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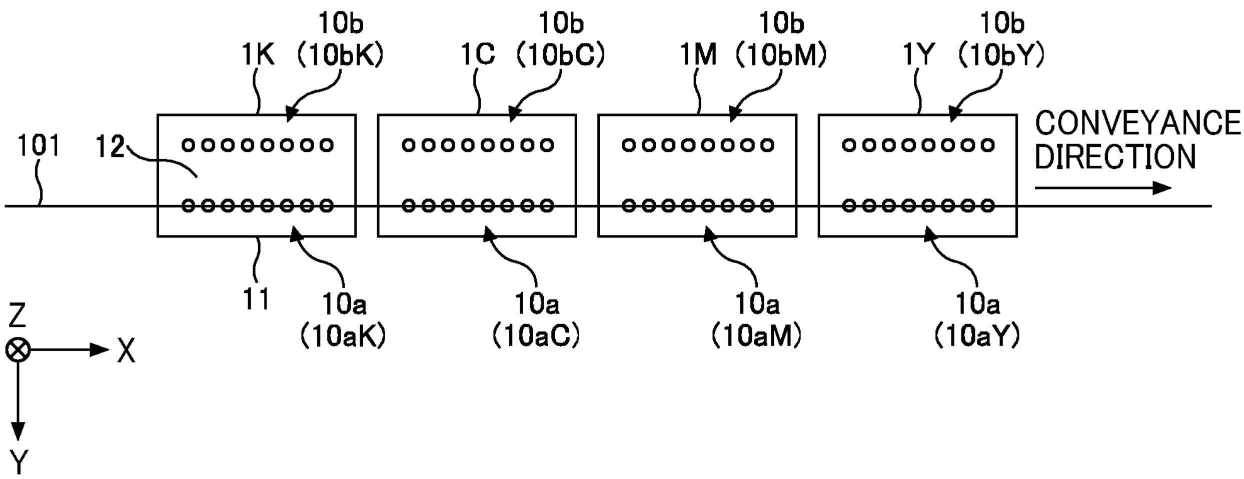
(54) LIQUID DISCHARGE APPARATUS AND DISCHARGE CONTROL METHOD FOR LIQUID DISCHARGE APPARATUS

(57) A liquid discharge apparatus (100) includes a conveyance unit (102), a discharge head (1), and a controller (401). The conveyance unit (102) is configured to convey a discharge-target medium. The discharge head (1) includes a plurality of nozzle rows (10a, 10b), each nozzle row of which includes a plurality of nozzles arranged in a row parallel to a conveyance direction of the discharge-target medium. The controller (401) is configured to control discharge of each nozzle row of the plurality of nozzle rows of the discharge head. The controller (401) is configured to assign a discharge operation for maintenance and a discharge operation for coloring to each nozzle row of the plurality of nozzle rows and cause the discharge head (1) to simultaneously perform the discharge operation for maintenance and the discharge operation for coloring.

FIG. 3



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Description

BACKGROUND

Technical Field

[0001] Embodiments of the present invention relate to a liquid discharge apparatus that discharges liquid onto a linear or band-shaped discharge-target medium such as a thread, and a discharge control method in the liquid discharge apparatus.

Related Art

[0002] In an inkjet-type image forming apparatus, when a discharge head is not capped for a long period of time, the viscosity of ink in the vicinity of nozzles may increase due to drying or the like, thus causing discharge abnormality. Therefore, for the purpose of preventing abnormal discharge due to thickening of ink in nozzles, there is a technique of periodically performing dummy discharge (flushing) as discharge for maintenance outside an image forming (printing) region and discarding thickened ink to stabilize discharge for printing (for example, JP-6241078-B (JP-2014-233904-A) and JP-2010-094950-A).

[0003] In such a dummy discharge method, dummy discharge is performed for every one scan or job break. For example, in JP-6241078-B, in a line printer in which nozzle rows are arranged so as to be orthogonal to a sheet conveyance direction, dummy discharge is performed at a page break between printing operations to remove thickened ink.

[0004] In addition, in JP-2010-094950-A, in a serial-type inkjet system, dummy discharge receivers are provided on both sides of a scanning region, and dummy discharge is performed into the dummy discharge receivers during scanning.

[0005] On the other hand, as illustrated in JP-2002-200381-A, in the case of coloring a medium such as a thread with an inkjet discharge head, the medium is arranged in parallel to a nozzle row although the machine configuration is close to the configuration of a line printer. Accordingly, there is no page break or one job is long. Thus, in this apparatus, the nozzle row used for discharge is always arranged in the scanning region (coloring region) on a thread, dummy discharge cannot be performed at page breaks as in a normal line printer. In addition, since the head does not move as in a serial printer, dummy discharge cannot be performed within the coloring operation.

[0006] Here, in a thread coloring apparatus as disclosed in JP-2002-200381-A, if dummy discharge operation is performed, for the maintenance operation during coloring operation, it is necessary to stop the conveyance of a thread, retract a nozzle row from the thread, perform the dummy discharge, return the nozzle row to the scanning position, and then restart the coloring operation. In other words, it is necessary to stop the apparatus to perform the dummy discharge. Accordingly, when the frequency of the dummy discharge operation is increased for uniform and stable discharge, other operations are stopped each time the dummy discharge operation is performed, thus reducing productivity.

SUMMARY

[0007] In view of the above circumstances, an object of the present invention is to provide a liquid discharge apparatus that discharges liquid onto a linear discharge-target medium with a discharge head and is capable of stabilizing discharge without substantially reducing productivity.

[0008] In an aspect of the present disclosure, there is provided a liquid discharge apparatus that includes a conveyance unit, a discharge head, and a controller. The conveyance unit is configured to convey a discharge-target medium. The discharge head includes a plurality of nozzle rows, each nozzle row of which includes a plurality of nozzles arranged in a row parallel to a conveyance direction of the discharge-target medium. The controller is configured to control discharge of each nozzle row of the plurality of nozzle rows of the discharge head. The controller is configured to assign a discharge operation for maintenance and a discharge operation for coloring to each nozzle row of the plurality of nozzle rows and cause the discharge head to simultaneously perform the discharge operation for maintenance and the discharge operation for coloring.

[0009] In another aspect of the present disclosure, there is provided a discharge control method for a liquid discharge apparatus including a conveyance unit to convey a discharge-target medium and a discharge head with a plurality of nozzle rows parallel to a conveyance direction of the discharge-target medium. The discharge control method includes performing a discharge operation for coloring on the discharge-target medium from one nozzle row of the plurality of nozzle rows; and performing a dummy discharge operation for maintenance from another nozzle row of the plurality of nozzle rows simultaneously with the discharge operation for coloring.

[0010] According to an aspect of the present invention, in a liquid discharge apparatus that discharges liquid onto a linear discharge-target medium by a discharge head, discharge can be stabilized without substantially reducing productivity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] 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 view of an example of a coloring-and-embroidering system including a liquid discharge apparatus according to an embodiment of the present invention;

FIG. 2 is a schematic side view of a liquid application unit in a liquid discharge apparatus according to an embodiment of the present invention;

FIG. 3 is a schematic bottom view of a liquid application unit according to an embodiment of the present invention;

FIGS. 4A, 4B, and 4C are diagrams illustrating movement of a head in a direction orthogonal to a thread conveyance direction in a liquid application unit according to an embodiment of the present invention, as viewed from the direction orthogonal to the thread conveyance direction.

FIG. 5 is a schematic view of a head moving unit of the liquid application unit and a cap mover of a maintenance recovery device;

FIG. 6 is a control block diagram of a section related to liquid discharge, head movement, and cap lifting in a liquid discharge apparatus according to a first embodiment of the present invention;

FIG. 7 is a functional block diagram of a head controller in FIG. 6;

FIG. 8 is a graph illustrating an example of a drive waveform applied by a drive waveform applying unit;

FIG. 9 is a timing chart of control in the first embodiment;

FIG. 10 is a flowchart of control of nozzle row switching and applied waveforms in the first embodiment;

FIG. 11 is a control block diagram of a section related to liquid discharge, head movement, cap lifting, and nozzle state detection in a liquid discharge apparatus according to a second embodiment of the present invention;

FIG. 12 is a control block diagram of a section related to liquid discharge, head movement, cap lifting, and nozzle state detection in a liquid discharge apparatus according to a third embodiment of the present invention;

FIGS. 13A and 13B are operation conceptual diagrams illustrating residual vibration generated in a pressure chamber;

FIGS. 14A and 14B are schematic views of an example of a coloring-and-embroidering system including a liquid discharge apparatus mounted with a sensor that detects a landing state on a thread, according to a fourth embodiment of the present invention; and

FIG. 15 is a schematic view of an example of a coloring system in which a liquid discharge apparatus according to an embodiment of the present invention is mounted.

[0012] The accompanying drawings are intended to depict embodiments of the present disclosure 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.

DETAILED DESCRIPTION

[0013] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present invention. 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.

[0014] 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.

[0015] Below, embodiments of the present disclosure are described with reference to accompanying drawings. In the following description, the same components are denoted by the same reference numerals, and redundant description may be omitted.

[0016] Hereinafter, embodiments of the present invention are described with reference to the drawings. In the following drawings, the same components are denoted by the same reference numerals, and redundant description may be omitted.

Overall Structure

[0017] First, a coloring-and-embroidering apparatus including a liquid discharge apparatus according to an embodiment of the present invention is described with reference to FIGS. 1 to 3. FIG. 1 is a schematic view of an example of a coloring-and-embroidering apparatus as coloring-and-embroidering system according to an embodiment of the present disclosure. FIG. 2 is a schematic side view of an area around a liquid application unit in a liquid discharge apparatus according to an embodiment of the present invention. FIG. 3 is a bottom view of a liquid application unit according to an embodiment of the present invention.

[0018] The coloring-and-embroidering apparatus 1000 is an in-line embroidery machine. The coloring-and-embroidering apparatus 1000 includes a supply reel 102 on which a thread 101 is wound, a liquid application unit 103, a fixing unit 104, a post-processing unit 105, and an embroidery head 106. The supply reel 102, the liquid application unit 103, the fixing unit 104, and the post-processing unit 105, excluding the embroidery head 106, function as a liquid discharge apparatus (coloring unit or dyeing unit) 100 in the present embodiment.

[0019] The thread 101 drawn from the supply reel 102 is guided by conveyance rollers 108 and 109 and continuously stretched to the embroidery head 106.

[0020] The conveyance roller 109 is provided with a rotary encoder 405. The rotary encoder 405 may be simply referred to as encoder. The rotary encoder 405 includes an encoder wheel 405a that rotates together with the conveyance roller 109 and an encoder sensor 405b that reads a slit of the encoder wheel 405a.

[0021] The liquid application unit 103 includes a plurality of heads 1 (1K, 1C, 1M, and 1Y) and a maintenance unit 2. The liquid application unit 103 discharges a liquid of a required color onto the thread 101 that is drawn out from the supply reel 102. The maintenance unit 2 incudes a plurality of individual maintenance units 20 (20K, 20C, 20M, and 20Y) to perform maintenance of the heads 1 (1K, 1C, 1M, and 1Y), respectively.

[0022] Hereinafter, the direction in which the thread 101 is conveyed from the liquid application unit 103 to the embroidery head 106 is referred to as X, the depth direction (head movement direction) of the coloring-and-embroidering apparatus 1000 is referred to as Y, and the height direction (vertical direction) is referred to as Z.

[0023] With reference to FIG. 2, in the liquid application unit 103, the plurality of heads 1K, 1C, 1M, and 1Y are discharge heads that discharge droplets (ink droplets) of different colors from each other. For example, the head 1Y is a head that discharges droplets of black (K), the head 1C is a head that discharges droplets of cyan (C), the head 1M is a head that discharges droplets of magenta (M), and the head 1Y is a head that discharges droplets of yellow (Y). The above-described order of colors is an example. In some embodiments, the colors may be arranged in an order different from the above-described order.

[0024] The individual maintenance units 20K, 20C, 20M, and 20Y are disposed below the liquid application unit 103 so as to face the heads 1K, 1C, 1M, and 1Y, respectively.

[0025] Here, as illustrated in FIG. 3, the head 1K has a nozzle surface 12 on which nozzle rows 10a and 10b are formed. In each of the nozzle rows 10a and 10b, a plurality of nozzles 11 that discharge liquid droplets are arranged in a row. Each of the heads 1K, 1C, 1M, and 1Y is disposed such that the direction of each nozzle row (i.e., the arrangement of the nozzles 11 in each nozzle row) is parallel to the conveyance direction (thread feeding direction) of the thread 101.

[0026] In the head 1K, ink droplets discharged from the nozzles 11 of one row (e.g., the nozzle row 10a in FIG. 3) placed directly below the thread 101 land on the thread 101 to color the thread 101. Note that FIG. 3 illustrates an example in which each head 1 has two nozzle rows, i. e., two nozzle rows 10a and 10b, on the nozzle surface 12. However, the number of nozzle rows in the head 1K may be one, or three or more. As illustrated in FIG. 3, the other heads 1C, 1M, and 1Y have a similar, even if not the same, structure as the structure of the head 1K.

[0027] With reference to FIG. 1, the fixing unit 104 performs a fixing process (drying process) on the thread 101 to which the liquid discharged from the liquid application unit 103 is applied. The fixing unit 104 includes, for example, a heater such as an infrared irradiation device and a hot air sprayer, and heats the thread 101 to dry.

[0028] The post-processing unit 105 includes, for example, a cleaning device that cleans the thread 101, a tension adjustment device that adjusts the tension of the thread 101, a feed amount detector that detects the amount of movement of the thread 101, and a lubricant application device that lubricates the surface of the thread 101.

[0029] The embroidery head 106 sews the colored thread 101 into a cloth to embroider a pattern or a design on the cloth, for example.

[0030] In the present embodiment, an example is described in which the liquid discharge apparatus is included in the coloring-and-embroidering apparatus 1000. However, a liquid discharge apparatus according to embodiments of the present invention is not limited threreto and is applicable to, e.g., an apparatus using a linear object such as a thread, for example, an apparatus such as a loom or a sewing machine.

[0031] Examples of "thread" include glass fiber thread, wool thread, cotton thread, synthetic thread, metal thread, wool, cotton, polymer, mixed metal thread, yarn, filament, and linear objects (e.g., linear member and continuous base materials) to which liquid can be applied. Example of the "thread" further includes braids and flat cords (flat braids).

[0032] In addition to the linear objects, examples of the "thread" further include band-shaped members (continuous base materials) to which liquid can be applied, such as a rope, a cable, and a cord, as discharge-target media that can be dyed by ink droplets. Each of the discharge-target media is a linear or band-shaped medium having a narrow width and being continuous in the conveyance direction.

Movement of position of head

[0033] Next, movement of the head and lifting of the cap are described with reference to FIGS. 4 and 5. FIGS. 4A, 4B, and 4C are diagrams illustrating movement of a head in a direction orthogonal to a thread conveyance direction in a liquid application unit of a liquid discharge apparatus according to an embodiment of the present invention. FIGS. 4A, 4B, and 4C are schematic views of a head moving unit of the liquid application unit 103 and a moving mechanism of a cap 21 of a maintenance unit 20.

[0034] Specifically, FIG. 4A depicts the position of the head 1K in a state in which droplets can be discharged from the nozzle row 10a onto the thread 101. FIG. 4B depicts the position of the head 1K in a state in which droplets can be discharged from the nozzle row 10b onto the thread 101. FIG. 4C depicts the position of the head 1K in a state in which the nozzle rows 10a and 10b are capped with the cap 21.

[0035] As illustrated in FIGS. 4A, 4B, and 4C, moving the head 1K perpendicularly to the conveyance direction of the thread 101 allows coloring with the nozzle row 10a, coloring with the nozzle row 10b, and capping of the nozzle surface 12 with the cap 21. The movement direction Y of the head is the same direction as the depth direction of the coloring-and-embroidering apparatus illustrated in FIG. 1.

[0036] Similarly, in the other heads, the heads 1K, 1C, 1M, and 1Y of the respective colors can freely move in the head movement direction for selection of the nozzle row to be used and the maintenance operation.

[0037] In addition, as illustrated in FIG. 4, there are two nozzle rows 10a and 10b on the lower surface of the head 1. Regarding the nozzle row that causes ink droplets to land on the thread to color the thread, the nozzle row to be appropriately used can be selectable by moving the head 1 and setting the nozzle row that discharges ink droplets directly above the thread.

[0038] In addition to the recovery operation by capping that engages with the cap 21, the maintenance unit 20K also collects ink that has run off the thread 101 and has not landed on the thread 101, on a collection surface 22 that is an upper surface on which the cap 21 and the thread 101 are not provided.

[0039] A home position sensor (HP sensor) 305 is disposed in the maintenance unit 20 as a reference for movement of the head 1. FIG. 5 depicts an example in which the HP sensor 305 that defines the position of the home position of the head 1 is provided at the end portion of the maintenance unit 20. In some embodiments, the HP sensor 305 may be provided at another position in the movement direction of the head.

[0040] Here, a mechanism that moves each of the heads 1K, 1C, 1M, and 1Y in the movement direction (depth direction of the apparatus) is described with reference to FIG. 5. FIG. 5 is a schematic view of a head moving unit of the liquid application unit 103 and a mover of the cap 21 of the maintenance unit 2.

[0041] As illustrated in FIG. 5, the head 1 is supported by a movable carriage 141. Ahead moving motor 304 moves arms 142 and 143 supporting the carriage 141, thus allowing the carriage 141 to move in a movable direction. As an example of the head movement, for example, the arm 142 itself extending in the horizontal direction may expand and contract, or the carriage 141 may be moved by changing the position of the carriage 141 with respect to the arm 142. In the present embodiment, the carriage 141, the arms 142 and 143, and the head moving motor 304 are collectively referred to as a head moving unit (head moving means) 140.

[0042] Such a structure allows the head 1K supported by the carriage 131 can be moved to the position of the cap 21 during standby and can be moved to the position of the thread 101 during coloring.

[0043] It is preferable that the head moving unit 140, which is a movable unit that moves the position of the discharge head 1, is provided for each head. Thus, the timing of replacement can be changed for each head.

[0044] In the maintenance unit 20, the cap 21 can be lifted up and down by a lifting arm 23. The lifting arm 23 is driven by a cap lifting motor 24. As illustrated in FIG. 4C, the cap 21 is raised to cap the head 1 to prevent ink on the head 1K from drying during standby. During coloring, as illustrated in FIGS. 4A and 4B, the cap 21 is lowered for decapping.

[0045] FIG. 4 depicts an example in which, in the maintenance unit 20, the cap 21 is disposed on the back side (+Y side) of the coloring-and-embroidering apparatus 1000. In some embodiments, in the maintenance unit 20, the cap 21 may be disposed on the front side (-Y side) of the coloring-and-embroidering apparatus 1000 as illustrated in FIG. 5.

Control block

[0046] FIG. 6 is a control block diagram of a section related to liquid discharge, head movement, and cap lifting in a liquid discharge apparatus according to a first embodiment of the present invention.

[0047] The head 1 includes a plurality of piezoelectric elements 13 as pressure generating elements that generate pressure for discharging the liquid from the plurality of nozzles 11. A drive waveform applying unit to apply a drive waveform to the head 1 is implemented by a head controller 401, a drive waveform generator 402, a waveform data storage 403, a head driver 410, and a discharge timing generator 404 to generate discharge timing.

[0048] Further, for example, a conveyance controller 300, the rotary encoder 405 of the conveyance roller 109, a rotary encoder 301 on the embroidery head side, and a conveyance motor 302 are provided as a conveyance control unit.

[0049] Ahead position controller 303, the head moving motor 304, and the HP sensor 305 are provided as head position control means.

[0050] The head controller 401 is an example of a controller. Receiving a discharge timing pulse stb, the head controller 401 outputs a discharge synchronization signal LINE that triggers generation of a drive waveform, to the drive waveform generator 402. The head controller 401 outputs a discharge timing signal CHANGE corresponding to the amount of delay from the discharge synchronization signal LINE, to the drive waveform generator 402.

[0051] The drive waveform generator 402 generates a common drive waveform Vcom at the timing based on the discharge synchronization signal LINE and the discharge timing signal CHANGE.

[0052] The head controller 401 receives thread coloring data and generates a mask control signal MN based on the thread coloring data. The mask control signal MN is for selecting a waveform of the common drive waveform Vcom according to the size of liquid droplet to be discharged from each nozzle 11 of the head 1. The mask control signal MN is a signal at a timing synchronized with the discharge timing signal CHANGE.

[0053] The head controller 401 transmits thread coloring data SD, a synchronization clock signal SCK, a latch signal LT instructing latch of the thread coloring data, and the generated mask control signal MN to the head driver 410.

[0054] The head driver 410 includes a shift register 411, a latch circuit 412, a gradation decoder 413, a level shifter 414, and an analog switch array 415.

[0055] The shift register 411 receives the thread coloring data SD and the synchronization clock signal SCK transmitted from the head controller 401. The latch circuit 412 latches each value on the shift register 411 according to the latch signal LT transmitted from the head controller 401.

[0056] The gradation decoder 413 decodes the value (thread coloring data SD) latched by the latch circuit 412 and the mask control signal MN and outputs the result. The level shifter 414 performs level conversion of a logic level voltage signal of the gradation decoder 413 to a level at which the analog switch AS of the analog switch array 415 can operate.

[0057] The analog switch AS of the analog switch array 415 is turned on and off by the output received from the gradation decoder 413 via the level shifter 414. The analog switch AS is provided for each nozzle 11 of the head 1 and is connected to an individual electrode of the piezoelectric element 13 corresponding to each nozzle 11. In addition, to the analog switch AS, the common drive waveform Vcom from the drive waveform generator 402 is input. In addition, as described above, the timing of the mask control signal MN is synchronized with the timing of the common drive waveform signal Vcom.

[0058] Therefore, the analog switch AS is switched between on and off timely in accordance with the output from the gradation decoder 413 via the level shifter 414. With this operation, the waveform to be applied to the piezoelectric element 13 corresponding to each nozzle 11 is selected from the drive waveforms forming the common drive waveform Vcom. As a result, the size of the liquid droplet discharged from the nozzle is controlled.

[0059] The discharge timing generator 404 generates and outputs the discharge timing pulse stb each time the thread 101 is moved by a predetermined amount, based on the detection result of a rotary encoder 405 that detects the rotation amount of the roller 109 illustrated in FIG. 1. The predetermined amount of movement of the thread 101 can be empirically obtained and stored in a memory.

[0060] The thread 101 is conveyed (fed) as consumed in the embroidery operation by the embroidery head 106 on the downstream side in the conveyance direction of the thread 101. The rotary encoder 301 on the downstream side of the embroidery head 106 is a feed amount detector that detects the amount of movement of the thread 101 in the embroidery head 106.

[0061] As the thread 101 is conveyed, the roller 109 guiding the thread 101 rotates to rotate the encoder wheel 405a of the rotary encoder 405. Then, the encoder sensor 405b generates and outputs an encoder pulse proportional to the linear speed of the thread 101.

[0062] The discharge timing generator 404 generates the discharge timing pulse stb based on the encoder pulse from the rotary encoder 405. The discharge timing pulse stb is used as the discharge timing of the head 1. The application of the liquid to the thread 101 is started as the thread 101 starts moving. Even if the linear speed of the thread 101 changes, deviations in the landing positions of the droplets can be prevented because the interval of the discharge timing pulse stb changes according to the encoder pulse.

[0063] The conveyance controller 300 is an example of a conveyance control unit, determines the conveyance speed of the thread 101 based on the movement amount of the rotary encoder 301 on the downstream side, and rotates the roller 108 by the conveyance motor 302 to convey the thread 101 at the determined conveyance speed. Further, the speed is detected with the rotary encoder 405 to control the thread conveyance of the conveyance motor 302.

[0064] The head position controller 303 is an example of a head position controller, and rotates the head moving motor 304 based on a head position command from the head controller 401 to move the heads 1K, 1C, 1M, and 1Y to predetermined positions.

[0065] For example, when the head moving motor 304 is a stepper motor, position control is performed by rotating the head moving motor 304 from a state in which the home position (HP) is detected by the HP sensor 305, by the number of steps corresponding to the distance from the HP to a target position such as the coloring position in the nozzle row 10a, the coloring position in the nozzle row 10b, or the capping position. The head position controller 303 notifies the head controller 401 that the head movement has been completed after the rotation by the number of steps corresponding to the distance is performed.

[0066] A cap lifting controller 306 rotates the cap lifting motors 24 to lift and lower the caps 21 based on the capping and decapping instructions from the head controller 401.

[0067] For example, when the cap lifting motor 24 is a stepping motor, the cap lifting controller 306 controls the cap lifting motor 24 to rotate by the number of steps corresponding to the distance between the capping position as the upper end and the decapping position as the lower end. After rotating the cap lifting motor 24 by the number of steps corresponding to the distance from the upper end to the lower end, the cap lifting controller 306 notifies the head controller 401 that capping or decapping of the nozzle row by lifting up and down of the cap 21 has been completed.

[0068] FIG. 7 is a functional block diagram of a state determination unit 500 included in the head controller 401 according to the first embodiment illustrated in FIG. 6.

[0069] Generally, in a nozzle row during coloring operation, there is a nozzle that does not perform a discharging operation depending on the coloring condition (thread coloring data) and is not used. Accordingly, there is a concern that the viscosity of ink (liquid) might be increased in the nozzle due to the decapping for a long time and cause unstable discharge. Hence, in the present embodiment, in the plurality of nozzle rows, before the discharge from nozzles of a nozzle row that is positioned above a thread and is used for a coloring operation becomes unstable, maintenance is performed on a nozzle row that is not positioned above the thread. Then, the nozzle row having been maintained is moved to above the thread and used for the discharge operation, thus preventing abnormal discharge.

[0070] In the present embodiment, the head controller 401 has a function of detecting (determining) in advance that the discharge of the nozzles becomes unstable, and a function of issuing a dummy discharge instruction based on the result. In the present embodiment, the head controller 401 determines whether the discharge of the nozzle row positioned above the thread during the coloring operation becomes unstable by using, e.g., an elapsed time after the decapping, an elapsed time after the replacement, coloring conditions (e.g., a non-discharge period in the discharge), and the like as determination conditions.

[0071] Therefore, in the head controller 401, the state determination unit 500 includes a decapping elapsed time counter 501, a decapping elapsed time comparator 502, a post-switch elapsed time counter 503, a post-switch elapsed time comparator 504, a nozzle-specific non-discharge period counter 505, a nozzle non-discharge period comparator 506, a threshold storing unit 507, a nozzle-row destabilization determining unit 508, and a dummy discharge operation instruction unit 509.

[0072] When a coloring operation is started in response to a coloring request and nozzle rows 10a and 10b are decapped, a decapping elapsed time counter 501 counts an elapsed time after the decapping. Accordingly, at the start of coloring operation, the decapping elapsed time counter 501 starts counting when receiving, from the cap lifting controller 306, decapping completion information indicating that the cap 21 is lowered and decapped.

[0073] Then, the decapping elapsed time comparator 502 compares the counted decapping elapsed time with a threshold stored in the threshold storing unit 507 and sets a decapping time comparison signal to Hi when the elapsed time exceeds the threshold.

[0074] The post-switch elapsed time counter 503 counts a post-switch elapsed time after the nozzle row to be used is switched to the other nozzle row one or more times. Accordingly, after the head 1 is moved in the direction orthogonal to the thread conveyance direction in order to switch the nozzle rows 10a and 10b, the post-switch elapsed time counter 503 starts counting when the nozzle row that was not above the thread immediately before reaches the thread and receives the head movement completion information from the head position controller 303.

[0075] Then, the post-switch elapsed time comparator 504 compares the counted post-switch elapsed time with a threshold stored in the threshold storing unit 507 and sets a post-switch time comparison signal to Hi when the elapsed time exceeds the threshold.

[0076] In a case in which there is a non-discharge nozzle in the nozzles of the nozzle row that is positioned above the thread and is performing the discharge operation, the nozzle-specific non-discharge period counter 505 counts the non-discharge time of the non-discharge nozzle. Accordingly, the data (thread coloring data SD) that is the basis of the discharging operation is input to the nozzle-specific non-discharge period counter 505, and the non-discharge period in the nozzle assigned in the coloring data is counted.

[0077] Here, depending on the coloring conditions, the nozzle row that is performing the discharging operation for coloring may include a nozzle(s) that does not perform the discharging operation. Specifically, in a case in which coloring is performed by discharging liquid droplets from all the nozzles of the nozzle row, for example, in a case in which the coloring is performed on the thread in a solid manner, there is no non-discharge period in the nozzle row. Therefore, the counting is not started. On the other hand, for example, when a stripe pattern is formed on the thread, there are nozzles that are used and nozzles that are not used in the nozzle row 10a.

[0078] Alternatively, when respective nozzle rows 10aK, 10aC, IOaM, and 10aY of the heads 1K, 1C, 1M, and 1Y of the plurality of colors are present on a thread and the color for coloring the thread is a single primary color, there are heads of colors that are not used for the coloring. In such a case, in each of the heads of the colors that are not used, none of the nozzles of the nozzle row above the thread discharges liquid. In this way, during the coloring operation, the nozzle-specific non-discharge period counter 505 counts the non-discharge period of each nozzle that is not used in all nozzles of the nozzle row positioned above the thread.

[0079] Then, the nozzle non-discharge period comparator 506 compares the counted non-discharge period with a threshold stored in the threshold storing unit 507 and sets a non-discharge period comparison signal to Hi when the non-discharge period exceeds the threshold.

[0080] When the decapping time comparison signal, the post-switch time comparison signal, or the non-discharge period comparison signal becomes Hi, the nozzle-row destabilization determining unit 508 becomes Hi for an arbitrary period. Specifically, in the case immediately after the start of coloring, when one of the decapping time comparison signal and the non-discharge period comparison signal becomes Hi, a discharge instability signal, which is the output of the nozzle-row destabilization determining unit 508, becomes Hi. In addition, after the nozzle rows are switched one or more times after the start of coloring, the discharge instability signal becomes Hi only for an arbitrary period when the post-switch time comparison signal and the non-discharge period comparison signal become Hi.

[0081] Then, when the signal becomes Hi, the dummy discharge operation instruction unit 509 instructs execution of dummy discharge. When the dummy discharge operation is instructed, in all the nozzles of the nozzle row 10b which is not above the thread, a drive waveform for dummy discharge is applied to the piezoelectric element 13 and the dummy discharge operation of discharging liquid to a region (dummy discharge region) that is not on the thread is executed. The period for executing the dummy discharge or the number of times of the dummy discharge is set in advance.

[0082] The head controller 401 also has a function of generating a mask control signal MN and generates the mask control signal MN based on the thread coloring data SD and the dummy discharge instruction from the state determination unit 500.

[0083] Thereafter, the head 1 is moved so that the nozzle row having completed the dummy discharge operation comes above the thread.

Drive waveform

[0084] FIG. 8 is a graph of an example of a drive waveform generated by the drive waveform generator 402 in an embodiment of the present invention.

[0085] As illustrated in FIG. 8, the drive waveform (common drive waveform) Vcom of the present example includes not only a general coloring pulse P1 and a micro-drive pulse P2 but also a dummy discharge pulse P3 as a waveform configuration.

[0086] Any one of the three types of pulses included in the common drive waveform Vcom is selected for each nozzle row or for each nozzle of the nozzle row by the mask control signal MN output from the head controller 401 based on the thread coloring data SD and the dummy discharge instruction. Thus, even when the drive circuits (head drivers 410) of the two nozzle rows for the head 1 are common, discharge operations for different purposes can be performed.

[0087] By using such a waveform, in the present embodiment, discharge for different purposes can be simultaneously performed in the plurality of nozzle rows 10a and 10b in the head 1.

Variation 1

[0088] Although the block diagram of FIG. 5 illustrates an example in which the drive waveform generator 402 is provided for each head, the drive waveform generator 402 may be shared by a plurality of heads instead of being provided for each head. Even in such a case, while one discharge head is performing the coloring operation on the thread, another discharge head can be switched moved to switch the one nozzle row 10a and the other nozzle row 10b so that the other discharge head is positioned above the thread. Thus, the discharge operation for maintenance and the discharge operation for coloring can be switched in the other discharge head.

Variation 2

[0089] Alternatively, the drive waveform generator 402 may be provided for each of the nozzle rows 10a and 10b in one head. In such a configuration, the setting of the drive waveform, the drive frequency, and the like can also be set for each nozzle row. For example, instead of generating a common drive waveform, for example, a drive waveform generator corresponding to one nozzle row generates a discharge waveform for coloring, and a drive waveform generator corresponding to the other nozzle row generates a drive waveform for dummy discharge. Thus, the degree of freedom in setting the dummy discharge is increased, and the effect of the dummy discharge can be increased.

[0090] As the number of the drive waveform generators and the drive circuits increases, more appropriate control can be executed and the effect is enhanced. However, since the cost increases due to the increase in the number of components, it is preferable to appropriately select the number the drive waveform generators and the drive circuits according to the specification and the cost.

[0091] The waveform application timing and overall control are described with reference to FIGS. 9 and 10.

Timing chart

[0092] FIG. 9 is a timing chart of control in the first embodiment.

[0093] In the plurality of nozzle rows 10a and 10b, the coloring operation is executed in a nozzle row (for example, the nozzle row 10a in FIG. 3) that is being subjected to the coloring operation and is arranged on the thread (t1).

[0094] FIG. 9 depicts an example in which the coloring waveform is applied to the nozzle row 10a positioned above the thread at a timing immediately after the start. A micro-drive waveform is applied to nozzles not used in the nozzle row 10a. In addition, in a case in which a head for one color discharges liquid droplets and other heads for other colors do not discharge liquid droplets, the micro-drive waveform is applied to all the nozzle rows of the color that is not used.

[0095] When the drive waveform of FIG. 8 is used, the coloring pulse P1 and the micro-drive pulse P2 are used for the nozzle row 10a above the thread based on the thread coloring data SD.

[0096] The nozzle row 10b which is not positioned above the thread and does not perform the coloring operation performs the micro-drive operation.

[0097] In the case of using the drive waveform of FIG. 8, the micro-drive pulse P2 is selected from the drive waveform by the mask signal and used for all the nozzles of the nozzle row 10b that does not exist above the thread. Thus, the micro-drive to apply vibrations (oscillations) to the meniscuses to the extent that ink is not discharged from the nozzles.

[0098] Until it is determined that the discharge becomes unstable in the nozzle row 10a during the coloring operation, the nozzle row 10a continues the coloring operation as it is, and the nozzle row 10b continues the micro-drive operation.

[0099] When the head controller 401 determines that discharge becomes unstable (t2), the micro-drive operation is switched to the maintenance operation by the dummy discharge operation in the nozzle row 10b that is not performing the coloring operation and is not positioned above the thread (t3). The dummy discharge operation is performed for all the nozzles of the nozzle row 10b. Accordingly, even if ink is thickened in the nozzles while the nozzle row 10b waits at a position other than the position above the thread, the thickened ink is forcibly discharged to a region (the collection surface 22 as a dummy discharge receiver) that is not above the thread, and the inside of the nozzles is refreshed.

[0100] In the case of using the drive waveform of FIG. 8, the dummy discharge pulse P3 is selected by the mask signal and is used to perform maintenance of the nozzle row 10b by the dummy discharge. At this time, as illustrated in FIG. 8, the number and amplitude of pulses for dummy discharge are greater than the number and amplitude of the pulses for coloring. Accordingly, the pulses for the dummy discharge discharges more droplets than the pulses for coloring, thus allowing the thickened liquid to be effectively discharged.

[0101] Here, the head controller 401 outputs the discharge instability signal that becomes high for an arbitrary period at a timing at which any one of the decapping time comparison signal, the post-switch time comparison signal, and the non-discharge period comparison signal becomes high. For example, t2 indicates an example in which the discharge instability signal becomes Hi at the timing when the decapping time comparison signal becomes Hi, t6 indicates an example in which the discharge instability signal becomes Hi at the timing when the post-switch time comparison signal becomes Hi, and t10 indicates an example in which the discharge instability signal becomes Hi at the timing when the non-discharge period comparison signal becomes Hi.

[0102] Then, the nozzle row 10b immediately after the maintenance, which is not above the thread, is moved perpendicularly to the thread conveyance direction (t4 →t5), and after the nozzle row 10b is positioned above he thread, the coloring operation is performed by the control based on the thread coloring data SD.

[0103] Such a configuration can previously detect the unstable state of the nozzle row 10a (or 10b) that is positioned above the thread and is performing the coloring operation, thus allowing the use of the nozzle row 10a (or 10b) to be stopped before the occurrence of the abnormality. In addition, the nozzle row 10b (or 10a) that is positioned other than above the thread, waits by micro-drive of all nozzles, and perform maintenance by dummy discharge immediately before can be used to prevent abnormal discharge.

[0104] In this way, in the control of the present embodiment, the discharge for coloring can be performed in one nozzle row while the dummy discharge is performed in the other nozzle row in the predetermined periods of t3 to t4, t7 to t8, and t11 to t12 after the determination of the discharge instability. Accordingly, an interval for the dummy discharge is unnecessary, and the discharge for coloring can be stabilized without reducing the productivity.

Flowchart

[0105] FIG. 10 is a control flowchart relating to switching of nozzle rows and applied waveforms in the first embodiment. The control flow of the present embodiment is described with reference to FIG. 10, FIG. 3, and FIG. 9.

[0106] When a coloring request is received, the process in this flow is started. In S1, in response to the coloring request, all the nozzle rows 10a and 10b are decapped, and the decapping elapsed time counter 501 starts counting the decapping time (t0 in FIG. 9).

[0107] In S2, the head is moved so that the nozzle row (for example, 10a) to perform a coloring operation comes above a thread (t0 → t1 in FIG. 9).

[0108] In S3, coloring pulses or micro-drive pulses are applied to piezoelectric elements 13a to 13x of the nozzle row 10a that has reached above the thread, to perform the coloring operation. At this time, the nozzle-specific non-discharge period counter 505 counts the non-discharge period of each nozzle of the nozzle row 10a on the thread during the discharge operation (t1 in FIG. 9).

[0109] During the coloring operation of the nozzle row 10a, the micro-drive operation is performed in the nozzle row 10b that is not above the thread and is not performing the coloring operation. Then, until it is determined that the nozzle row 10a in the coloring operation is "unstable", the coloring operation and the micro-drive operation are continued in the nozzle rows 10a and 10b, respectively, (t1 → t3 in FIG. 9).

[0110] In step S4, the head controller 401 determines whether the discharge becomes unstable in the nozzle row 10a during the coloring operation. In this determination, the head controller 401 determines that the discharge becomes unstable at the timing when any one of the decapping time comparison signal and the non-discharge period comparison signal becomes Hi (t2 in FIG. 9).

[0111] When it is determined that the discharge becomes unstable in the nozzle row 10a during the coloring operation (YES in S4), in S5, the micro-drive pulse P2 (FIG. 9, t3 → t5) is switched to the dummy discharge pulse P3, and the dummy discharge pulse P3 is applied to the piezoelectric elements 13a to 13x corresponding to all the nozzles of the nozzle row 10b which are not above the thread. Thus, the dummy discharge is performed to perform maintenance on the nozzle row 10b.

Accordingly, the nozzle row 10b can be prepared for use in the coloring operation.

[0112] When the dummy discharge operation of the nozzle row 10b has elapsed for a predetermined time, in S6, the head is moved perpendicularly to the thread conveyance direction while continuing the dummy discharge operation of the nozzle row 10b, and the nozzle row 10b for which maintenance has been executed immediately before is positioned above the thread (t4 → t5 in FIG. 9). At this time, the post-switch elapsed time counter 503 starts counting the elapsed time after the switching (t5 in FIG. 9).

[0113] In S7, the pulse to be used is switched from the dummy discharge pulse P3 to the coloring pulse P1 or the micro-drive pulse P2, and the coloring pulse P1 or the micro-drive pulse P2, which is based on the thread coloring data SD, is applied to the piezoelectric element 13 of each nozzle of the nozzle row 10b, which is positioned above the thread by the switching from the nozzle row 10a. At this time, the nozzle-specific non-discharge period counter 505 counts the non-discharge period of each nozzle of the nozzle row 10b above the thread during the discharge operation, based on the thread coloring data SD (t5 in FIG. 9).

[0114] In addition, during the coloring operation of the other nozzle row 10b, the micro-drive operation is performed in the nozzle row 10a that is not above the thread and is not performing the coloring operation. In the nozzle row 10a that had been performed the coloring operation until immediately before, when the head 1 starts to move so that the nozzle row 10a moves away from the thread, the micro-drive pulse P2 may be applied instead of the coloring pulse P1 to start the micro-drive operation (t4 in FIG. 9).

[0115] When an instruction to terminate the coloring operation is issued in S8, in S10, the head 1 is moved to the position of the cap 21 and the operation is terminated.

[0116] On the other hand, when the instruction to terminate the coloring operation is not generated, the coloring operation in the nozzle row 10b and the micro-drive operation in the nozzle row 10a are continued (t5 → t7 in FIG. 9) until the nozzle row 10b in the coloring operation is determined to be "unstable" in S9 (t6 in FIG. 9).

[0117] In the determination of the head controller 401 in S9 after the switching, it is determined that the discharge becomes unstable at a timing when any one of the post-switch time comparison signal and the non-discharge period comparison signal becomes Hi (t6 and t10 in FIG. 9).

[0118] When it is determined in S9 that the nozzle row 10b in the coloring operation is "unstable", the process returns to before S5. In S5, the dummy discharge is performed on the nozzle row 10a (t7 → t9 in FIG. 9). In S6, the position of the head is moved to position the nozzle row 10a above the thread (t8 → t9 in FIG. 9). In S7, the coloring operation is performed on the nozzle row 10a (t9 in FIG. 9) and the micro-drive operation is performed on the nozzle row 10b (t8 in FIG. 9).

[0119] The above-described steps S5, S6, S7, and S9 are repeated while switching the nozzle rows 10a and 10b to be used until a coloring operation end instruction is received in S8.

[0120] In this manner, since the maintenance discharge and the coloring discharge can be simultaneously performed in parallel for each nozzle row, the dummy discharge can be performed even in the middle of the coloring operation, thus allowing the discharge stability to be enhanced.

[0121] In the present embodiment, as described above, in the plurality of nozzle rows, one nozzle row discharges liquid onto a thread and the other nozzle row dummy-discharges liquid onto the collection surface 22 (as a dummy discharge receiver) other than the thread. Accordingly, the linear or band-shaped medium such as the thread as a discharge target needs to be a thin medium having a width narrower than the inter-row distance of the plurality of nozzle rows.

[0122] Since the head moving unit 140 that moves the position of the discharge head 1 is provided for each head, the switching timing can be changed for each head. For example, nozzle rows above the thread in a head of a color that is not used can be switched even which another head is discharging liquid onto the thread.

Second Embodiment

[0123] In the first embodiment described above, the head controller 401 counts and predicts the time at which the discharge in the nozzles becomes unstable based on the time and the thread coloring data SD. However, the states in the nozzles may be directly measured.

[0124] FIG. 11 is a control block diagram of a section related to liquid discharge, head movement, cap lifting, and nozzle state detection in a liquid discharge apparatus according to a second embodiment of the present invention.

[0125] In the present embodiment, viscometers 15a to 15x are provided in a head 1A as nozzle-state detecting means for directly measuring the state in the nozzles 11. The viscometers 15a to 15x communicate with the nozzles 11 and are provided in all pressure chambers pressurized by the piezoelectric elements 13 (13a to 13x). The ink viscosity in each pressure chamber is detected with the viscometer 15.

[0126] In the present embodiment, the head controller 401A detects the state of the nozzle 11 based on the ink viscosity in the pressure chamber detected by the viscometer 15. Thus, the head controller 401A determines that "discharge is unstable" at a timing corresponding to the actual ink state in the nozzle 11, shifts the nozzle row not positioned above the thread to maintenance of dummy discharge to switch the nozzle row to be used.

[0127] Here, in the present embodiment, the maintenance is performed slightly before the discharge becomes unstable and becomes completely abnormal. Therefore, in the head controller 401A of the present embodiment, the "viscosity that may become abnormal" slightly before the ink viscosity becomes high and becomes abnormal is set as a threshold value for determining that the "discharge becomes unstable".

[0128] In this configuration, the nozzle rows can be switched in accordance with the current state of the nozzles, and the frequency of switching can be minimized.

Third Embodiment

[0129] FIG. 12 is a control block diagram of a section related to liquid discharge, head movement, cap lifting, and nozzle state detection in a liquid discharge apparatus according to a third embodiment of the present invention.

[0130] In the present embodiment, a piezoelectric element connecting board 16 and a residual vibration detector 17 are provided in a head 1B as nozzle-state detecting means for directly measuring the state in the nozzles. Specifically, the piezoelectric element connecting board 16 is provided corresponding to all the pressure chambers, and the ink viscosity is detected by the residual vibration detector 17 based on the damping vibration detected by the piezoelectric element connecting board 16. In the present embodiment, a head driver 410B is provided inside the head 1B.

[0131] FIGS. 13A and 13B are operation conceptual diagrams of residual vibration detected in the third embodiment.

[0132] As illustrated in FIG. 13A, when a drive waveform generated by a drive waveform generator 402 is applied to a piezoelectric element 13 (specifically, an electrode of the piezoelectric element connecting board 16), the piezoelectric element 13 expands and contracts. An expansion and contraction force acts on ink in a pressure chamber 27 from the piezoelectric element 13 via a diaphragm plate 30, and a pressure change occurs in the pressure chamber 27. Thus, an ink droplet is discharged from the nozzle 11. For example, the falling operation of the drive waveform decreases the pressure in the pressure chamber 27, and the rising operation of the drive waveform increases the pressure in the pressure chamber 27.

[0133] As illustrated in FIG. 13B, after a drive waveform is applied to the piezoelectric element 13 (after the ink droplet is discharged), the residual pressure vibration is generated in the ink in the pressure chamber 27. A residual pressure wave is propagated from the ink in the pressure chamber 27 to the piezoelectric element 13 via the diaphragm plate 30. The residual vibration waveform of the residual pressure wave is a damped vibration waveform. As a result, a residual vibration voltage is induced in the piezoelectric element 13 (specifically, the electrode of the piezoelectric element connecting board 16). The residual vibration detector 17 detects the residual vibration voltage and outputs the detection result to a head controller 401B as an output of the residual vibration detector.

[0134] In the present embodiment, the head controller 401B calculates the ink viscosity based on the residual vibration detected by the residual vibration detector 17, and detects the ink state based on the calculated ink viscosity. Thus, the head controller 401B can determine that the discharge is unstable at the timing corresponding to the actual ink state in the nozzles, shift to maintenance, and switch the nozzle row to be used.

[0135] The first embodiment determines that the discharge from the nozzle becomes unstable based on the time and the thread coloring data. The second embodiment and the third embodiment determine that the discharge from the nozzle becomes unstable based on the nozzle state. In some embodiments, the nozzle instability may be detected based on the time, the thread coloring data, and the measured nozzle state.

Fourth Embodiment

[0136] Furthermore, as another method of determining "the discharge from the nozzle is unstable", the landing state on a thread may be detected after liquid is actually discharged onto the thread. FIGS. 14A and 14B are schematic views of an example of a coloring-and-embroidering system including a liquid discharge apparatus mounted with a sensor that detects a landing state on a thread, according to a fourth embodiment of the present invention.

[0137] A sensor 107 of the present embodiment is provided so as to be positioned behind a head 1 of a liquid application unit 103 in the conveyance direction of a thread in order to detect a formed inspection pattern.

[0138] In a liquid discharge apparatus 100A illustrated in FIG. 14A, an example is illustrated in which the sensor 107 is provided immediately downstream from the liquid application unit 103 in the conveyance direction of the thread. Further, as long as the sensor is downstream from the liquid application unit 103 in the conveyance direction, the position of the sensor 107 as the sensor is not limited to the position immediately downstream from the liquid application unit 103.

[0139] Therefore, as in the liquid discharge apparatus 100B illustrated in FIG. 14B, a sensor 107B may be disposed downstream from a fixing unit 104 and a post-processing unit 105. Alternatively, a sensor may be between the fixing unit 104 and the post-processing unit 105.

[0140] In the fourth embodiment, the sensor 107 is provided downstream from the head 1 in the conveyance path of the thread 101 as a linear object, thus allowing automatic detection of the predetermined inspection pattern formed on a thread 101.

[0141] In FIGS. 14A and 14B, when a photosensor is employed as the sensor 107, the photosensor is installed only on the upper side. Accordingly, an example is illustrated in which a reflection type photosensor is employed in which a light emitting unit to irradiate a linear object with light and a light receiving unit to detect reflected light are integrated. In some embodiments, a transmission type photosensor may be employed in which a light emitting unit and a light receiving unit are separately provided on the upper side and the lower side of a thread conveying path.

Alternatively, the sensor 107 may be an image sensor (camera).

[0142] In the present embodiment, a head controller detects the discharge or non-discharge of each nozzle and the size of a discharged droplet based on the landing state of the droplet on the thread detected by the sensor 107, and grasps an ink state (ink clogging) based on the discharge state. Thus, the head controller can determine that the discharge is unstable at a necessary timing in accordance with the actual landing state on the thread. Then, based on the determination, the head controller can shift a nozzle row to maintenance and switch the nozzle row to be used.

[0143] The first embodiment determines that the discharge from the nozzle becomes unstable based on the time and the thread coloring data. The second and third embodiments determines that the discharge from the nozzle becomes unstable based on the nozzle state. The fourth embodiment determines that the discharge from the nozzle becomes unstable based on the detection result of the landed droplets on the thread. In some embodiments, two or three of the time and the thread coloring data, the measured nozzle state, and the detected landing state of the droplet on the thread may be combined to determine that the discharge from the nozzle becomes unstable.

Other Liquid Discharge Apparatus

[0144] Next, another example of a coloring apparatus according to an embodiment of the present invention is described with reference to FIG. 15. FIG. 15 is a schematic view of an example of a coloring system in which a liquid discharge apparatus according to an embodiment of the present invention is mounted.

[0145] In a coloring system 2000, the embroidery head 106 of the coloring-and-embroidering apparatus 1000 illustrated in FIG. 1 is replaced with a winding reel 110 to wind a colored thread 101.

[0146] The coloring system 2000 supplies the thread 101 from a supply reel 102, discharges and applies a liquid of a required color from a liquid application unit 103, colors the thread 101 to a target color, and winds the colored thread 101 around a winding reel 110.

[0147] The coloring system 2000 can also determine that the discharge from the nozzle row in the coloring operation becomes unstable by the control according to any of the first embodiment, the second embodiment, the third embodiment, and the fourth embodiments, and can simultaneously perform the discharge for maintenance and the discharge for coloring for each nozzle row of the plurality of nozzles. Accordingly, the dummy discharge can be performed even in the middle of coloring, thus allowing the discharge stability to be enhanced.

[0148] Although some embodiments and examples of the present invention have been described above, the present invention is not limited to the above-described embodiments and examples. The present invention can be variously modified or changed in light of the appended claims.

Claims

1. A liquid discharge apparatus (100) comprising:

a conveyance unit (102) configured to convey a discharge-target medium;
a discharge head (1) including a plurality of nozzle rows (10a, 10b), each nozzle row of which includes a plurality of nozzles arranged in a row parallel to a conveyance direction of the discharge-target medium; and
a controller (401) configured to control discharge of each nozzle row of the plurality of nozzle rows of the discharge head,
the controller (401) being configured to assign a discharge operation for maintenance and a discharge operation for coloring to each nozzle row of the plurality of nozzle rows and cause the discharge head (1) to simultaneously perform the discharge operation for maintenance and the discharge operation for coloring.

2. The liquid discharge apparatus according to claim 1, wherein the discharge-target medium is a linear or band-shaped medium having a width narrower than an inter-row distance of the plurality of nozzle rows and being continuous in the conveyance direction.

3. The liquid discharge apparatus according to claim 1 or 2, further comprising:

a plurality of discharge heads (1K, 1C, 1M, 1Y), each being constituted of the discharge head (1); and
a head moving unit (140) configured to move the plurality of discharge heads in a direction perpendicular to the conveyance direction of the discharge-target medium,
wherein the head moving unit (140) is configured to move the plurality of discharge heads for each discharge head, and
wherein the head moving unit (140) is configured to move one discharge head of the plurality of discharge heads during a coloring operation of another one of the plurality of discharge heads onto the discharge-target medium, to switch a nozzle row positioned above the discharge-target medium from one nozzle row of the one dis-

charge head to another nozzle row of the one discharge head to switch between the discharge operation for maintenance and the discharge operation for coloring in the one discharge head.

4. The liquid discharge apparatus according to claim 3, further comprising a drive waveform generator (402) configured to generate a drive waveform,
wherein the plurality of discharge heads (1K, 1C, 1M, 1Y), each including a plurality of pressure generating elements (13) configured to apply pressure to liquid in the nozzles, respectively, of the plurality of nozzle rows,
wherein the controller (104) is configured to, based on coloring data, apply one of a coloring drive waveform to cause the liquid to adhere to the discharge-target medium and a micro-drive waveform for vibrating a meniscus of each nozzle to each one of the plurality of pressure generating elements (13) corresponding to each nozzle of the nozzle row positioned above the discharge-target medium, to perform a discharge operation for the coloring, and
the controller (104) is configured to apply a micro-drive waveform for vibrating the meniscus of each nozzle or a drive waveform for dummy discharge to discharge the liquid to a region above the discharge-target medium to each one of the plurality of pressure generating elements (13) corresponding to each nozzle of a nozzle row not positioned above the discharge-target medium, to perform a micro-drive operation or a dummy discharge operation.

5. The liquid discharge apparatus according to claim 4, wherein the controller (104) determines whether discharge from at least some nozzles of the nozzle row positioned above the discharge-target medium to perform the discharge operation for coloring becomes unstable, and
wherein the controller is configured to cause each nozzle of the nozzle row not positioned above the discharge-target medium to perform the micro-drive operation before the controller (104) determines that the discharge becomes unstable, and
the controller is configured to, when the controller (104) determines that the discharge becomes unstable, cause each nozzle of the nozzle row not positioned above the discharge-target medium to perform the dummy discharge operation and move the one discharge head so that the nozzle row having performed the dummy discharge operation is positioned above the discharge-target medium.

6. The liquid discharge apparatus according to claim 5, wherein the controller is configured to count a non-discharge period of a non-discharge nozzle in the nozzle row positioned above the discharge-target medium to perform the discharge operation for coloring, and
the controller is configured to determine that discharge from the nozzle row including the non-discharge nozzle becomes unstable, when the non-discharge period is equal to or longer than a threshold time.

7. The liquid discharge apparatus according to claim 5, wherein the controller is configured to count an elapsed time after a coloring start instruction or a previous movement of a discharge head currently positioned above the discharge-target medium, and the controller is configured to determine that discharge from the nozzle row currently positioned above the discharge-target medium becomes unstable, when the elapsed time is equal to or longer than a threshold time.

8. The liquid discharge apparatus according to claim 5, wherein each of the plurality of discharge heads includes a nozzle-state detecting means (15, 16, 17) for determining a state of the liquid inside each nozzle of the plurality of nozzle rows, and
wherein the controller is configured to, when the nozzle-state detecting means determines that a state of liquid in a liquid chamber communicating with a nozzle is likely to cause an abnormality, is likely to be abnormal determine that discharge from a nozzle row including the nozzle and currently positioned on the discharge-target medium becomes unstable.

9. The liquid discharge apparatus according to any one of claims 4 to 8,
wherein the drive waveform generated by the drive waveform generator (402) includes a pulse for performing a discharge operation for coloring and a pulse for performing a discharge operation for maintenance, and
the controller is configured to select pulses for different uses from the drive waveform and use the pulses for the plurality of nozzle rows.

10. The liquid discharge apparatus according to any one of claims 1 to 8,
wherein the discharge head includes a plurality of drive waveform generators (402) corresponding to the plurality of nozzle rows, respectively, to generate pulses for different uses between the plurality of nozzle rows and performs discharge with the pulses for different uses.

11. A discharge control method for a liquid discharge apparatus including a conveyance unit to convey a discharge-target medium and a discharge head with a plurality of nozzle rows parallel to a conveyance direction of the discharge-target medium, the discharge control method comprising:

performing a discharge operation for coloring on the discharge-target medium from one nozzle row of the plurality of nozzle rows; and performing a dummy discharge operation for maintenance from another nozzle row of the plurality of nozzle rows simultaneously with the discharge operation for coloring.

FIG. 1

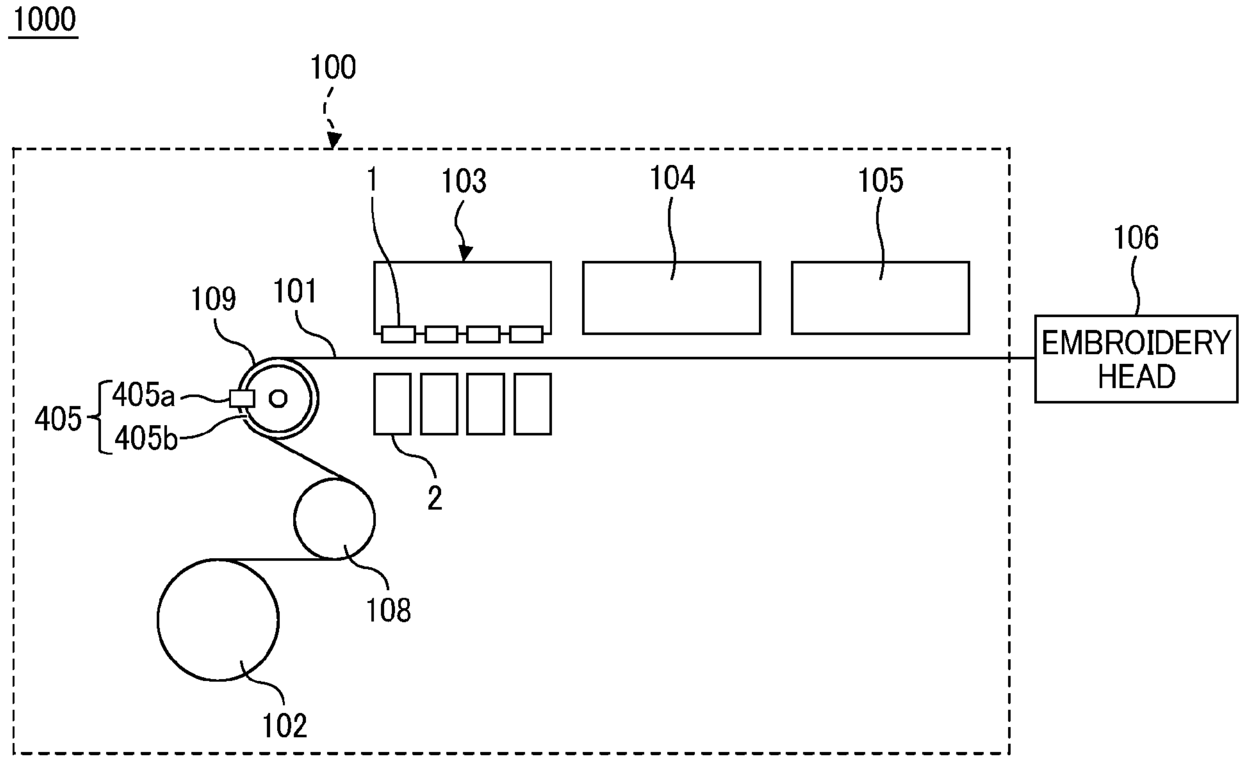

1000
100
1
103
104
105
106
109
101
EMBROIDERY
HEAD
405
405a
405b
2
108
102

FIG. 2

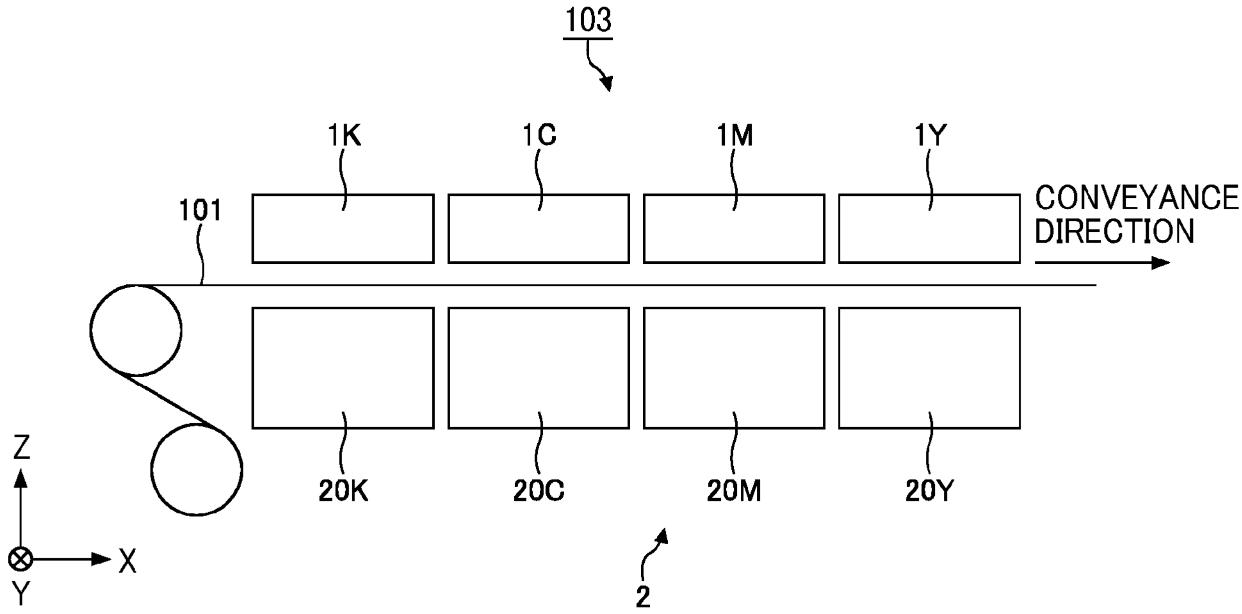

103
1K
1C
1M
1Y
101
CONVEYANCE
DIRECTION
20K
20C
20M
20Y
Z
X
Y
2

FIG. 3

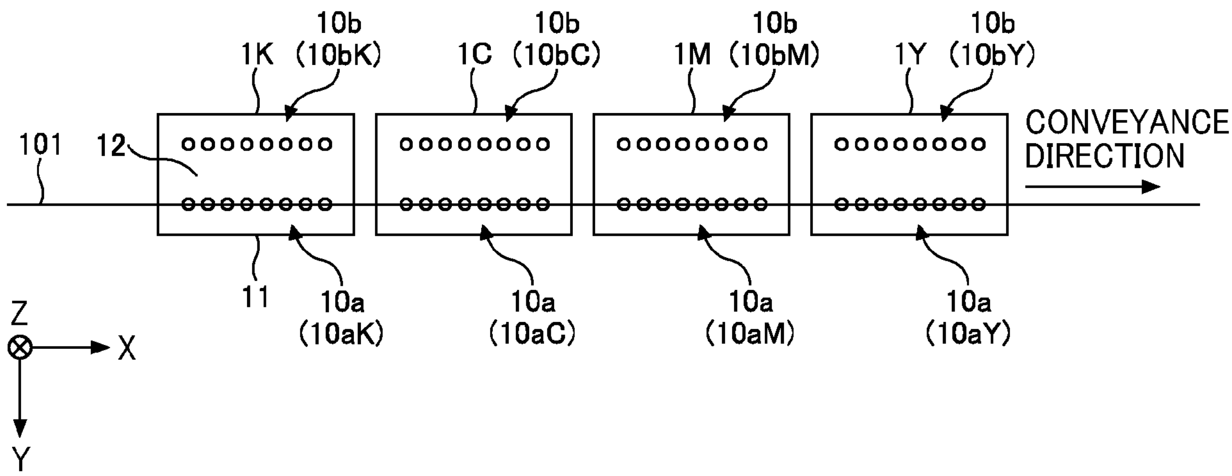

10b
1K (10bK)
10b
1C (10bC)
10b
1M (10bM)
10b
1Y (10bY)
CONVEYANCE
DIRECTION
101
12
11
10a
(10aK)
10a
(10aC)
10a
(10aM)
10a
(10aY)
Z
X
Y

FIG. 4A

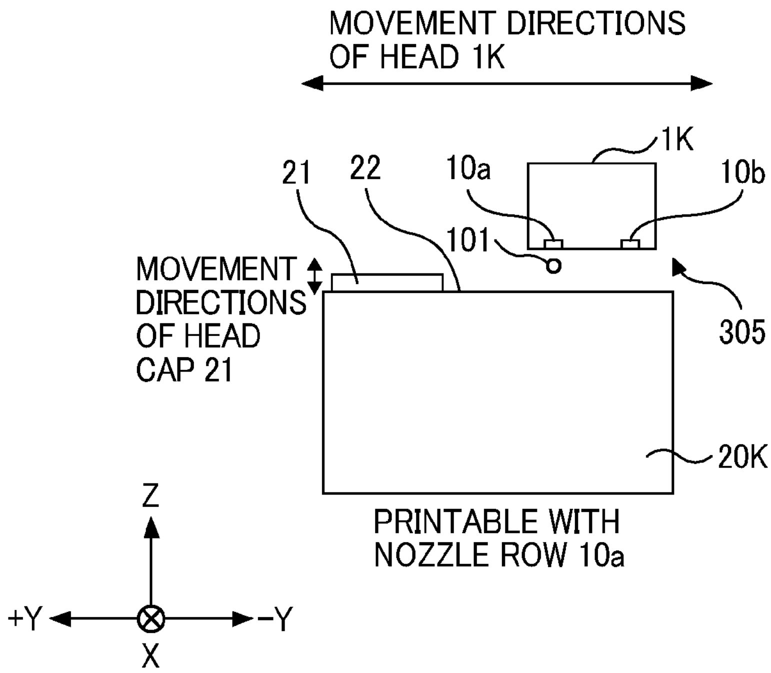


FIG. 4B

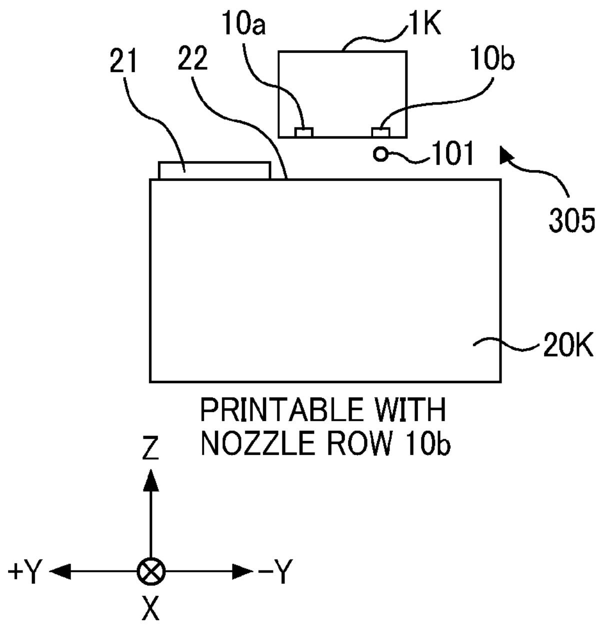


FIG. 4C

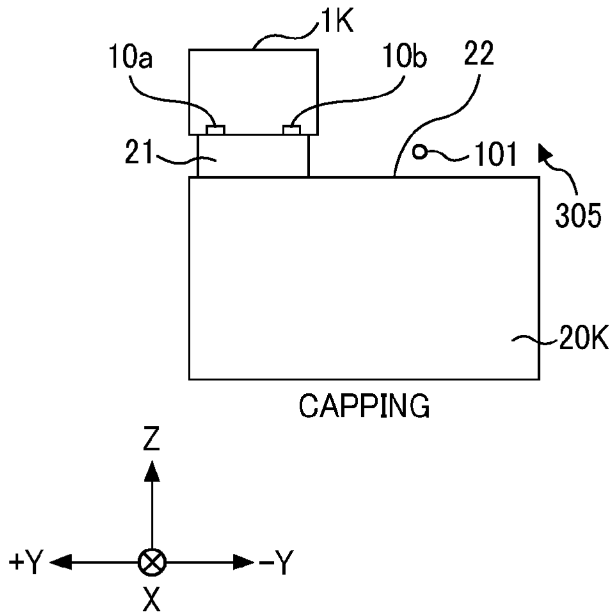
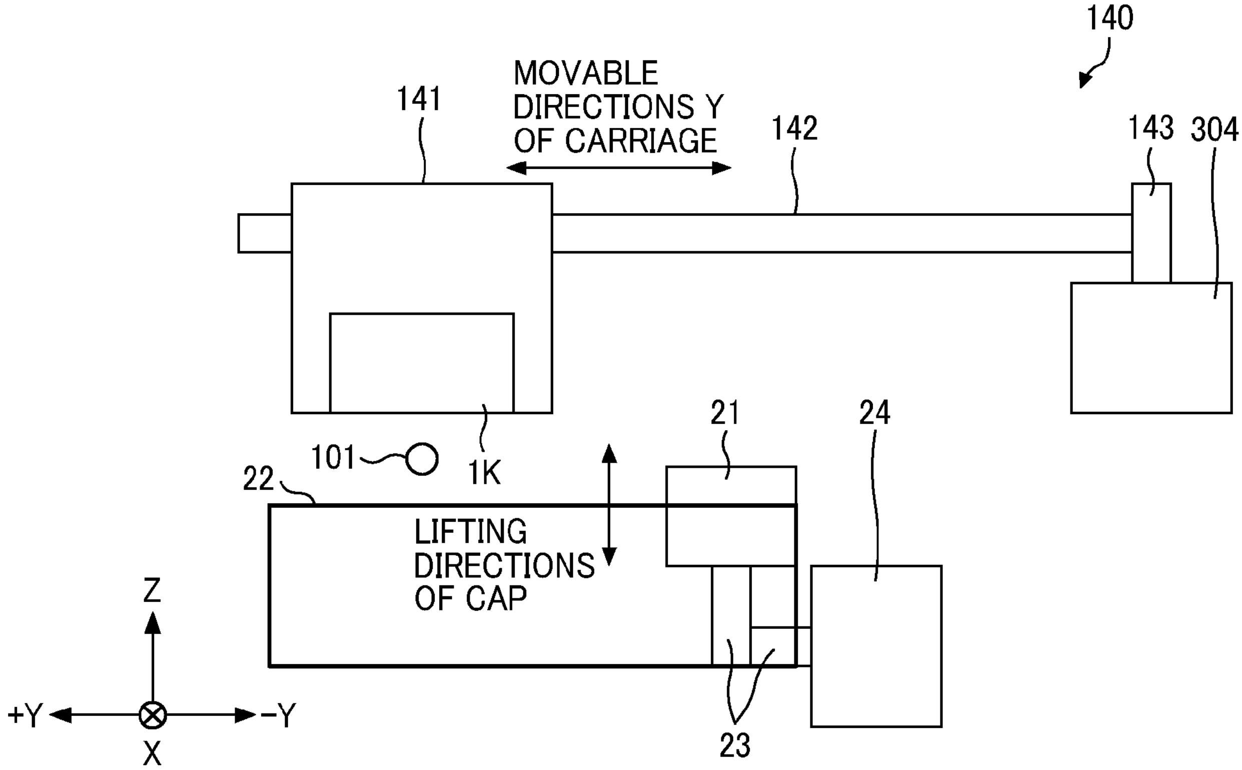
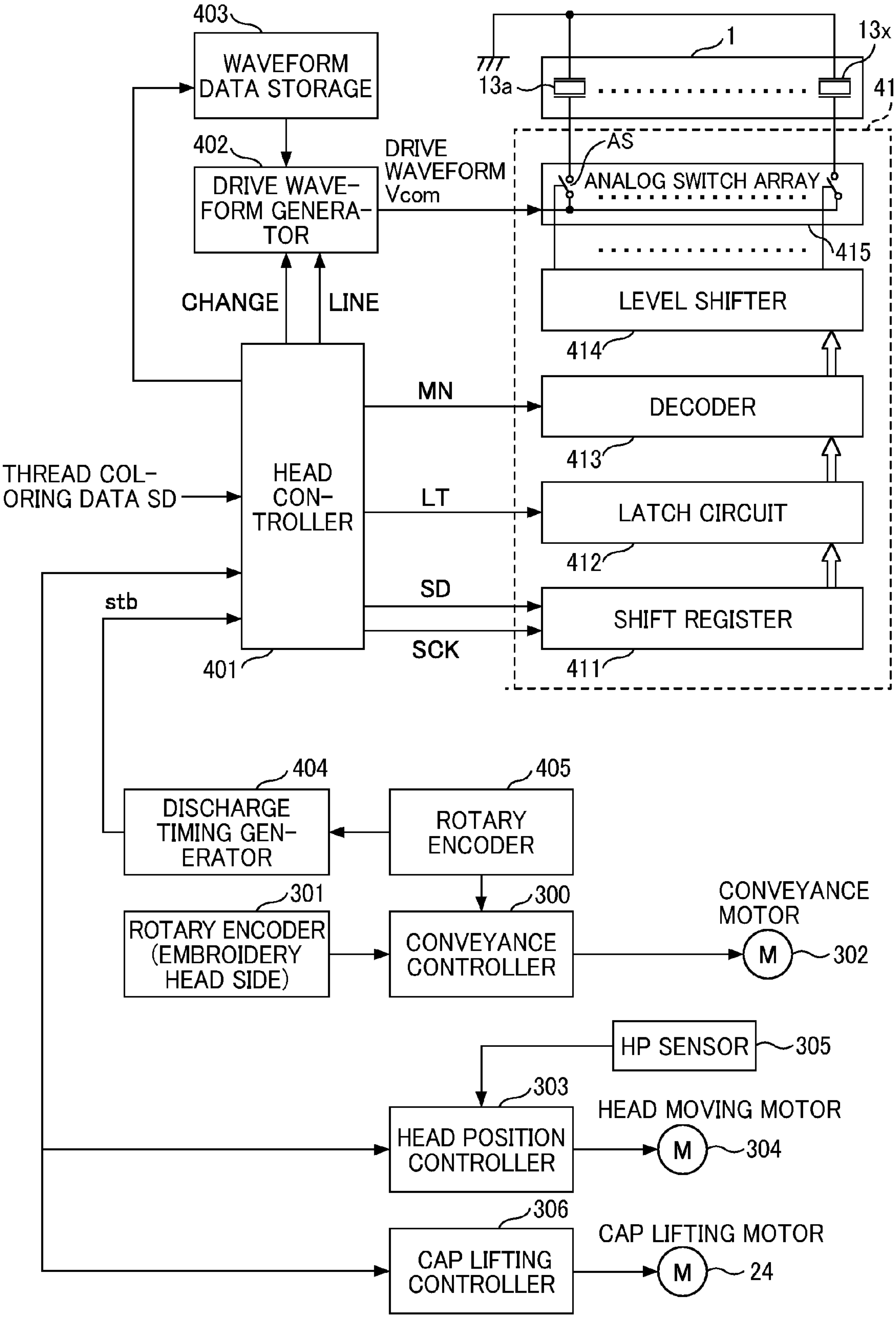


FIG. 5



140
MOVABLE DIRECTIONS Y OF CARRIAGE
141
142
143
304
21
24
101
22
1K
LIFTING DIRECTIONS OF CAP
Z
+Y
-Y
X
23

FIG. 6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WAVEFORM DATA STORAGE
402
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DRIVE WAVEFORM Vcom
CHANGE
LINE
1
13x
13a
410
AS
ANALOG SWITCH ARRAY
415
LEVEL SHIFTER
414
MN
DECODER
413
THREAD COL-ORING DATA SD
HEAD CON-TROLLER
LT
LATCH CIRCUIT
412
stb
SD
SHIFT REGISTER
SCK
401
411
404
DISCHARGE TIMING GEN-ERATOR
405
ROTARY ENCODER
301
ROTARY ENCODER (EMBROIDERY HEAD SIDE)
300
CONVEYANCE CONTROLLER
CONVEYANCE MOTOR
M
302
HP SENSOR
305
303
HEAD POSITION CONTROLLER
HEAD MOVING MOTOR
M
304
306
CAP LIFTING CONTROLLER
CAP LIFTING MOTOR
M
24

FIG. 7

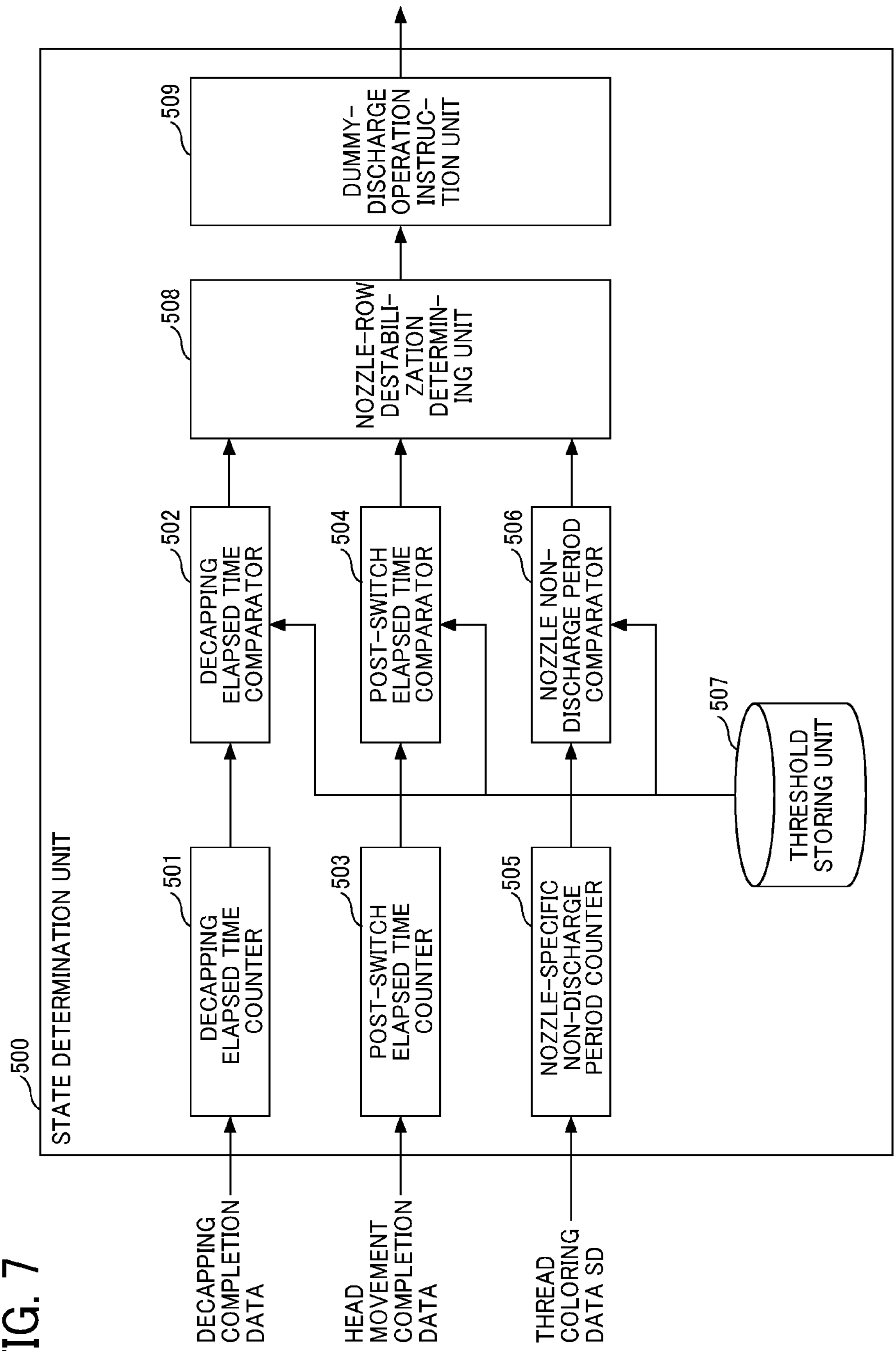

500
STATE DETERMINATION UNIT
DECAPPING COMPLETION DATA
HEAD MOVEMENT COMPLETION DATA
THREAD COLORING DATA SD
501
DECAPPING ELAPSED TIME COUNTER
503
POST-SWITCH ELAPSED TIME COUNTER
505
NOZZLE-SPECIFIC NON-DISCHARGE PERIOD COUNTER
502
DECAPPING ELAPSED TIME COMPARATOR
504
POST-SWITCH ELAPSED TIME COMPARATOR
506
NOZZLE NON-DISCHARGE PERIOD COMPARATOR
507
THRESHOLD STORING UNIT
508
NOZZLE-ROW DESTABILIZATION DETERMINING UNIT
509
DUMMY-DISCHARGE OPERATION INSTRUCTION UNIT

FIG. 8

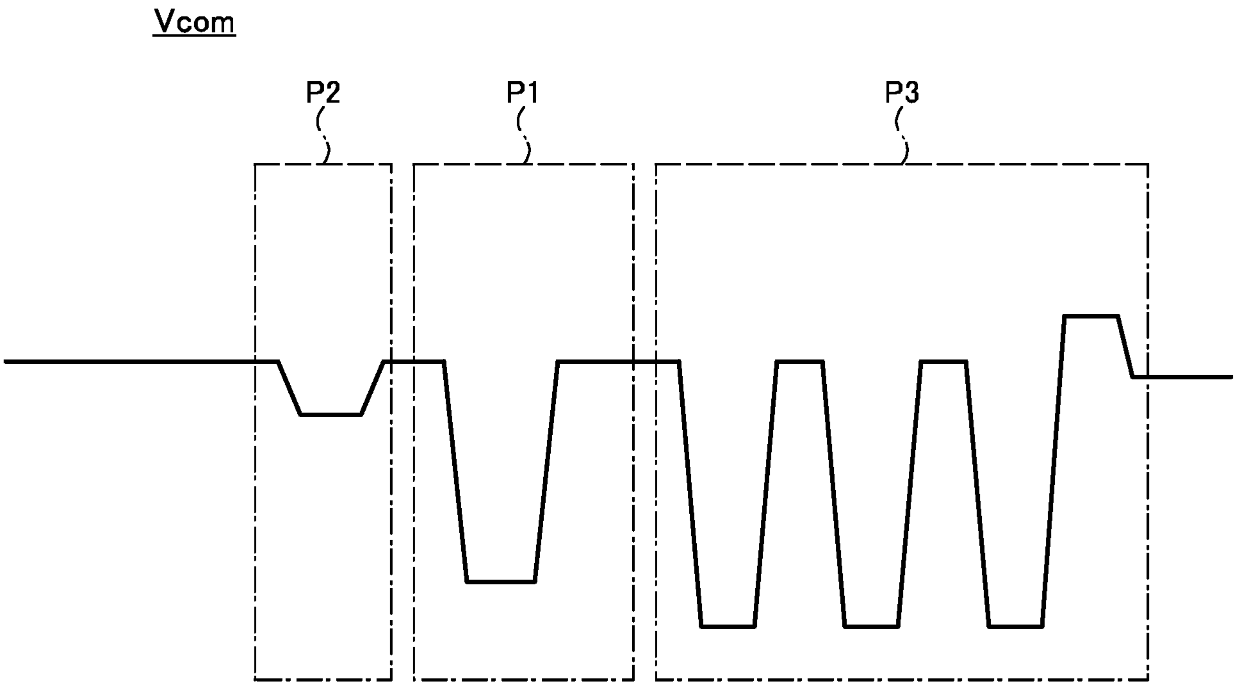


FIG. 9

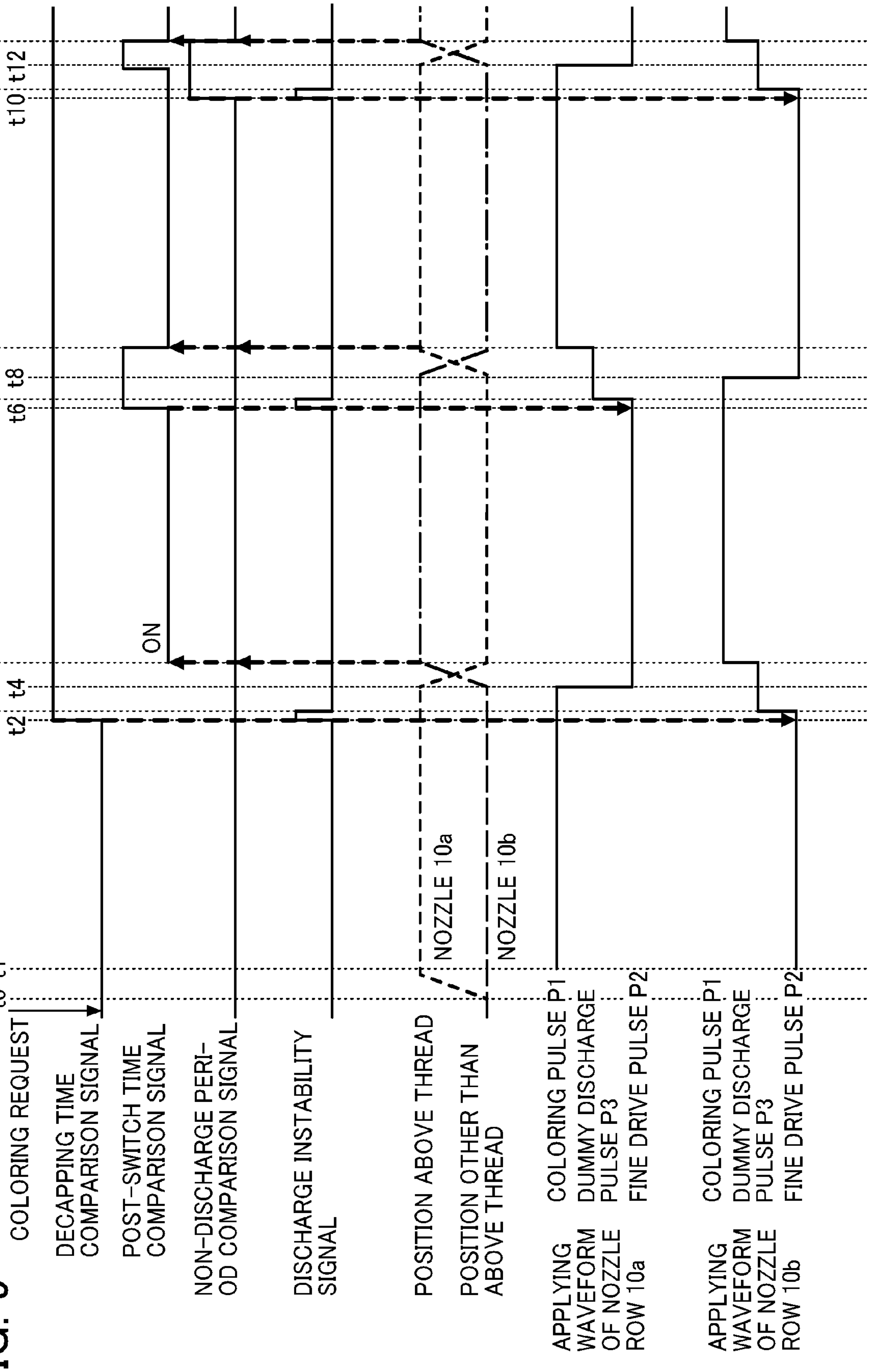

COLORING REQUEST
DECAPPING TIME COMPARISON SIGNAL
POST-SWITCH TIME COMPARISON SIGNAL
NON-DISCHARGE PERIOD COMPARISON SIGNAL
DISCHARGE INSTABILITY SIGNAL
POSITION ABOVE THREAD
POSITION OTHER THAN ABOVE THREAD
APPLYING WAVEFORM OF NOZZLE ROW 10a
COLORING PULSE P1
DUMMY DISCHARGE PULSE P3
FINE DRIVE PULSE P2
APPLYING WAVEFORM OF NOZZLE ROW 10b
COLORING PULSE P1
DUMMY DISCHARGE PULSE P3
FINE DRIVE PULSE P2
NOZZLE 10a
NOZZLE 10b
ON
t0
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
t11
t12
t13

FIG. 10

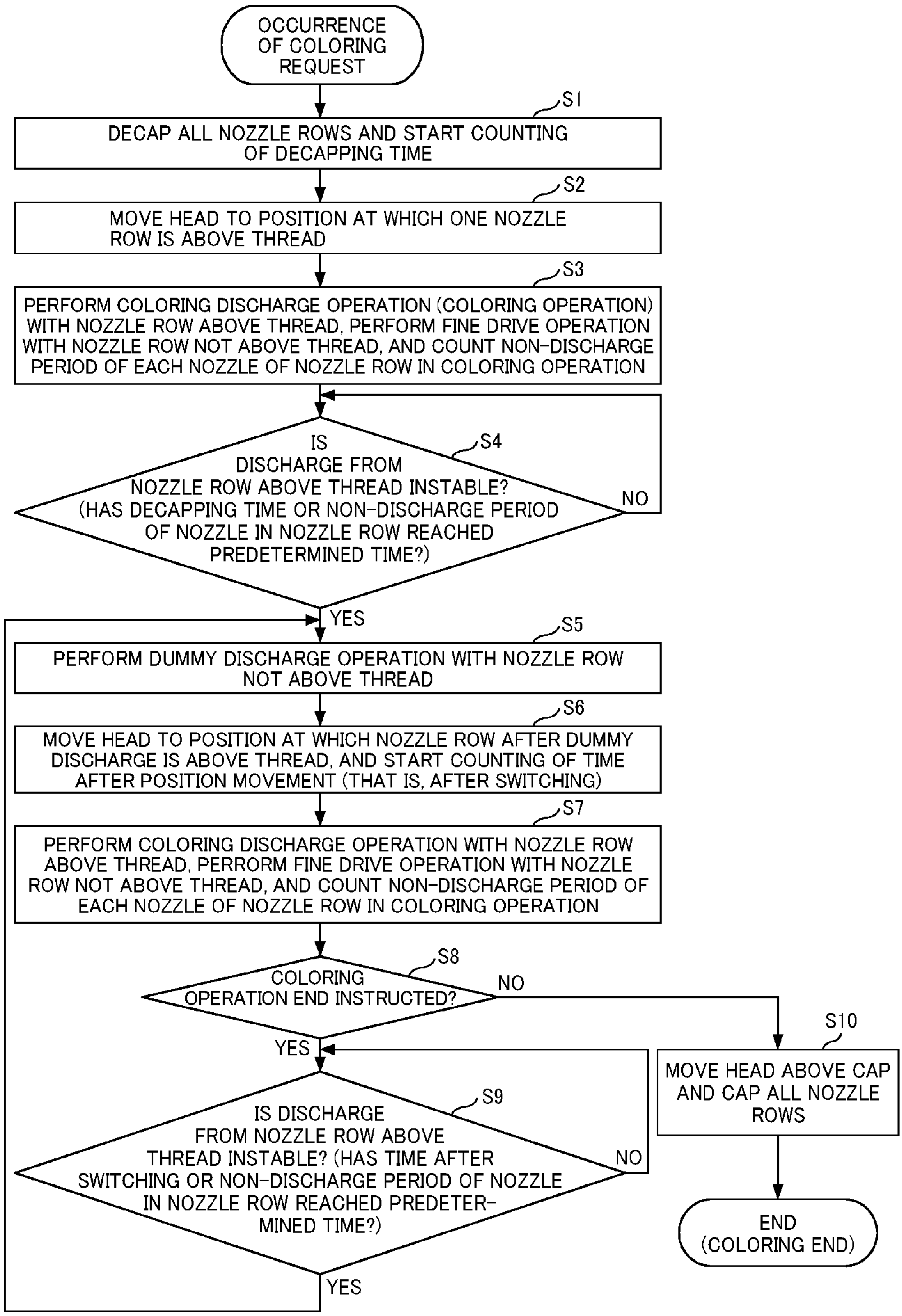

OCCURRENCE OF COLORING REQUEST
S1
DECAP ALL NOZZLE ROWS AND START COUNTING OF DECAPPING TIME
S2
MOVE HEAD TO POSITION AT WHICH ONE NOZZLE ROW IS ABOVE THREAD
S3
PERFORM COLORING DISCHARGE OPERATION (COLORING OPERATION) WITH NOZZLE ROW ABOVE THREAD, PERFORM FINE DRIVE OPERATION WITH NOZZLE ROW NOT ABOVE THREAD, AND COUNT NON-DISCHARGE PERIOD OF EACH NOZZLE OF NOZZLE ROW IN COLORING OPERATION
S4
IS DISCHARGE FROM NOZZLE ROW ABOVE THREAD INSTABLE? (HAS DECAPPING TIME OR NON-DISCHARGE PERIOD OF NOZZLE IN NOZZLE ROW REACHED PREDETERMINED TIME?)
NO
YES
S5
PERFORM DUMMY DISCHARGE OPERATION WITH NOZZLE ROW NOT ABOVE THREAD
S6
MOVE HEAD TO POSITION AT WHICH NOZZLE ROW AFTER DUMMY DISCHARGE IS ABOVE THREAD, AND START COUNTING OF TIME AFTER POSITION MOVEMENT (THAT IS, AFTER SWITCHING)
S7
PERFORM COLORING DISCHARGE OPERATION WITH NOZZLE ROW ABOVE THREAD, PERRORM FINE DRIVE OPERATION WITH NOZZLE ROW NOT ABOVE THREAD, AND COUNT NON-DISCHARGE PERIOD OF EACH NOZZLE OF NOZZLE ROW IN COLORING OPERATION
S8
COLORING OPERATION END INSTRUCTED?
NO
YES
S9
IS DISCHARGE FROM NOZZLE ROW ABOVE THREAD INSTABLE? (HAS TIME AFTER SWITCHING OR NON-DISCHARGE PERIOD OF NOZZLE IN NOZZLE ROW REACHED PREDETER-MINED TIME?)
NO
YES
S10
MOVE HEAD ABOVE CAP AND CAP ALL NOZZLE ROWS
END (COLORING END)

FIG. 11

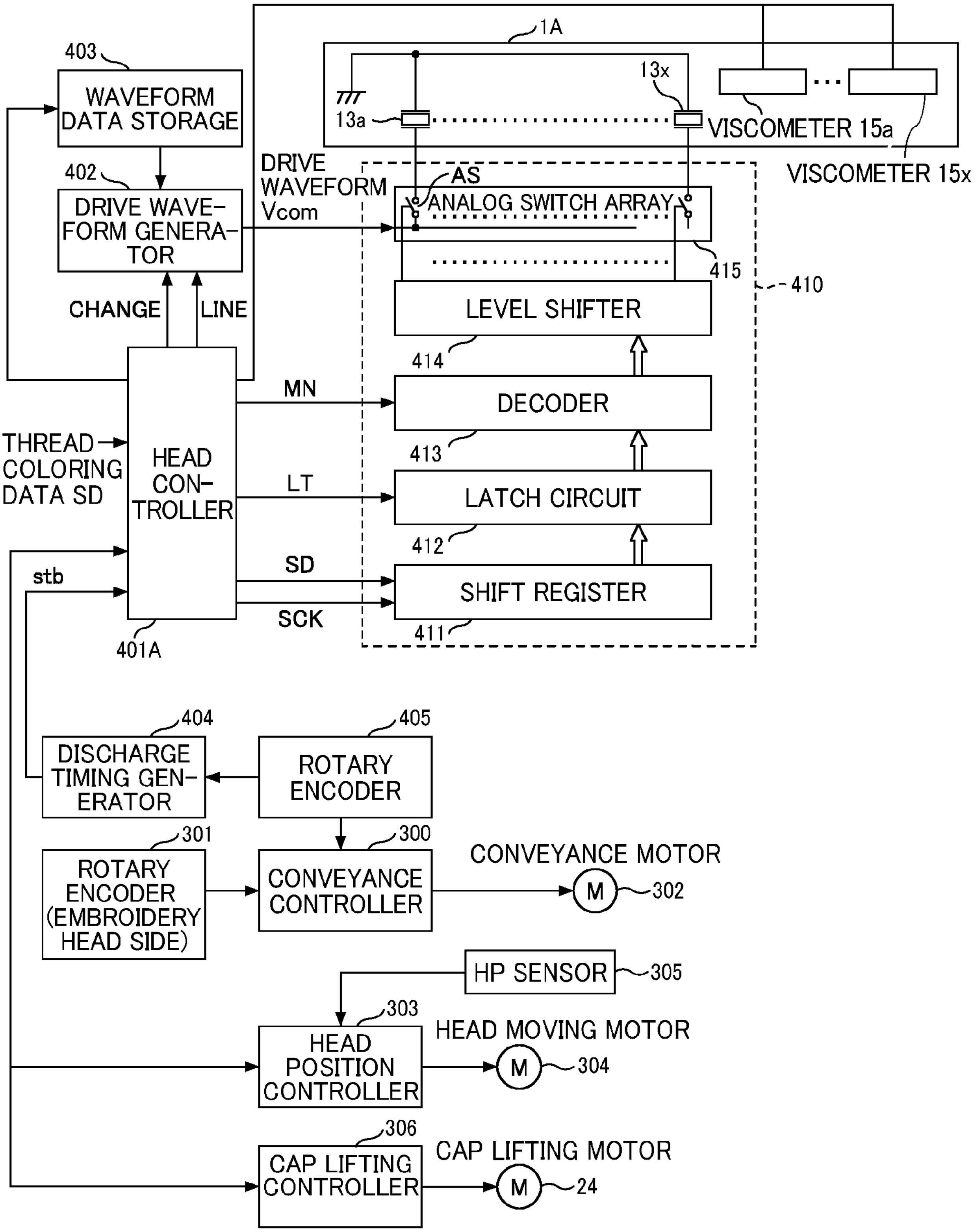
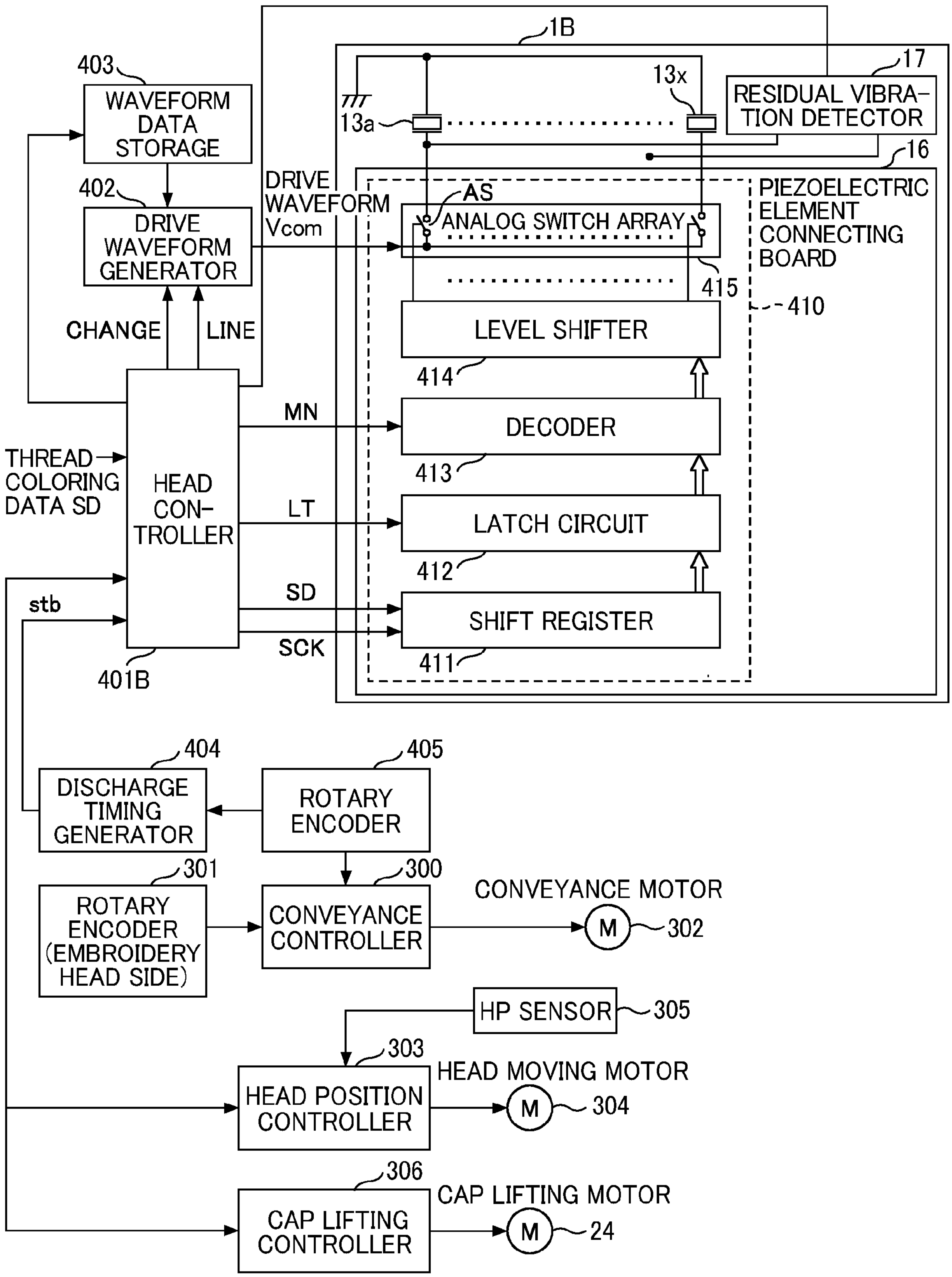

1A
13x
13a
VISCOMETER 15a
VISCOMETER 15x
403
WAVEFORM DATA STORAGE
402
DRIVE WAVE-FORM GENERA-TOR
DRIVE WAVEFORM Vcom
AS
ANALOG SWITCH ARRAY
415
410
CHANGE
LINE
LEVEL SHIFTER
414
MN
DECODER
413
THREAD COLORING DATA SD
HEAD CON-TROLLER
LT
LATCH CIRCUIT
412
stb
SD
SHIFT REGISTER
SCK
411
401A
404
DISCHARGE TIMING GEN-ERATOR
405
ROTARY ENCODER
301
ROTARY ENCODER (EMBROIDERY HEAD SIDE)
300
CONVEYANCE CONTROLLER
CONVEYANCE MOTOR
M
302
HP SENSOR
305
303
HEAD POSITION CONTROLLER
HEAD MOVING MOTOR
M
304
306
CAP LIFTING CONTROLLER
CAP LIFTING MOTOR
M
24

FIG. 12


1B
17
RESIDUAL VIBRATION DETECTOR
13x
13a
16
PIEZOELECTRIC ELEMENT CONNECTING BOARD
403
WAVEFORM DATA STORAGE
402
DRIVE WAVEFORM GENERATOR
DRIVE WAVEFORM Vcom
AS
ANALOG SWITCH ARRAY
415
410
LEVEL SHIFTER
414
CHANGE
LINE
MN
DECODER
413
THREAD COLORING DATA SD
HEAD CONTROLLER
LT
LATCH CIRCUIT
412
SD
stb
SHIFT REGISTER
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CONVEYANCE MOTOR
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HP SENSOR
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HEAD POSITION CONTROLLER
HEAD MOVING MOTOR
M
304
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CAP LIFTING CONTROLLER
CAP LIFTING MOTOR
M
24

FIG. 13A

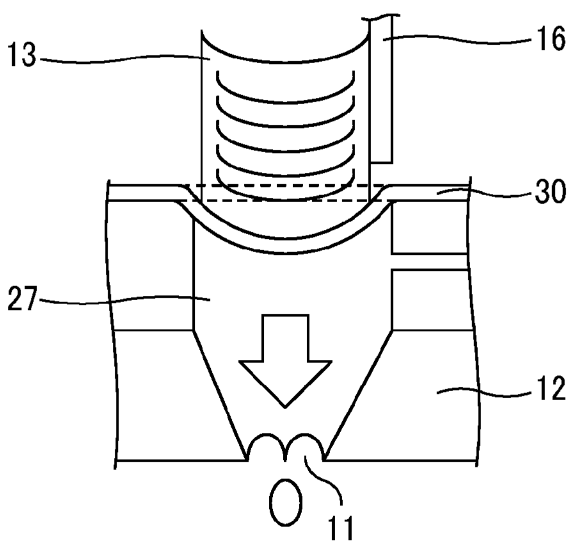


FIG. 13B

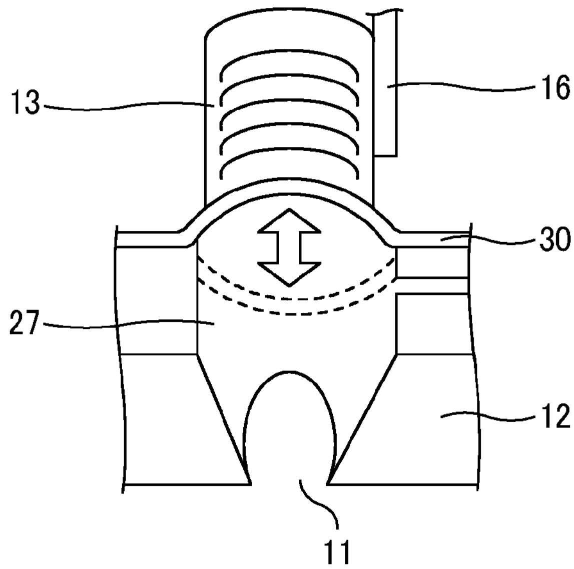


FIG. 14A

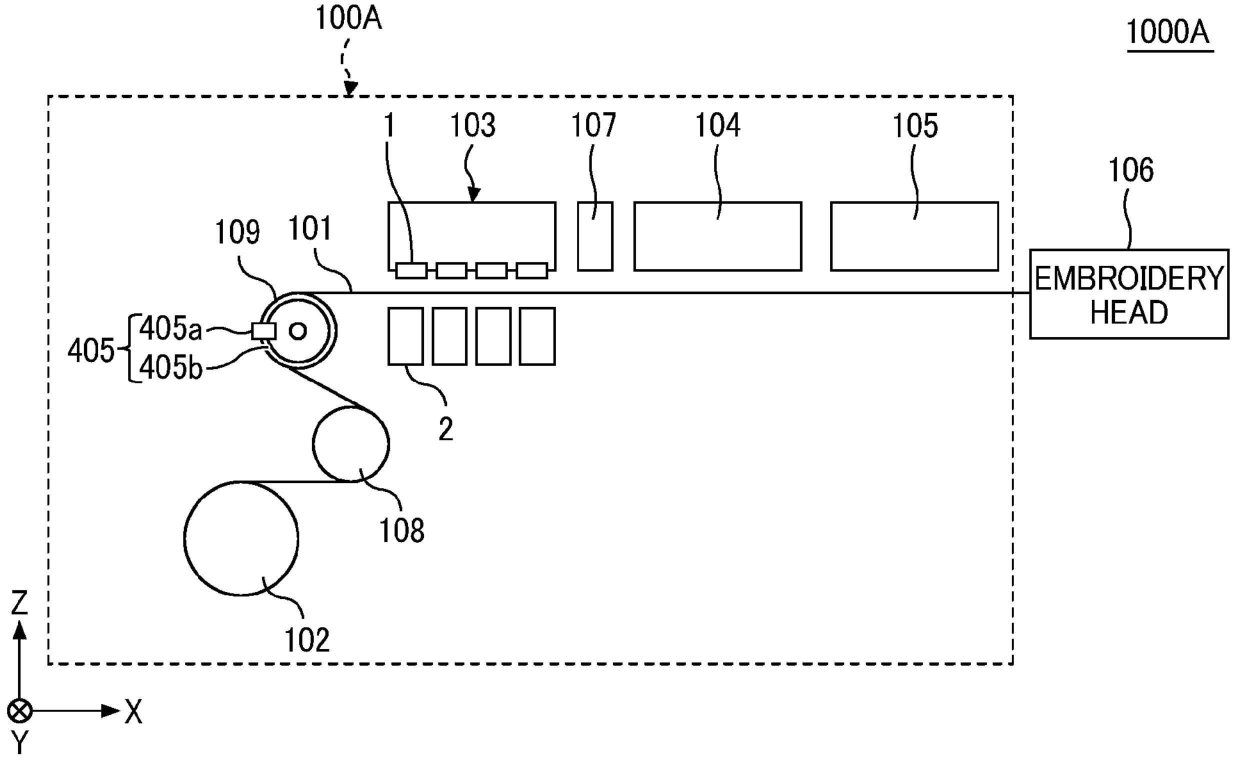


FIG. 14B

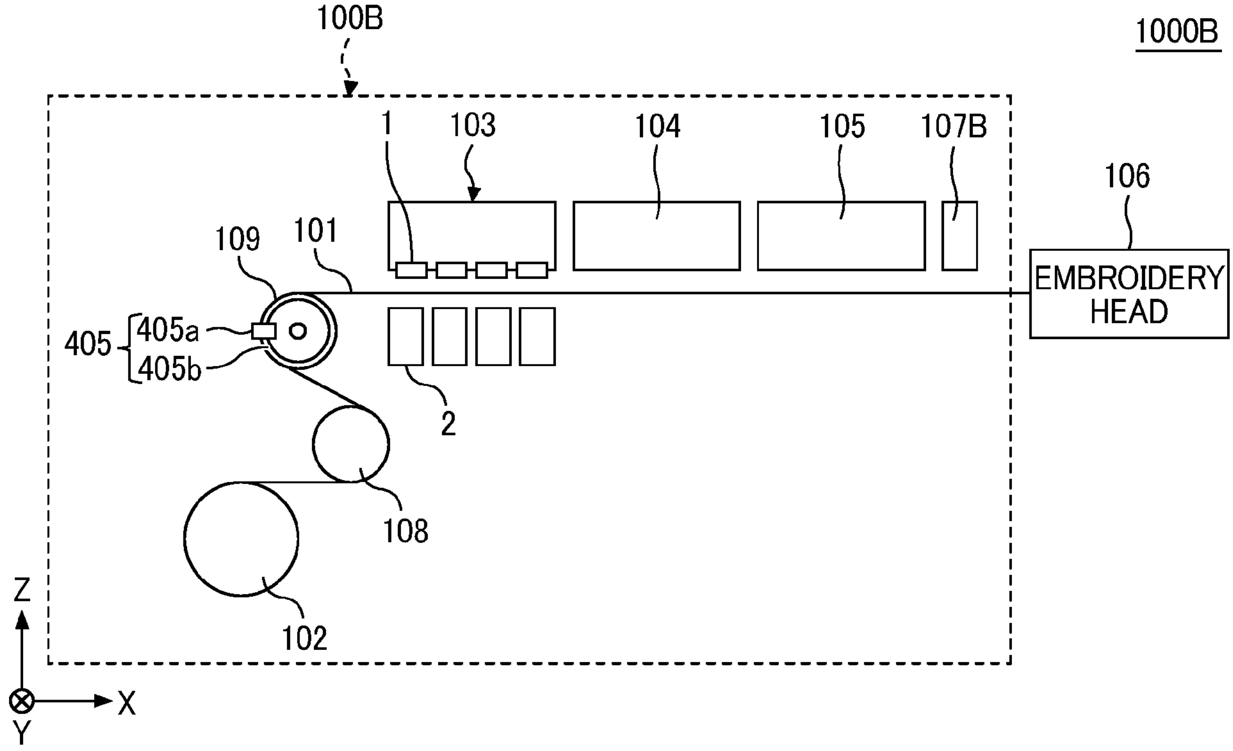
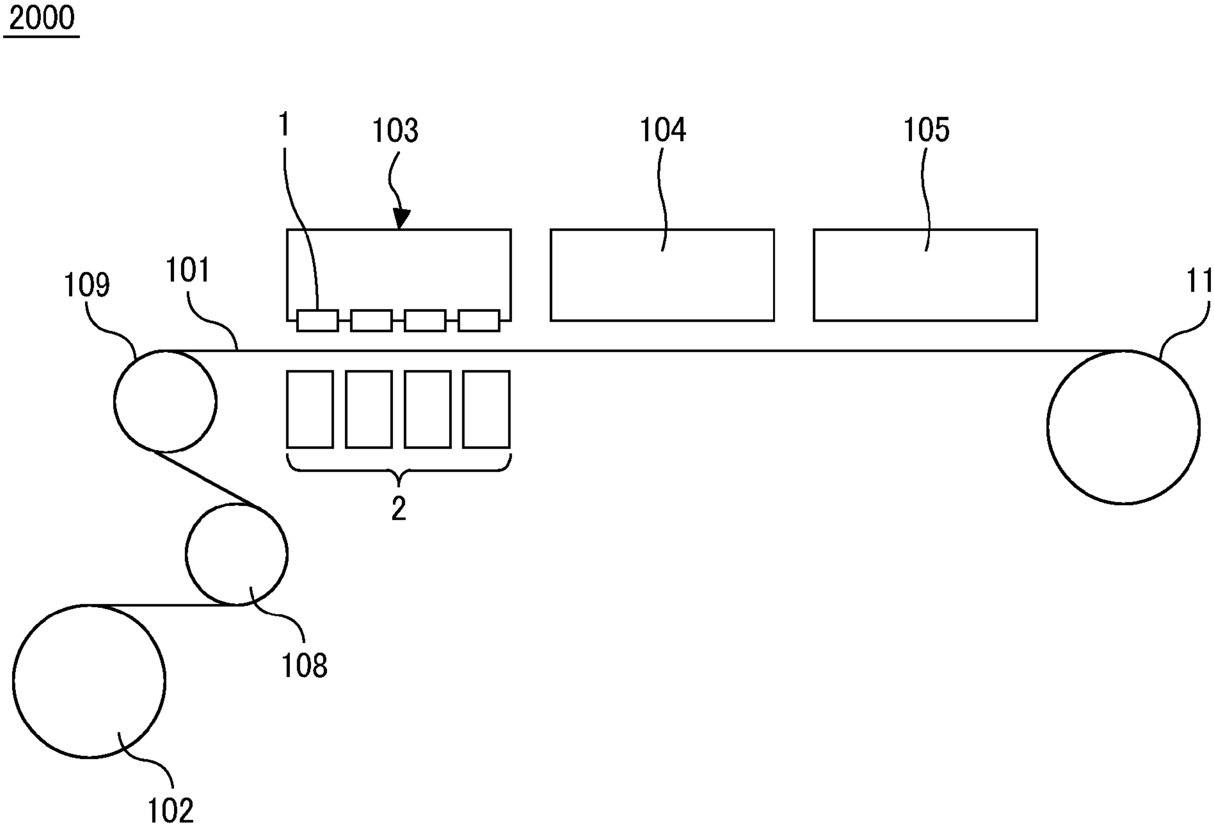


FIG. 15



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EUROPEAN SEARCH REPORT

Application Number
EP 20 20 8014

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	JP H06 305129 A (CANON KK) 1 November 1994 (1994-11-01) * the whole document * -----	1-11	INV. B41J2/165 B41J3/407 B05B5/14 D05C11/24 D06B11/00
A	JP H06 304359 A (CANON KK) 1 November 1994 (1994-11-01) * the whole document * -----	1-11	
A	US 2011/157287 A1 (KAWAKAMI TAKAYUKI [JP]) 30 June 2011 (2011-06-30) * the whole document * -----	1,11	

TECHNICAL FIELDS SEARCHED (IPC)

B41J
B65D
B05B
D05C
D06B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	8 April 2021	Hartmann, Mathias

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08-04-2021

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JP H06305129 A	01-11-1994	NONE	
JP H06304359 A	01-11-1994	NONE	
US 2011157287 A1	30-06-2011	CN 102126345 A	20-07-2011
		JP 2011131193 A	07-07-2011
		US 2011157287 A1	30-06-2011

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Patent documents cited in the description

- JP 6241078 B **[0002] [0003]**
- JP 2014233904 A **[0002]**
- JP 2010094950 A **[0002] [0004]**
- JP 2002200381 A **[0005] [0006]**