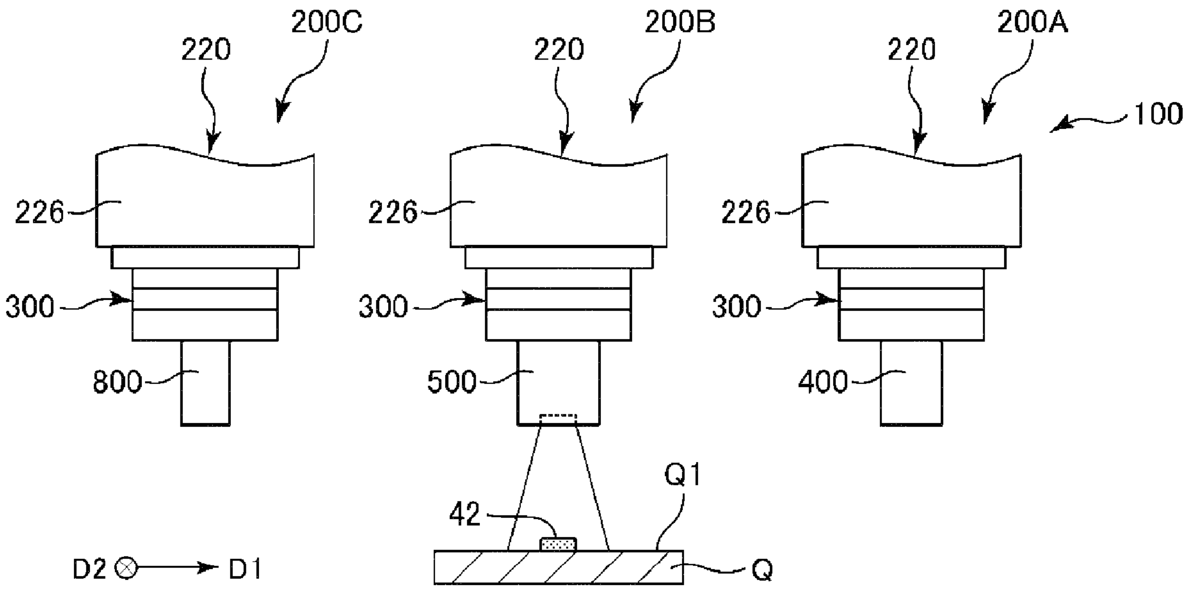

FIG. 11

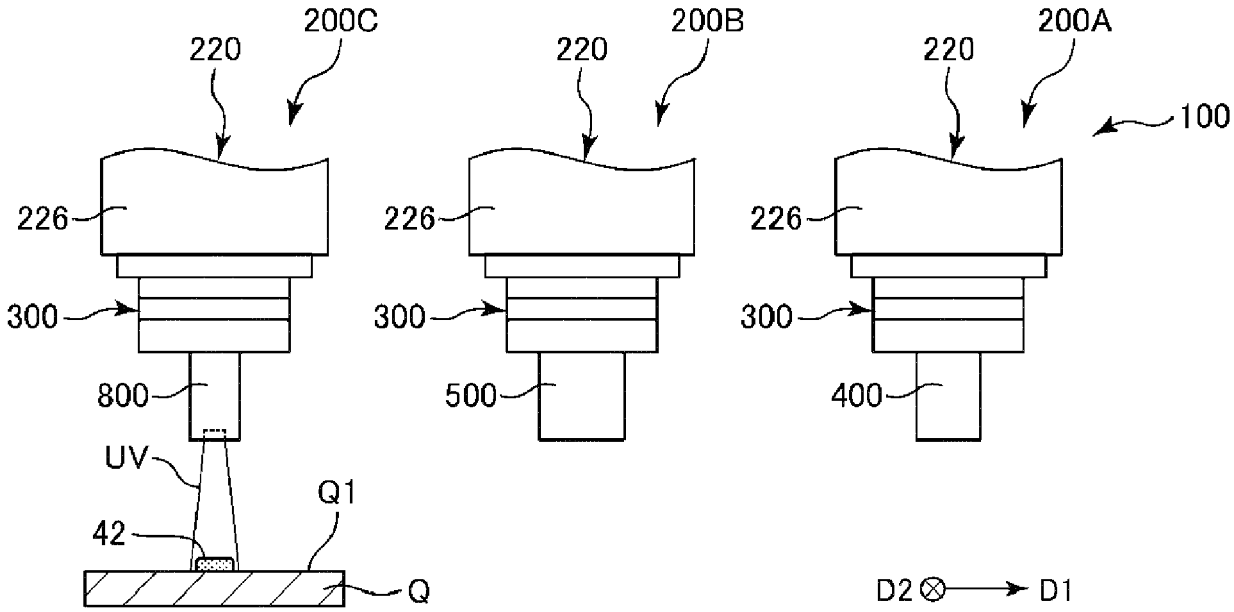
200C
220
200B
220
200A
220
100
226
226
226
300
300
300
800
500
400
UV
Q1
42
Q
D2
D1

FIG. 12

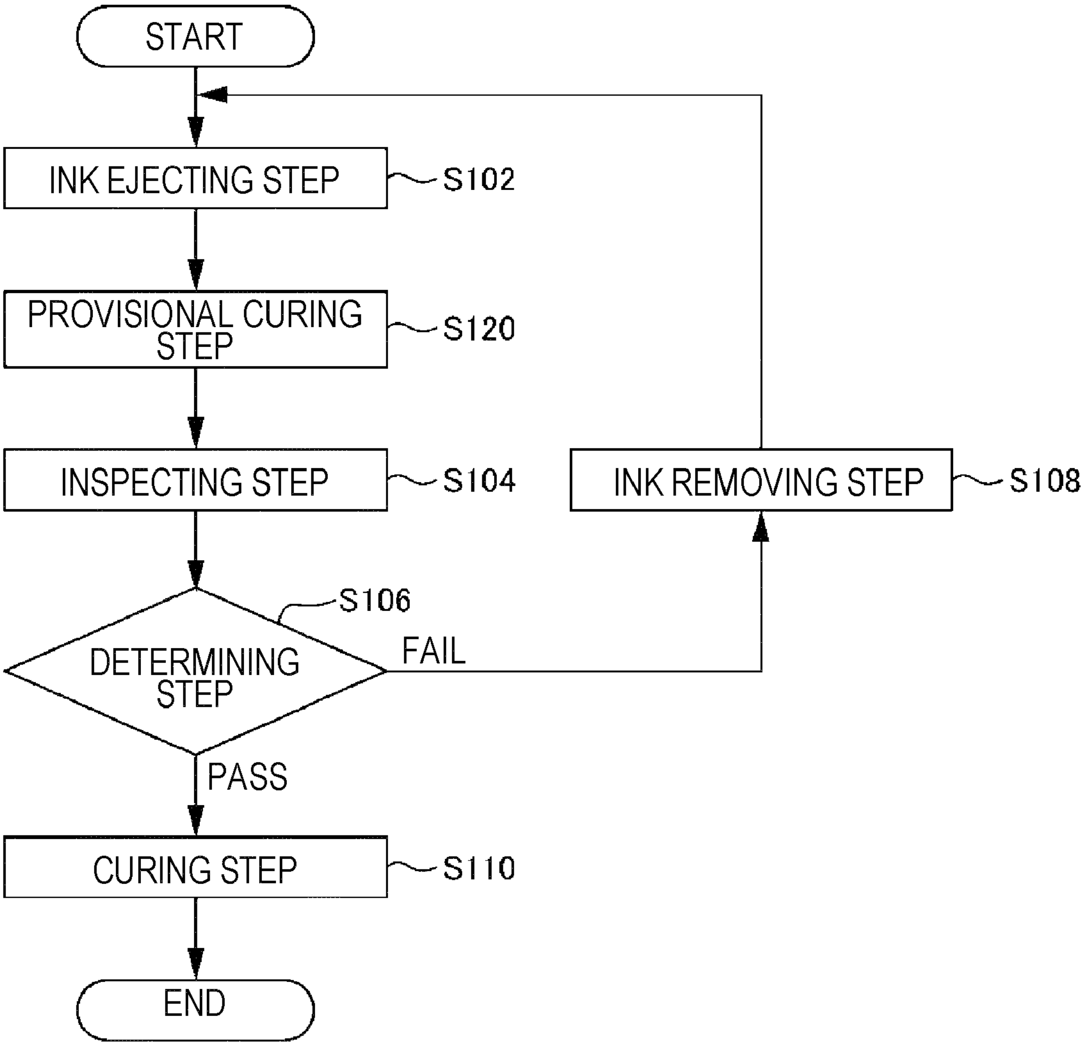
START
INK EJECTING STEP
S102
PROVISIONAL CURING STEP
S120
INSPECTING STEP
S104
INK REMOVING STEP
S108
S106
DETERMINING STEP
FAIL
PASS
CURING STEP
S110
END

FIG. 13

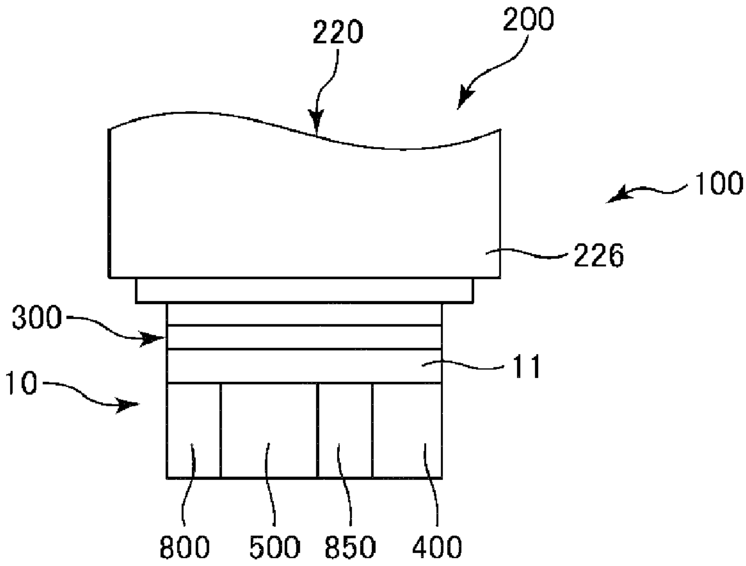

FIG. 14

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 24 17 6139

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y A	US 2022/288864 A1 (SUGAI KEIGO [JP] ET AL) 15 September 2022 (2022-09-15) * paragraphs [0043], [0085], [0086], [0088], [0125]; figures 1, 3 * -----	7,8 1-4,6,9 5	INV. B41J3/407 B41J11/00
Y	US 2013/120490 A1 (NAKAJIMA MIKITO [JP]) 16 May 2013 (2013-05-16) * paragraph [0069] - paragraph [0087]; figures 1-9 * -----	1-4,6,9	
A	US 2011/141177 A1 (IZUO SEIJI [JP]) 16 June 2011 (2011-06-16) * figures 4A-4E * -----	1-9	
A	JP 2010 100011 A (SEIKO EPSON CORP) 6 May 2010 (2010-05-06) * the whole document * -----	1-9	

TECHNICAL FIELDS SEARCHED (IPC)

B41J

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	7 October 2024	Loi, Alberto

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 24 17 6139

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

07-10-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2022288864 A1	15-09-2022	JP 2022139559 A	26-09-2022
		US 2022288864 A1	15-09-2022
US 2013120490 A1	16-05-2013	EP 2594404 A1	22-05-2013
		JP 2013103462 A	30-05-2013
		US 2013120490 A1	16-05-2013
		US 2014320567 A1	30-10-2014
US 2011141177 A1	16-06-2011	JP 2011121311 A	23-06-2011
		US 2011141177 A1	16-06-2011
JP 2010100011 A	06-05-2010	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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

- JP 2023082096 A **[0001]**
- JP 2013202781 A **[0004]**