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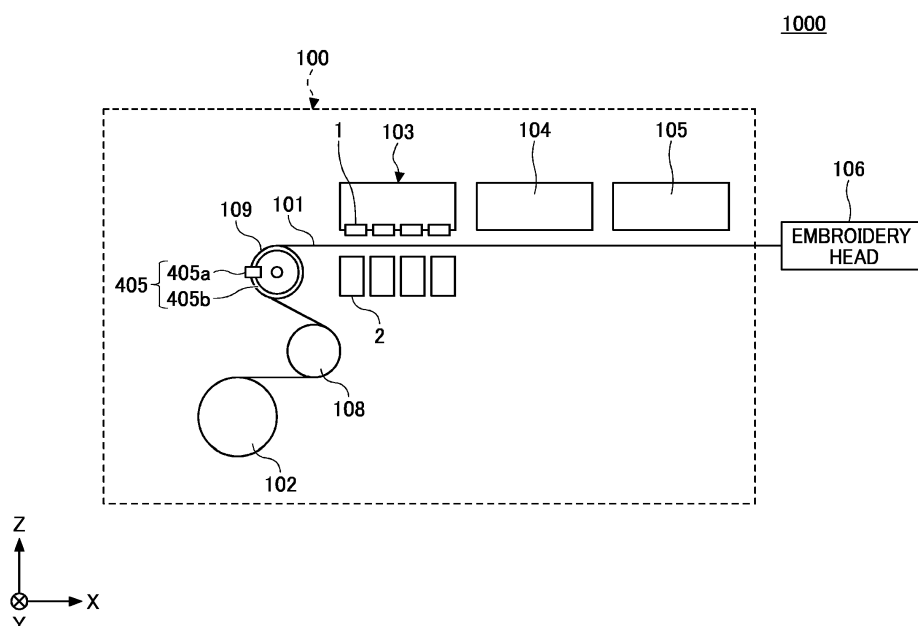
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(54) **LIQUID DISCHARGE APPARATUS AND METHOD FOR FORMING TEST PATTERN IN THE LIQUID DISCHARGE APPARATUS**

(57) A liquid discharge apparatus (100, 100A, 100B) including a head (1a, 1b, 1c, 1d) having a nozzle row with nozzles in line, a conveyor (102, 108, 109) to convey a discharge target medium (101) in parallel with alignment of the nozzle row, and a controller (200, 200A) that controls a liquid discharge in association with conveyance of the discharge target medium (101). The controller (200, 200A) determines, with a test pattern, whether the nozzles of the head (1a, 1b, 1c, 1d) discharge a color

liquid. When forming the test pattern without discharging droplets of the color liquid from adjacent nozzles simultaneously, the controller (200, 200A) discharges a droplet from a first nozzle of the adjacent nozzles, suspends the liquid discharge for a predetermined period of conveyance of the discharge target medium (101), and discharges a droplet from a second nozzle of the adjacent nozzles after the predetermined period.

FIG. 1



Description

BACKGROUND

5 Technical Field

[0001] Embodiments of the present disclosure relate to a liquid discharge apparatus that discharges liquid to a linear or belt-shaped discharge target medium such as a thread, and a method for forming a test pattern in the liquid discharge apparatus.

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Discussion of the Background Art

[0002] Various types of image forming apparatuses are known to include a head having a plurality of nozzles and form a test pattern including dots by discharging ink from each nozzle of the head onto a sheet so as to clean an identified clogged nozzle or nozzles.

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[0003] For example, JP H11-078050-A discloses a technique of an image forming apparatus including a display unit that displays each nozzle separately so that a clogged nozzle is identified easily, and an identification unit that separately identifies each nozzle displayed on the display unit, so as to identify a clogged nozzle or nozzles easily. Based on the result of this identification unit, the image forming apparatus of JP H11-078050-A cleans the identified clogged nozzle or nozzles.

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[0004] Further, in a serial printer in which a general head moves in a direction orthogonal to the sheet conveyance direction, the carriage moves in a direction orthogonal to the head nozzle row, so that a test pattern for nozzle check can be printed for the whole rows simultaneously.

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[0005] However, when applying the technique of JP H11-078050-A is attempted to a thread printing apparatus (for example, a thread coloring apparatus) that includes a head nozzle row disposed horizontal to the thread conveyance direction, the nozzles do not move in the orthogonal direction to the medium (that is, the thread), which makes it difficult to check liquid discharge of the whole nozzles.

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[0006] Further, when there is a missing dot or dots in the pattern on a thin medium such as a thread, if the nozzles in the same nozzle row discharge liquid simultaneously, the droplets bleed on the thread to make it difficult to detect which nozzle is clogged, and a plurality of nozzle rows are not able to be checked. Accordingly, these issues have not been solved.

SUMMARY

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[0007] In view of the above-described disadvantages, an object of the present disclosure is to provide a liquid discharge apparatus capable of confirming a missing nozzle (that is a non-discharge nozzle) even if a droplet bleeds on a discharge target medium having a small discharge target area, and to provide a method for forming a test pattern in the liquid discharge apparatus.

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[0008] Embodiments of the present disclosure described herein provide a novel liquid discharge apparatus including a head, a conveyor, and a controller. The head has a nozzle row with nozzles aligned in line. Each of the nozzles is configured to discharge a color liquid. The conveyor is configured to convey a discharge target medium in parallel with a direction of alignment of the nozzle row of the head. The controller is configured to control a liquid discharge from each of the nozzles of the head in association with a state of conveyance of the discharge target medium. The controller is configured to form a test pattern and perform a test to determine whether each of the nozzles of the head discharges the color liquid with the test pattern. The controller is configured to, when forming the test pattern without discharging droplets of the color liquid from adjacent nozzles of the nozzle row of the head simultaneously: discharge a droplet of the color liquid from a first nozzle of the adjacent nozzles; suspend the liquid discharge of the color liquid to the discharge target medium for a predetermined discharge suspension period while the discharge target medium is conveyed; and discharge a droplet of the color liquid from a second nozzle of the adjacent nozzles after the predetermined discharge suspension period.

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[0009] Further, embodiments of the present disclosure described herein provides a method for forming a test pattern in a liquid discharge apparatus including a head having a nozzle row with nozzles aligned in line. Each of the nozzles is configured to discharge a color liquid and a conveyor configured to convey a discharge target medium in parallel with a direction of alignment of the nozzle row of the head. The method includes discharging a droplet of the color liquid from a first nozzle of adjacent nozzles of the nozzle row of the head without discharging droplets of the color liquid from the adjacent nozzles of the nozzle row of the head simultaneously, suspending a liquid discharge of the color liquid to the discharge target medium for a predetermined discharge suspension period while the discharge target medium is conveyed after the discharging, and discharging a droplet of the color liquid from a second nozzle of the adjacent nozzles after

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the predetermined discharge suspension period.

[0010] According to the present disclosure, the liquid discharge apparatus is capable of detecting a missing nozzle even if a droplet bleeds on the discharge target medium having a small discharge target area, and a method for forming a test pattern is used in the liquid discharge apparatus.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0011] Exemplary embodiments of the present disclosure will be described in detail based on the following figures, wherein:

FIG. 1 is a schematic view illustrating an example of a thread coloring-embroidering system incorporating a liquid discharge apparatus according to an embodiment of the present disclosure;

FIG. 2 is a schematic side view illustrating a liquid applier provided in the liquid discharge apparatus according to an embodiment of the present disclosure;

FIG. 3 is a schematic view illustrating the lower face of the liquid applier according to an embodiment of the present disclosure;

FIG. 4 is a control block diagram of a liquid discharge part in the liquid discharge apparatus according to Embodiment 1 of the present disclosure;

FIG. 5 is a diagram illustrating a nozzle check method performed in a comparative general image forming apparatus;

FIGS. 6A and 6B are diagrams each illustrating a state when the nozzle check method performed in the comparative image forming apparatus of FIG. 5 is applied to a thread;

FIGS. 7A and 7B are diagrams each illustrating the state when an intermittent test pattern according to Control Example 1 of the present disclosure is formed on a thread;

FIGS. 8A and 8B are diagrams each illustrating the encoder timing at liquid discharge and thread conveyance when forming the test pattern according to Control Example 1 of the present disclosure;

FIG. 9 is a flowchart of test pattern formation according to Control Example 1 of the present disclosure;

FIG. 10 is a diagram illustrating an example of marks having the same color for the test pattern of FIG. 8B;

FIG. 11 is a diagram illustrating an example of marks having different colors for the test pattern of FIG. 8B;

FIG. 12 is a table of combination of marks having different colors for the test pattern of FIG. 11;

FIG. 13 is a diagram illustrating another example of a test pattern of yellow color;

FIGS. 14A and 14B are diagrams each illustrating the state when an intermittent test pattern according to Control Example 2 of the present disclosure is formed on a thread;

FIG. 15 is a functional block diagram of an image processing unit according to Control Example 2 of the present disclosure;

FIGS. 16A and 16B are examples of correlation tables each stored for forming the test pattern according to Control Example 2 of the present disclosure;

FIG. 17 is a flowchart of test pattern formation according to Control Example 2 of the present disclosure;

FIGS. 18A and 18B are schematic side views each illustrating the position of each sensor according to Embodiments 2 and 3 of the present disclosure;

FIG. 19 is a control block diagram of a liquid discharge part in the liquid discharge apparatus according to Embodiment 2 of the present disclosure;

FIG. 20 is a diagram illustrating the timings of detection by the conveyance encoder and by the photosensor when forming the test pattern according to the present disclosure;

FIG. 21 is a flowchart of test pattern formation in Control Example 1 detected with the photosensor;

FIG. 22 is a flowchart of test pattern formation in Control Example 2 detected with the photosensor;

FIG. 23 including FIGS. 23A and 23B is a control block diagram of a liquid discharge part in the liquid discharge apparatus according to Embodiment 3 of the present disclosure;

FIG. 24 is a flowchart of detection with an image sensor; and

FIG. 25 is a schematic view illustrating an example of a thread coloring system incorporating a liquid discharge apparatus according to an embodiment of the present disclosure.

[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] It will be understood that if an element or layer is referred to as being "on," "against," "connected to" or "coupled

to" another element or layer, then it can be directly on, against, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, if an element is referred to as being "directly on," "directly connected to" or "directly coupled to" another element or layer, then there are no intervening elements or layers present. Like numbers referred to like elements throughout. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0014] Spatially relative terms, such as "beneath," "below," "lower," "above," "upper" and the like may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements describes as "below," or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, term such as "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors herein interpreted accordingly.

[0015] The terminology used herein is for describing particular embodiments and examples and is not intended to be limiting of exemplary embodiments of this disclosure. 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. It will be further understood that the terms "includes" and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0016] Referring now to the drawings, embodiments of the present disclosure are described below. In the drawings for explaining the following embodiments, the same reference codes are allocated to elements (members or components) having the same function or shape and redundant descriptions thereof are omitted below.

[0017] A description is given of a liquid discharge apparatus and a test pattern formation method, according to an embodiment of the present disclosure with reference to drawings. In each drawing below, the same configuration shares the same reference numeral and the overlapped description may be omitted.

(Overall Configuration)

[0018] Now, a description is given of a thread coloring-embroidering apparatus according to an embodiment of the present disclosure, including a liquid discharge apparatus according to the present disclosure, with reference to FIGS. 1 to 3.

(Embodiment 1)

[0019] FIG. 1 is a schematic view illustrating an example of a thread coloring-embroidering apparatus 1000 according to an embodiment of the present disclosure.

[0020] FIG. 2 is a schematic side view illustrating a liquid applier provided in the liquid discharge apparatus according to an embodiment of the present disclosure.

[0021] FIG. 3 is a schematic view illustrating the lower face of the liquid applier according to an embodiment of the present disclosure.

[0022] Note that FIGS. 1, 2, and 3 are illustrated based on an example in which the X direction, the Y direction, and the Z direction are orthogonal to each other. However, directions used to explain the configuration of the thread coloring-embroidering apparatus 1000 are not limited to a direction orthogonal to another direction.

[0023] Referring to FIG. 1, the thread coloring-embroidering apparatus 1000 is an in-line embroidering apparatus and includes a thread feed reel 102 around which a thread 101 is wound, a liquid applying device 103, a fixing device 104, a post-processing device 105, and an embroidery head 106. The thread feed reel 102, the liquid applying device 103, the fixing device 104, and the post-processing device 105 are included in a liquid discharge apparatus 100 according to the present embodiment. The liquid discharge apparatus 100 does not include the embroidery head 106. The liquid discharge apparatus 100 is also referred to as a coloring device or a dyeing device.

[0024] The thread 101 is fed out from the thread feed reel 102 and then guided by rollers 108 and 109 to be serially conveyed to the embroidery head 106.

[0025] The thread feed reel 102 and the rollers 108 and 109 are constructed as a conveyor of the liquid discharge apparatus 100.

[0026] A rotary encoder 405 is mounted on the roller 109. Hereinafter, the rotary encoder 405 is simply referred to as the encoder 405. The encoder 405 includes an encoder wheel 405a and an encoder sensor 405b. The encoder wheel 405a rotates with the roller 109. The encoder sensor 405b reads the slits of the encoder wheel 405a.

[0027] The liquid applying device 103 includes a plurality of heads 1 (i.e., heads 1a, 1b, 1c, and 1d) and a maintenance device 2. The plurality of heads 1 discharge and apply respective colors to the thread 101 that is fed out from the thread

feed reel 102 and conveyed to the liquid applying device 103. The maintenance device 2 includes a plurality of recovery units 20 (i.e., recovery units 20a, 20b, 20c, and 20d). The plurality of recovery units 20 separately maintains the corresponding heads 1.

[0028] Referring to FIG. 2, the plurality of heads 1a, 1b, 1c, and 1d are liquid discharge heads that discharge colors different from each other. For example, the head 1a discharges liquid (ink) of black (K), the head 1b discharges liquid (ink) of cyan (C), the head 1c discharges liquid (ink) of magenta (M), and the head 1d discharges liquid (ink) of yellow (Y), respectively. Note that this order of colors is an example and that the colors may be disposed at respective positions different from this order.

[0029] Further, the recovery units 20a, 20b, 20c, and 20d are disposed below the heads 1a, 1b, 1c, and 1d, respectively. In order to recover the maintenance ability of each head 1 (that is, the heads 1a, 1b, 1c, and 1d), each of the recovery units 20a, 20b, 20c, and 20d caps the corresponding one of the heads 1a, 1b, 1c, and 1d when unused, performs as an idle discharge receiver of liquid from each of the heads 1a, 1b, 1c, and 1d, performs as a suction circulation operation of the nozzles while the idle discharge receiver is located near the idle discharge receiver, and performs a nozzle wiping operation.

[0030] Here, as illustrated in FIG. 3, each head 1 includes a nozzle face 12 on which a nozzle row 10 having a plurality of nozzles 11 to discharge liquid is formed. Each head 1 is aligned so that the direction of the nozzle row, which is the direction of alignment of the plurality of nozzles 11, is in a conveyance direction of the thread 101. Hereinafter, the conveyance direction of the thread 101 is also referred to as the thread conveyance direction.

[0031] Note that, in FIG. 3, one nozzle row 10 is depicted on the nozzle face 12. However, a plurality of nozzle rows 10 may be aligned on the nozzle face 12. Further, as the head 1 is moved in a direction orthogonal to the thread conveyance direction, the capping of the nozzle face 12 or the coloring operation with the different nozzle row 10 is performed.

[0032] Referring back to FIG. 1, the fixing device 104 performs the fixing operation, in other words, the drying operation, to the thread 101 to which liquid that is discharged from the liquid applying device 103 is applied. The fixing device 104 includes a heating unit that heats and dries the thread 101. The heating unit includes, for example, an infrared irradiator and a heated air blower.

[0033] The post-processing device 105 includes, for example, a cleaner to clean the thread 101, a tension force adjuster to adjust tension force of the thread 101, a feed distance detector to detect the amount (distance) of feed of the thread 101, and a lubricant applier to apply lubricant onto the surface of the thread 101.

[0034] The embroidery head 106 embroiders patterns, for example, on a cloth with the thread 101. Note that the present embodiment describes the thread coloring-embroidering apparatus as an example of a liquid discharge apparatus. However, the liquid discharge apparatus is not limited to the above-described thread coloring-embroidering apparatus. For example, the present disclosure may also be applied to an apparatus using a linear object such as a thread, in other words, a linear discharge target medium, to an apparatus such as a weaving machine and a sewing machine, and to other apparatuses such as a printing apparatus that prints an image on a general belt-shaped sheet member.

[0035] Also note that the term "thread" includes glass fiber thread; wool thread; cotton thread; synthetic fiber thread; metallic thread; mixed thread of wool, cotton, polymer, or metal; and linear object (linear member or continuous material) to which yarn, filament, or liquid is applied. The term "thread" also includes braided cord and flatly braided cord.

[0036] In addition to the linear object, the term "thread" further includes a belt-shaped member (continuous material) to which liquid is applied, such as rope, cable, and cord, as a discharge target medium that may be colored by ink (ink droplets). Each discharge target medium is a linear or belt-shaped medium with a narrow width and consecutively extends in the thread conveyance direction.

(Control Block (Embodiment 1))

[0037] FIG. 4 is a control block diagram of a liquid discharge part in the liquid discharge apparatus 100 according to Embodiment 1 of the present disclosure.

[0038] The head 1 includes a plurality of piezoelectric elements 13 each functioning a pressure generation element that generates pressure to discharge liquid from the plurality of nozzles 11. The liquid discharge part in the liquid discharge apparatus 100 in FIG. 4, as a portion related to application of drive waveform to apply a drive waveform to the head 1, further includes a head controller 401, a drive waveform generation unit 402, a waveform data storage unit 403, a head driver 410, and a discharge timing generation unit 404. The discharge timing generation unit 404 generates the liquid discharge timing.

[0039] In response to receipt of a discharge timing pulse stb, the head controller 401 outputs a discharge sync signal LINE to the drive waveform generation unit 402. The discharge sync signal LINE triggers generation of a drive waveform. The head controller 401 also outputs a discharge timing signal CHANGE to the drive waveform generation unit 402. The discharge timing signal CHANGE corresponds to the amount of delay from the discharge sync signal LINE

[0040] The drive waveform generation unit 402 generates a common drive waveform signal Vcom at the timing based

on the discharge synchronization signal LINE and the discharge timing signal CHANGE.

[0041] The head controller 401 receives image data from the image processing unit 300 and generates a mask control signal MN based on the image data. The mask control signal MN is for selecting the predetermined waveform of the common drive waveform signal Vcom according to the size of a droplet of liquid 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.

[0042] Then, the head controller 401 transmits image data SD, a synchronization clock signal SCK, a latch signal LT instructing latch of the image data SD, and the generated mask control signal MN, to the head driver 410.

[0043] 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.

[0044] The shift register 411 receives the image data SD and the synchronization clock signal SCK transmitted from the head controller 401. The latch circuit 412 latches each registration value on the shift register 411 according to the latch signal LT transmitted from the head controller 401.

[0045] The gradation decoder 413 decodes the value (image 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 an operable level of the analog switch AS of the analog switch array 415.

[0046] 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 separate electrode of the piezoelectric element 13 corresponding to each nozzle 11. In addition, the common drive waveform signal Vcom from the drive waveform generation unit 402 is input to the analog switch AS. In addition, the timing of the mask control signal MN is synchronized with the timing of the common drive waveform signal Vcom.

[0047] 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 drive waveform to be applied to the piezoelectric element 13 corresponding to each nozzle 11 is selected from the drive waveforms constituting the common drive waveform signal Vcom. As a result, the size of the droplet discharged from the nozzle 11 is controlled.

[0048] The discharge timing generation unit 404 generates and outputs the discharge timing pulse stb each time the thread 101 is moved by a predetermined amount (distance), based on the detection result of the encoder 405 that detects the number of rotations of the roller 109 illustrated in FIG. 1.

[0049] Here, the thread 101 is conveyed (moved) by being consumed due to the embroidery operation performed by the embroidery head 106 that is disposed downstream from the liquid discharge apparatus 100 in the thread conveyance direction. Conveyance of the thread 101 rotates the roller 109 guiding the thread 101, so that the encoder wheel 405a of the encoder 405 rotates to generate and output the encoder pulse in proportion to the linear velocity of the thread 101, from the encoder sensor 405b.

[0050] The discharge timing generation unit 404 generates the discharge timing pulse stb according to the encoder pulse from the encoder 405 so that the discharge timing pulse stb is used as a liquid discharge timing from the head 1. Application of the liquid to the thread 101 is applied from when the thread 101 starts to move. Even if the linear velocity of the thread 101 changes, the intervals of the discharge timing pulses stb varies according to the encoder pulse, thereby preventing deviation of the landing position of a droplet of liquid.

[0051] Further, the image processing unit 300 transmits the image data to the head controller 401. Further, the image processing unit 300 is used for selecting a pattern when executing Control Example 2. A detailed description of operations performed by the image processing unit 300 will be given below together with Control Example 2 with reference to FIG. 15.

[0052] Note that, in the embodiment illustrated in FIG. 4, the image processing unit 300, the head controller 401, and the discharge timing generation unit 404 each performing calculation are constituted as a controller 200 in the liquid discharge apparatus 100.

(Comparative Example)

[0053] FIG. 5 is a diagram illustrating a nozzle check method performed in a comparative image forming apparatus.

[0054] As a comparative example, when checking the state of nozzles of heads (for example, a Y head for yellow, a C head for cyan, an M head for magenta, and a K head for black, as illustrated in FIG. 5) mounted on a carriage, with a pattern formed on a medium having a relatively large printable area, a known inkjet image forming apparatus forms a nozzle check pattern, in other words, a test pattern, with droplets of liquid discharged simultaneously from the whole channels via each nozzle of the nozzle row of the heads as the carriage moves in a carriage scanning direction.

[0055] Even with such a test pattern, a medium such as a paper handled by the known inkjet image forming apparatus is relatively large and an operator can check the test pattern visually. Therefore, the operator has checked each nozzle corresponding to the missing dot in the test pattern as a missing nozzle or a non-discharge nozzle.

[0056] FIGS. 6A and 6B are diagrams each illustrating a state when the test pattern for detecting the missing dot from a nozzle illustrated in FIG. 5 is applied to a thread. In FIGS. 6A and 6B, the number of nozzles included in the nozzle

row aligned on the head, in parallel to the thread, is set to ten (10). In other words, the head has ten (10) channels in each nozzle row.

[0057] Specifically, FIG. 6A is a side view illustrating the head in a state in which droplets of liquid are simultaneously discharged from the whole channels of the nozzles included in the nozzle row on the head, onto the thread 101 that is a linear object.

[0058] FIG. 6B is a side view illustrating the test pattern onto which the droplets of liquid from the nozzles of the head are consecutively discharged, by performing the method of FIG. 6A.

[0059] Here, there is a case in which discharge of droplet of liquid from the nozzle is missed, in other words, in which a missing dot (missing nozzle) occurs. In FIG. 6B, the adjacent nozzles are illustrated spaced apart with a certain distance and the missing dot (missing nozzle) is enlarged and emphasized for easy visual recognition. However, the actual distance between the adjacent nozzles is approximately 150 dpi, which is significantly short.

[0060] When compared with an image forming apparatus that prints on a paper, a liquid discharge apparatus colors a thread and the thread that functions as a discharge target object has a liquid landing area, in other words, a discharge target area, smaller than the area of the paper. Further, considering that the thread is fiber, it is expected that the ink spreads on the thread due to bleeding.

[0061] Based on the above facts, as illustrated in FIG. 6B, it is significantly difficult to check a test pattern onto which droplets of liquid are simultaneously discharged from the whole channels, visually or by a sensor (for example, a photosensor or an image sensor). When there is a missing dot (missing nozzle), it is significantly difficult to find the missing dot (missing nozzle).

(Control Example 1)

[0062] In order to address the above-described inconvenience, a description is given of a method of detecting missing dot of a nozzle according to Control Example 1, with reference to FIGS. 7A and 7B.

[0063] FIGS. 7A and 7B are diagrams each illustrating the state when an intermittent test pattern according to Control Example 1 of the present disclosure is formed on a thread. To be more specific, FIG. 7A is a side view illustrating the head in a state in which droplets of liquid are discharged on the thread 101 in the order from the nozzles of the nozzle row on the head. FIG. 7B is a side view of the head and the test pattern onto which the droplets of liquid are intermittently discharged, by performing the method of FIG. 7A.

[0064] In Control Example 1, when checking whether each nozzle of the nozzle row of the head 1 discharges liquid or not, one droplet of the color liquid is discharged from one nozzle of the nozzle row of the head 1 for each discharge, the thread 101 is conveyed during a discharge suspension period in which no liquid is discharged from the head 1, that is, the liquid discharge of the color liquid is suspended in the discharge suspension period while the thread is conveyed, and another one droplet is discharged from the next nozzle of the nozzle row of the head 1 for another discharge, that is, the controller 200 changes the nozzle that has discharged one droplet to another nozzle next to the nozzle. By repeating these processes, a test pattern is formed. That is, as illustrated in FIG. 7A, the discharge timing of each nozzle for one discharge is shifted in sequence, thereby forming an intermittent test pattern.

[0065] Note that the thread is continuously conveyed from overlapping with the landing droplets (dots) discharged from the other nozzles, in the discharge target area on the downstream side toward which the thread is conveyed. Therefore, in order to prevent the landing droplets (dots) discharged from one nozzle and landed on the thread, it is preferable to discharge droplets of liquid from the nozzles of the nozzle row sequentially in the order from a downstream nozzle to the adjacent upstream nozzle of the nozzle row. In other words, in the present embodiment of the present disclosure, the controller 200 does not cause the head 1 to discharge respective droplets of liquid from the adjacent nozzles of a nozzle row of the head 1 simultaneously. That is, the controller 200 forms a test pattern without discharging droplets of liquid from the adjacent nozzles of the nozzle row of the head 1 simultaneously.

[0066] By forming the intermittent test pattern as described above, as illustrated in FIG. 7B, when no droplet of liquid is discharged from a nozzle, in other words, when a missing dot (i.e., missing nozzle) in the test pattern occurs, the landing position at which a droplet of liquid should have landed is spaced away from the landing position of the previous droplet of liquid and from the landing position of the subsequent droplet of liquid. Therefore, even if the adjacent droplet bleeds, the missing dot on the thread, that is, the missing nozzle, is detected with the test pattern.

[0067] FIG. 8A is a diagram illustrating the encoder timing at liquid discharge and thread conveyance when the test pattern according to the present disclosure is formed.

[0068] FIG. 8B is a top view illustrating the test pattern of Control Example 1.

[0069] With reference to the number of pulses of the encoder signal of the encoder 405 illustrated on the upper side of FIG. 8A, a period in which no liquid is discharged, in other words, the controller 200 suspends liquid discharge at the discharge timing on the lower side of FIG. 8A. Hereinafter, the period in which no liquid is discharged is referred to as a "discharge suspension period."

[0070] Even if one droplet is discharged from each nozzle, if the droplets are continuously discharged, a continuous

pattern will be formed on the thread. In order to address this inconvenience, Control Example 1 provides the timing of the discharge suspension period between successive (adjacent) liquid discharges and sets a liquid discharge interval (also, discharge interval). Setting the liquid discharge interval leads to separation of the positions of adjacent landing droplets, thereby avoiding the failure that the missing nozzle is not determined when a discharge, the following discharge, or both bleed on the thread.

[0071] In Control Example 1, as illustrated in FIG. 8B, there is no problem as long as adjacent nozzles of ink discharge are spaced apart by at least the length of one droplet of ink on the thread. Therefore, as a rough indication for the discharge suspension period illustrated in FIG. 8A, the conveyance interval t [s] in which a thread that functions as a linear object is conveyed in the above-described predetermined discharge suspension period is set to be " $t = (\text{diameter of ink droplet}) / (\text{conveying speed of thread})$ " or greater.

[0072] Here, FIG. 8A illustrates an example that a pulse x equals to 1 (pulse $x = 1$), where the pulse x defines the discharge suspension period at the discharge timing that is controlled by the encoder signal. The pulse x that defines the discharge suspension period is adjusted according to the conveying speed of a thread and the interval of the landing droplets on the desired thread.

[0073] Further, as another control example, the interval of conveyance of the thread, instead of an encoder signal, may be previously set as a constant interval t [s] in the head controller 401, so that the subsequent ink is discharged each time after the thread is conveyed by the constant interval t [s].

[0074] Note that, when forming the intermittent test pattern of Control Example 1 according to the present embodiment, in order to prevent the nozzle from drying, the drive waveform of fine drive is applied to the whole nozzles during the discharge suspension period.

Flow of Test Pattern Formation in Control Example 1

[0075] FIG. 9 is a flowchart of test pattern formation according to Control Example 1 of the present disclosure. Note that it is assumed that the thread is constantly conveyed at a constant speed during the period of forming the intermittent test pattern.

[0076] Further, as to the parameters in the flow, "C" represents the count value of the nozzles that have already finished discharging, among the nozzles in the nozzle row to be checked, "n" represents the number of nozzles in one nozzle row, and "x" represents the number of pulses of the encoder signal to be spaced between ink discharges. Further, each of these parameters are fed back to the head controller 401 to proceed the process.

[0077] First, in step S101, the liquid discharge interval is set for "n" intermittent landing droplets from the "n" nozzles, where the "n" intermittent landing droplets from the "n" nozzles are included in the intermittent detection pattern used for this nozzle check and are intermittently discharged in the thread conveyance direction. At this time, as illustrated in FIG. 8A, the number of pulses "x" in the discharge suspension period is provided with reference to the number of pulses of the encoder signal.

[0078] For example, in a case in which ink bleeds on the thread easily due to the compatibility between the ink and the thread, the liquid discharge interval is set to be relatively long. By contrast, in a case in which ink hardly bleeds on the thread, the liquid discharge interval is set to be relatively short.

[0079] Alternatively, when the test pattern is visually checked to detect a missing dot or dots, the liquid discharge interval is set to be relatively long. On the other hand, when the test pattern is checked by a photosensor or an image sensor to detect a missing dot or dots, the mechanical instrument allows the detailed discharge condition, and therefore the liquid discharge interval is set to be relatively short.

[0080] Then, a droplet of liquid is discharged for a pre-check mark immediate before the target position, in step S102. The detailed description of the pre-check mark immediate before the target position will be given below, with reference to FIGS. 10 to 12.

[0081] In step S103 of the flowchart in FIG. 9, one droplet is discharged from one specific nozzle (in other words, a first nozzle). Here, the size of each ink droplet forming the test pattern may be large, medium or small.

[0082] In step S104, the count value C indicating the discharged nozzle is incremented by 1.

[0083] In step S105, the droplet of liquid is not discharged by the amount corresponding to the pulse "x" of the encoder signal (that is, the interval of discharges of the "n" intermittent landing droplets corresponding to the "n" nozzles) set in step S101. The thread is continuously being conveyed throughout this period. In other words, the controller 200 suspends the liquid discharge to the thread 101 for such a predetermined period while the thread is conveyed.

[0084] In step S106, it is determined whether the count value C of discharges (that is, the number of discharges) from the nozzle (that is, the number of liquid discharges from the nozzle) has reached the number of nozzles of the nozzle row, that is, the "n" nozzles.

[0085] When the count value C of discharges from the nozzle has not reached the "n" nozzles (NO in step S106), the process proceeds to step S107.

[0086] In step S107, one droplet is discharged from the next nozzle disposed next (adjacent) to the nozzle from which

one droplet has been discharged in step S103. This nozzle is referred to as an upstream nozzle or a second nozzle. Then, the process goes back to step S104 to increment the count value C of discharges from the discharged nozzles, by 1. Then, in step S105, the thread is conveyed to provide another discharge suspension period.

[0087] Then, steps S107, S104, and S105 are repeated in this order until the count value C of discharges from the discharged nozzles reaches "n" (i.e., $C = n$), that is, until the result of step S106 becomes YES after the steps are repeated for "n" times. In other words, these steps are repeated for "n" times while the controller 200 causes the head 1 to discharge each one droplet of the color liquid in the order from the downstream nozzle to the upstream nozzle of the nozzle row of the head 1 in the thread conveyance direction of the thread 101.

[0088] When the count value C of discharges from the discharged nozzle has reached the "n" nozzles (i.e., $C = n$) (YES in step S106), a mark pattern (post-check mark) is discharged to land on the thread, in step S108, to indicate completion of the formation of the test pattern for the nozzle check for one nozzle row (the "n" intermittent landing droplets).

[0089] With this discharge of the mark pattern, the formation of the test pattern for nozzle check for one nozzle row is finished.

[0090] By forming the test pattern as described above, in Control Example 1, an intermittent pattern is formed by discharging liquid onto the thread in sequence by one nozzle with the time interval to detect the missing nozzle on the thread, so that a missing nozzle that does not discharge liquid on the thread is detected. Therefore, even if the thread has a relatively small discharge target area, the missing nozzle is checked smoothly.

[0091] Note that, in the present example, the thread has been described as the discharge target medium, but the discharge target medium onto which liquid is discharged may be another linear or belt-shaped medium having a narrow width and continuing in the thread conveyance direction. In the present disclosure, it is assumed that one color is dyed in one discharge in the width direction of a discharge target medium other than the thread, for example, a linear discharge target medium or a strip-shaped discharge target medium.

[0092] Then, in confirmation of the missing nozzle, whether each of the droplets corresponding to the plurality of nozzles is landed on the discharge target medium or not needs to be determined visually or by the sensor described below (see FIG. 20), where the landing droplets are included in the intermittent pattern formed on the discharge target medium.

[0093] Therefore, the liquid discharge apparatus according to the present disclosure employs a discharge target medium having a relatively narrow width, so that, for example, when the droplet of liquid for forming the test pattern is discharged from each nozzle and lands on the discharge target medium to bleed over at least 1/2 or more of the width of the discharge target medium, more preferably, to bleed over substantially the whole widthwise area of the discharge target medium.

(Mark Pattern 1)

[0094] As described in step S108 of the flowchart of FIG. 9, when formation of the intermittent test pattern for nozzle check for one nozzle row is completed, a mark pattern is discharged to land on the thread as an end signal indicating the end of test pattern formation. The mark pattern as the end signal corresponds to the post-check mark. Further, as described in S102 of the flowchart of FIG. 9, as a start signal indicating the start of test pattern formation, another mark pattern is discharged onto the thread at the position immediately before the formation of the intermittent test pattern for one nozzle row. The mark pattern as the start signal corresponds to the pre-check mark.

[0095] FIG. 10 is a diagram illustrating an example of marks having the same color for the test pattern of FIG. 8B.

[0096] This example of the mark pattern is a mark having the same color with different shapes of the landing droplet. Specifically, the mark pattern illustrated in FIG. 10 is a long pattern (in other words, a group of droplets) with two or more consecutive landing droplets for nozzle check, which is different from the intermittent test pattern in which the landing drops are spaced apart from each other.

[0097] The number of consecutive landing droplets forming the mark pattern may be any number. Further, when forming a continuous mark pattern, the droplets may be continuously discharged in chronological order or may be discharged from two or more nozzles simultaneously at one discharge.

[0098] As illustrated in FIG. 10, when forming a mark pattern with the same color as the liquid discharging head that is a test target by changing the liquid discharge method, one liquid discharging head is controlled along the order of the flowchart of FIG. 9, thereby simplifying the control.

(Mark Pattern 2)

[0099] FIG. 11 is a diagram illustrating an example of marks having the different colors from each other for the test pattern.

[0100] As described above, a pattern that functions as a mark pattern is discharged onto the thread as a signal at a position immediately before the start of formation of the intermittent test pattern for the nozzle check for one nozzle row,

a position immediately after completion of the formation of the intermittent test pattern, or the both of the positions.

[0101] In FIG. 11, the marker pattern includes droplets with colors different from the color of the droplets included in the test pattern. Note that FIG. 11 illustrates the example in which the mark pattern having the color different from the color of the test pattern is formed with one droplet in the same manner as the droplets included in the test pattern. However, the mark pattern having the color different from the color of the test pattern may be a long pattern with two or more droplets consecutively formed, as illustrated in FIG. 10.

[0102] FIG. 12 is a table of one example combination of marks having different colors for the test pattern of FIG. 11.

[0103] As illustrated in FIG. 12, it is preferable not to use yellow color as the color of the mark pattern for the test patterns of other colors. Since yellow color has a low color difference from white color of the thread that functions as a discharge target object, it is difficult to detect visually. Further, since the color difference is low when any of the other colors is detected as a threshold value, it is significantly difficult to detect yellow color even by the photosensor and the image sensor.

[0104] Note that, as illustrated in FIG. 2, the heads 1a, 1b, 1c, and 1d, from which droplets of respective colors are discharged, are aligned for each color along the thread conveyance direction. That is, the heads 1a, 1b, 1c, and 1d, from which droplets of different colors are discharged, are disposed separately, in other words, at different positions along the thread conveyance direction. Therefore, when the mark pattern is formed in a color that is different from the color of the test pattern, the timing of discharge for forming the mark pattern is controlled to be slightly different from the timing of discharge in the flow of FIG. 9 in order to discharge liquid to form the mark pattern at the positions immediately before and after the test pattern on the thread.

[0105] For example, in a case in which a head that discharges liquid to form the mark pattern is located downstream from another head that discharges liquid to form the test pattern in the thread conveyance direction, after a droplet is discharged from the first nozzle in step S103 of the flowchart in FIG. 9, a droplet of the pre-check mark that is discharged in step S102 of the flowchart in FIG. 9 is discharged at a predetermined discharge timing. Then, after it is determined that the result of step S106 is YES, the subsequent discharge of droplet is held until the last landing droplet for forming the test pattern on the thread has been passed immediately below the head that forms the mark pattern. Then, in step S108, a droplet for the post-check mark immediately after the test pattern is discharged.

[0106] On the other hand, in a case in which a head that discharges liquid to form the mark pattern is located upstream from another head that discharges liquid to form the test pattern in the thread conveyance direction, a droplet of the pre-check mark in step S102 of the flowchart in FIG. 9 is discharged at a predetermined discharge timing long before the timing at which a droplet is discharged from the first nozzle in step S103 of the flowchart in FIG. 9. Then, before it is determined that the result of step S106 is YES, the timing after the discharge of the last droplet from the head that functions as a test target is calculated backward. Then, in step S108 of the flowchart in FIG. 9, a droplet of the post-check mark is discharged from the head that forms the mark pattern at the timing immediately after the calculated timing.

[0107] As illustrated in FIGS. 11 and 12, in a case in which the mark pattern is formed with a color different from the color of the test pattern, the discharge timings are adjusted with respect to the plurality of heads, which makes the control a bit complicated. However, the different colors may make it easier to determine the test pattern visually or by a sensor.

[0108] As illustrated in FIGS. 10 to 12, in the present disclosure, the mark pattern may be formed by a plurality of different method of discharging liquid. Therefore, it is preferable to selectively employ the type of the mark pattern according to the application appropriately.

[0109] FIG. 13 is a diagram illustrating another example of a test pattern for detecting yellow dots more easily.

[0110] As described above, since yellow color has a low color difference from white color of the thread, it is difficult to detect visually. Therefore, a test pattern may be prepared by combining the yellow dots with the dots of a different color to reduce the color difference with white color.

[0111] When the dots are combined in the test pattern as described above, the combination colors other than the yellow color are used from the colors for which the nozzle check using the test pattern has already been completed. Note that, even though FIG. 13 illustrates an example of black dots as a combination color, any other colors except for yellow, for example, cyan dots or magenta dots, may be selected as a combination color.

[0112] By forming the test pattern as described above, the missing dots of the yellow landing droplets may be detected in the intermittent test pattern more easily.

(Control Example 2)

[0113] FIGS. 14A and 14B are diagrams each illustrating the state when an intermittent test pattern according to Control Example 2 of the present disclosure is formed on a thread.

[0114] As illustrated in FIG. 14A, the nozzle numbers at the first discharge are set alternately (at an interval in every other nozzle), that is, the 1ch, 3ch, 5ch, 7ch, and 9ch nozzles. Accordingly, each droplet is discharged from five nozzles at the same time.

[0115] As illustrated in FIG. 14B, after the first discharge, the thread is conveyed to perform the second discharge.

The nozzle numbers in the second discharge are set alternately (at an interval in every other nozzle), that is, the 2ch, 4ch, 6ch, 8ch, and 10ch nozzles.

[0116] Here, the thread is conveyed to avoid overlapping the landing position of liquid discharged in the first discharge on the landing position of liquid discharged in the second discharge. Therefore, as long as the setting is made corresponding to the number of nozzles in the nozzle row, at least droplets of liquid are not overlapped.

[0117] Further, in order to precisely provide the constant interval of the landing droplets on the thread, it is more preferable to provide an alternate interval between a (landing) droplet from the 9ch nozzle at the last end (the extreme upstream end) of the first discharge and a (landing) droplet from the 2ch nozzle at the front end (the extreme downstream end) of the second discharge, which is similar to the interval of the nozzles in the nozzle row at each discharge. Therefore, it is more preferable that the distance of conveyance of the thread between the first discharge and the second discharge in FIG. 13 is by 9 nozzles of 10 nozzles of the nozzle row (e.g., by the distance of 9/10 nozzles of the nozzle row).

[0118] The calculation method of the distance of conveyance of the thread will be described in detail together with FIG. 16B.

[0119] Here, FIG. 15 is a functional block diagram of the image processing unit 300 according to Control Example 2 of the present disclosure.

[0120] The image processing unit 300 includes an image data buffer 301, an image data controller 302, an image data output unit 303, a resolution information controller 304, a discharge-nozzle table selection unit 305, a discharge-nozzle table storage unit 306, and a test correlation data storage unit 307.

[0121] The image data buffer 301 temporarily stores original image data received from a host controller or an external personal computer (PC).

[0122] The resolution information controller 304 converts information received from the host controller, an operation unit, or other devices, for example, image quality information, speed information, and other selection information, into resolution information, and outputs the converted resolution information. The discharge-nozzle table storage unit 306 previously stores a discharge-nozzle table based on the resolution used in a regular thread coloring.

[0123] In the regular thread coloring, the discharge-nozzle table selection unit 305 makes an inquiry about the discharge-nozzle table to the discharge-nozzle table storage unit 306, then selects a discharge-nozzle table based on the resolution, and outputs the selected discharge-nozzle table to the image data controller 302.

[0124] The image data controller 302 sorts the image of the original data into four gradations, and outputs the image data of each color with reference to the selected discharge-nozzle table. The image data output unit 303 outputs the processed image data at the discharge of liquid to the head controller 401 of each of the heads 1a to 1d.

[0125] Here, the test correlation data storage unit 307 previously stores information related to the test pattern (see FIG. 16B and Table 1).

[0126] Then, in the nozzle check, the discharge-nozzle table selection unit 305 makes an inquiry to the test correlation data storage unit 307 and obtains information of the number of discharges and the nozzle number each related to the nozzle interval information. The detail description of the correlation table in the test will be given below.

[0127] Next, a detailed description is given of the control in Control Example 2 according to the present disclosure, with reference to FIGS. 16A and 16B.

[0128] FIGS. 16A and 16B are examples of correlation tables including data for forming the test pattern according to Control Example 2 of the present disclosure. To be more specific, FIG. 16A is a table indicating various test patterns. FIG. 16B is a table indicating an example of a correlation table that is stored for forming a test pattern according to Control Example 2 of the present disclosure.

[0129] Note that the tables in FIGS. 16A and 16B represent a case in which the number of nozzles "n" in one nozzle row is 10 ($n = 10$), but the information in FIGS. 16A and 16B is an example. That is, even if the number of nozzles in one nozzle row is more than 10, the same case classification and correlation table may be applied.

[0130] The uppermost row in the table of FIG. 16A indicates the test pattern of a comparative example illustrated in FIG. 5. As described above, if the liquid discharge interval per discharge is zero, a missing dot (no liquid discharge) may not be detected properly when the ink bleeds. Therefore, this test pattern is not employed in the present disclosure.

[0131] The lowermost row in the table of FIG. 16A indicates the test pattern of Control Example 1 illustrated in FIGS. 7A and 7B. Since the test pattern according to Control Example 1 is formed by discharging one droplet per discharge, the liquid discharge interval within the nozzle row per discharge is not specified, and therefore no case classification is generated.

[0132] When the liquid discharge interval is set to one or more, the flowchart of Control Example 2 is applied and executed. In the case of FIG. 16A, when the number of nozzles "n" in the nozzle row is expressed as " $n = 10$ " and the liquid discharge interval (that is, the nozzle interval at simultaneous discharges) "m" is selected as "1", the number of droplets per discharge "a" is five droplets as illustrated in FIG. 14A and the total of discharges "b" is twice.

[0133] Further, when the liquid discharge interval "m" is selected as "2", the number of droplets per discharge "a" is three or four droplets and the total of discharges "b" is three times. When the liquid discharge interval "m" is selected as "3", the number of droplets per discharge "a" is two or three droplets and the total of discharges "b" is four times.

When the liquid discharge interval "m" is selected as "4", the number of droplets per discharge "a" is two droplets and the total of discharges "b" is five times.

[0134] The control executed in Control Example 2 is slightly more complicated than the control executed in Control Example 1, as described below. However, since the total of discharges in Control Example 2 is half (1/2) or less than the total of discharges in Control Example 1, the time taken for forming the test pattern is reduced.

[0135] Note that it is preferable that the liquid discharge interval "m" at each discharge is set to one or less than $n/2$, where "n" represents the number of nozzles in a nozzle row of the head. If the liquid discharge interval "m" is set to $n/2$ or more, the number of droplets per discharge is one or two. Therefore, the difference increases between one droplet and two droplets and the total of discharges "b" is more than $n/2$. As a result, no advantage in time is found.

[0136] Here, the correlation table of FIG. 16B is a correlation list in which the total of discharges based on liquid discharge interval "m" corresponding to the length of "m" nozzles (m: positive number more than 1 and less than $n/2$) is associated with the nozzle number at each discharge in Control Example 2 where the plurality of nozzles discharge droplets of the color liquid simultaneously. Such a correlation table is stored in the test correlation data storage unit 307 illustrated in FIG. 15.

[0137] For example, in the correlation table of FIG. 16B with the number of nozzles "n" in a nozzle row is 10 ($n = 10$), when the nozzle interval "m" at each discharge is one, the number of discharge nozzles (the number of multiple nozzles) at each discharge is five in common. As illustrated in FIGS. 14A and 14B, the nozzle numbers at the first discharge are 1ch, 3ch, 5ch, 7ch, and 9ch, and the nozzle numbers at the second discharge are 2ch, 4ch, 6ch, 8ch, and 10ch.

[0138] When the nozzle interval "m" at each discharge is two, the nozzle numbers for the first discharge are four, that is, 1ch, 4ch, 7ch, and 10ch, the nozzle numbers for the second discharge are three, that is, 2ch, 5ch, and 8ch, and the nozzle numbers for the third discharge are three, that is, 3ch, 6ch, and 9ch.

[0139] When the nozzle interval "m" at each discharge is three, the nozzle numbers for the first discharge are three, that is, 1ch, 5ch, and 9ch, the nozzle numbers for the second discharge are three, that is, 2ch, 6ch, and 10ch, the nozzle numbers for the third discharge are two, that is, 3ch and 7ch, and the nozzle numbers for the fourth discharge are two, that is, 4ch and 8ch.

[0140] When the nozzle interval "m" at each discharge time is 4, the number of discharge nozzles at each discharge is two in common. To be more specific, the nozzle numbers at the first discharge are 1ch and 6ch, the nozzle numbers at the second discharge are 2ch and 7ch, the nozzle numbers at the third discharge are 3ch and 8ch, the nozzle numbers at the fourth discharge are 4ch and 9ch, and the nozzle numbers at the fifth discharge are 5ch and 10ch.

[0141] Here, a description is given of the method of calculating the distance of conveyance of a discharge target medium between successive liquid discharges, in other words, between the n-th discharge and the (n + 1)th discharge.

[0142] The interval of the landing droplets between the liquid discharge times matters between the last landing droplet of the current liquid discharge and the first landing droplet of the subsequent liquid discharge. In other words, the controller 200 sets a conveying distance of the thread 101 from a last landing droplet of a current discharge to a first landing droplet of a subsequent discharge, to be the length of "m" nozzles or greater in the predetermined discharge suspension period.

(Equations)

[0143] When $\{\text{the number of "n" nozzles} + (\text{the first nozzle number of the subsequent discharge}) - (\text{the last nozzle number of the current discharge})\} - \{(\text{the nozzle interval}) + 1\} = 0$ is established, the distance of conveyance of a discharge target medium between the successive liquid discharges: $10 / 10 = 1$ nozzle row.

[0144] When $\{\text{the number of "n" nozzles} + (\text{the first nozzle number of the subsequent discharge}) - (\text{the last nozzle number of the current discharge})\} - \{(\text{the nozzle interval}) + 1\}$ is a negative number, the distance of conveyance of the thread between the successive liquid discharges: $(10 + |\text{the negative number}|) / 10$ nozzle row.

[0145] When $\{\text{the number of "n" nozzles} + (\text{the first nozzle number of the subsequent discharge}) - (\text{the last nozzle number of the current discharge})\} - \{(\text{the nozzle interval}) + 1\}$ is a positive number, the distance of conveyance of the thread between the successive liquid discharges: $(10 - |\text{the positive number}|) / 10$ nozzle row.

[0146] If $\{n + (\text{the first nozzle number of the subsequent discharge}) - (\text{the last nozzle number of the current discharge})\} - \{(\text{the nozzle interval}) + 1\}$ is 0, the distance of conveyance of a discharge target medium between the successive liquid discharges is set to $n/n = 1$ nozzle row. Note that, although no example is indicated in the table of FIG. 16B, this case may occur if the number of nozzles in one nozzle row is different from the number of nozzles in another nozzle row on the same head.

[0147] If the result of $\{n + (\text{the first nozzle number of the subsequent discharge}) - (\text{the last nozzle number of the current discharge})\} - \{(\text{the nozzle interval}) + 1\}$ is a negative number, the distance of conveyance between the successive liquid discharges is set to $(n + |\text{the absolute value of the negative number}|) / n$ nozzle rows.

[0148] For example, the distance of conveyance of a discharge target medium between the first discharge and the second discharge in "Discharge Interval 2" of the second row in the table of FIG. 16B is expressed and calculated as $(10 + 2 - 10) - (2 + 1) = -1$. According to this result, one nozzle row is short for the distance of conveyance of the thread

between the first discharge and the second discharge. To obtain the interval corresponding to two nozzles between the landing droplet of the 2ch nozzle at the second discharge and the landing droplet of the IOch nozzle at the first discharge, the amount of $(10 + |1|) / 10 = 11/10$ nozzle row is set as the distance of conveyance of the thread between the successive liquid discharges.

[0149] On the other hand, if the result of $\{n + (\text{the first nozzle number of the subsequent discharge}) - (\text{the last nozzle number of the current discharge})\} - \{(\text{the nozzle interval}) + 2\}$ is a positive number, the distance of conveyance of the thread between the successive liquid discharges is set to $(n - |\text{the positive number}|) / n$ nozzle row.

[0150] For example, the distance of conveyance of the thread between the first discharge and the second discharge in "Discharge Interval 1" in the uppermost step of the table of FIG. 16B is expressed and calculated as $(10 + 2 - 9) - (1 + 2) = +1$. According to this result, one nozzle row is longer than the distance of conveyance of the thread between the liquid discharges. To obtain the interval corresponding to one nozzle between the landing droplet of the 2ch nozzle at the second discharge and the landing droplet of the 9ch nozzle at the first discharge, the amount of $(10 - |1|) / 10 = 9/10$ nozzle row is set as the distance of conveyance of the thread between the successive liquid discharges.

[0151] By setting the distance of conveyance of the thread between the successive liquid discharges as illustrated in the table of FIG. 16B, the constant interval of the landing droplets is provided in the test pattern to be formed.

[0152] Further, in order to immediately apply the distance of conveyance of the thread between the successive liquid discharges set as described above, it is preferable to store a speed-distance table, as indicated in Table 1 below, for conveying the thread by the distance of conveyance of the thread between the successive liquid discharges. The speed-distance table provides the number of pulses of the encoder for conveyance of a thread associated with the distance of conveyance of the thread between the successive liquid discharges.

(Table 1)

CONVEYING SPEED B	yB1	yB2	yB3	yB4	
CONVEYING SPEED C (FASTER)	yC1	yC2	yC3	yC4	



[0153] When using Control Example 2, the correlation table illustrated in FIG. 16B and the speed-distance table such as Table 1 are used to firstly select the nozzle interval "m" for simultaneous discharges, the selected nozzle interval "m" is read by the image processing unit 300, and the total of discharges based on the selected nozzle interval "m" and the nozzle number for each liquid discharge are retrieved. Then, the number of pulses "y" of the encoder signal corresponding to each distance of conveyance between the respective successive liquid discharges corresponding to the selected nozzle interval is also retrieved. Next, a description is given of the control flow in Control Example 2 according to the present disclosure, with reference to the flowchart of FIG. 17.

(Flow of Test Patter Formation of Control Example 2)

[0154] FIG. 17 is a flowchart of test pattern formation according to Control Example 2 of the present disclosure.

[0155] First, in step S201, the liquid discharge interval (in other words, nozzle interval) is selected (set) at each liquid discharge in the intermittent test pattern used for the current nozzle check.

[0156] Then, in S202, the discharge-nozzle table selection unit 305 retrieves the nozzle number of each liquid discharge, based on the selected nozzle interval, from the correlation table stored in the test correlation data storage unit 307.

[0157] Further, in step S203, the discharge-nozzle table selection unit 305 retrieves the pulse interval "y" (in other words, the encoder pulses "y") corresponding to the distance of conveyance of the thread, which is retrieved from the speed-distance table stored in the test correlation data storage unit 307.

[0158] Then, in step S204, a droplet for the pre-check mark pattern is discharged, as illustrated in FIGS. 10 to 12.

[0159] In step S205, droplets are simultaneously discharged from the respective nozzles (the first nozzles) of the plurality of nozzle numbers at the first discharge. The size of each ink droplet forming the test pattern may be large, medium or small.

[0160] In step S206, the count value E of the number of discharged nozzles is incremented by 1.

[0161] In step S207, the controller 200 suspends the liquid discharge by the period corresponding to the number of encoder pulses "y" of the encoder signal set in step S203. Hereinafter, this period is also referred to as a discharge suspension period. The thread is continuously being conveyed throughout this period.

[0162] In step S208, it is determined whether the count value E of the number of discharges (of droplets from the nozzles) has reached the set total of discharges "b".

[0163] When the count value E has not reached the total number of discharges "b" ($E < b$) (NO in step S208), the process proceeds to step S209. In step S209, droplets are simultaneously discharged from the respective nozzles (the second nozzle) of the plurality of nozzle numbers at the subsequent discharge following the current discharge. Then, the process goes back to returning to S206 to increment the count value E of the number of discharged nozzles by 1 again, and the liquid discharge is held during the discharge suspension period while the thread is conveyed in step S207.

[0164] Then, the processes in S209, S206, and S207 are repeated in this order until the count value E reaches the total of discharges "b" ($E = b$) in step S208.

[0165] When the count value E reaches the total of discharges "b" (YES in step S208), a droplet indicating a post-check mark pattern is discharged to land on the thread to indicate that the nozzle check for one nozzle row is finished, in step S210.

[0166] With this discharge of the post-check mark pattern, formation of the test pattern (the "n" intermitted landing droplets) for one nozzle row is completed.

[0167] By forming the test pattern as described above, in the configuration of Control Example 2, each droplet is discharged onto the thread from the corresponding nozzle while the nozzles are disposed spaced apart from each other along the nozzle row. According to this configuration, a missing nozzle that is clogged and unable to discharge liquid is detected on the thread, and therefore the missing nozzle that could not be detected due to the relatively small discharge target area is checked successfully.

[0168] Here, it is confirmed whether there is the missing landing droplet in the test pattern for nozzle check, which was formed along the process flow provided in the flowchart of FIG. 9 or the flowchart of FIG. 17. Visual confirmation fulfills the purpose, but alternatively, automatic confirmation by a photosensor or an image sensor as described below may also be applicable.

(Embodiment 2)

[0169] FIGS. 18A and 18B are schematic side views each illustrating the position of each sensor according to Embodiments 2 and 3 of the present disclosure. To be more specific, FIG. 18A is a schematic side view of Configuration Example 1 including a sensor and FIG. 18B is a schematic side view of Configuration Example 2 indicating the position of the sensor.

[0170] A sensor 107 is disposed downstream from the head 1 of the liquid applying device 103 in the thread conveyance direction to detect the test pattern formed on the thread.

[0171] FIG. 18A illustrates an example that a liquid discharge apparatus 100A includes a sensor 107 disposed immediately downstream from the liquid applying device 103 in the thread conveyance direction. Further, as long as the sensor is disposed downstream from the liquid applying device 103 in the thread conveyance direction, the sensor 107 may not be disposed immediately downstream from the liquid applying device 103 in the thread conveyance direction.

[0172] Therefore, as a liquid discharge apparatus 100B illustrated in FIG. 18B, a sensor 107B may be disposed downstream from the fixing device 104 and the post-processing device 105 in the thread conveyance direction. Alternatively, a sensor may be disposed between the fixing device 104 and the post-processing device 105 in the thread conveyance direction.

[0173] In Embodiment 2, in the course of conveyance of the thread 101 that functions as a linear object, the photosensor 107, that is, the sensor 107, is disposed downstream from the head 1. By so doing, the intermittent test pattern formed on the thread 101 is detected automatically.

[0174] Note that, when the sensor 107 is a photosensor, the sensor 107 (hereinafter, also the photosensor 107) is disposed above the thread 101 in FIGS. 18A and 18B. Consequently, the photosensor 107 is a reflection type photosensor including a light emitting part that emits light to the thread 101 and a light receiving part that detects the reflection light, as a single unit. However, the type of the photosensor 107 is not limited to the reflection type photosensor. For example, a transmission type photosensor that includes a light emitting part and a light receiving part separately disposed across the thread conveyance passage, for example, the light emitting part on the upper side from the thread conveyance passage and the light receiving part on the lower side from the thread conveyance passage.

Control Block (Embodiment 2)

[0175] FIG. 19 is a control block diagram of a liquid discharge part in the liquid discharge apparatus according to

Embodiment 2 of the present disclosure.

[0176] Now, a description is given of the control executed in Embodiment 2, except for the same operations performed in Embodiment 1 illustrated in FIG. 4.

[0177] The photosensor 107 is connected to a host controller 400. The host controller 400 may be an internal component of the thread coloring-embroidering system 1000A or may be a host computer that is connected to the thread coloring-embroidering system 1000A.

[0178] Further, the recovery units 20a, 20b, 20c, and 20d each functioning as a maintenance-recover unit or simply a recovery unit of a maintenance device are connected to the host controller 400 to maintain and recover an ability of a missing nozzle of the head 1. The image processing unit 300 that is used to execute the operation in Control Example 2 is also connected to the host controller 400.

[0179] Note that, in Embodiment 2 illustrated in FIG. 19, the image processing unit 300, the head controller 401, the discharge timing generation unit 404, and the host controller 400 each performing calculation are constituted as a controller 200A in the liquid discharge apparatus 100A.

[0180] FIG. 20 is a diagram illustrating the timings of detection by the photosensor and by the conveyance encoder when forming the test pattern according to the present disclosure.

[0181] A description is given of a method of detecting a missing nozzle by the photosensor 107, with reference to FIG. 20.

[0182] When the photosensor 107 is used, the photosensor 107 is disposed on the thread conveyance passage, so that the photosensor 107 synchronizes with the pulse of the encoder signal of the encoder 405 and detects a missing dot (missing nozzle).

[0183] As illustrated in FIG. 8A, the head 1 discharges ink onto the thread in accordance with the encoder signal or the liquid discharge interval "t" [s]. When discharging a droplet at a cycle of the liquid discharge interval "t" [s], it is assumed that the head controller 401 of the host controller 400 generates the pulse signal in the cycle. Therefore, the photosensor 107 performs sensing in synchrony with the cycle. Further, the head controller 401 or the host controller 400 confirms the synchronization of detection process and sequence.

[0184] The lower side of FIG. 20 indicates an example of the detection signal of the photosensor 107. In the test actual detection signal on the lower side of FIG. 20, since one pulse does not make a rise of the three pulse patterns, the detection signal of the photosensor 107 is not output in the corresponding portion. Therefore, the head controller 401 or the host controller 400 detects that the nozzle to discharge a droplet to land on the position is missing, in other words, does not discharge a droplet.

[0185] Note that, in FIG. 20, a waveform starting with a rising pulse is described as an example of detection result of the photosensor 107 when detecting the landing droplets (also referred to as the pattern) of the test pattern on the thread. However, a waveform starting with a falling pulse may be employed as an example of detection result of the photosensor 107.

(Test Flowchart (Control Example 1))

[0186] FIG. 21 is a flowchart along which the photosensor 107 detects the test pattern formed in Control Example 1.

[0187] Note that, in the example provided in the flowchart of FIG. 21, the head controller 401 confirms the synchronization. However, confirmation of the synchronization may be made by the host controller 400.

[0188] In step S301, the head controller 401 calculates the timing at which each of droplets included in the test pattern (in other words, a plurality of intermittent landing droplets) reaches immediately below the photosensor 107.

[0189] In step S302, the head controller 401 starts reading the encoder signal of conveyance of the thread.

[0190] In step S303, the photosensor 107 starts monitoring the thread and transmits the detection signal that is monitor information, to the head controller 401. Starting monitoring of the thread indicates starting light emission from the light emitting part of the photosensor 107.

[0191] In step S304, it is determined, based on the encoder signal, whether the droplet on the thread has reached the timing to reach immediately below the photosensor 107. When the droplet on the thread has not reached the timing (NO in step S304), step S304 is repeated until the droplet on the thread reaches the timing. When the droplet on the thread has reached the timing (YES in step S304), the process goes to step S305.

[0192] In step S305, the signal from the photosensor 107 is compared with the encoder signal and it is determined whether the signal from the photosensor 107 is synchronized with the encoder signal to detect the droplet. To be more specific, in step S305, as illustrated in FIG. 19, it is compared to check whether the rising (or falling) timing of the encoder signal is synchronized with the rising (or falling) timing of the detection signal from the photosensor 107, in other words, the encoder signal has the synchronization with the detection signal from the photosensor 107.

[0193] When the detection signal from the photosensor 107 is not synchronized with the encoder signal at the timing in step S304 (NO in step S305), the process goes to step S306.

[0194] In step S306, the head controller 401 detects the nozzle that should have discharged liquid is missing.

[0195] In other words, the photosensor 107 detects the test pattern formed on the thread 101, and the head controller

401 of the controller 200A determines whether the head 1 has a missing nozzle, based on a timing of conveyance of the thread 101 on the conveyor including the thread feed reel 102 and the rollers 108 and 109 and a timing of each detection of the plurality of "n" intermittent landing droplets of the test pattern.

[0196] Then, in step S307, the head controller 401 informs the nozzle number corresponding to the missing nozzle, to the host controller 400. By so doing, the missing nozzle is informed to the engine side, so as to cause the recovery units 20 to recover the clogging of the nozzle, for example, by cleaning the head 1.

[0197] In step S308, the count value D of the number of detected nozzles is incremented by 1.

[0198] In step S309, it is determined whether the count value D has reached the number of "n" nozzles of one nozzle row. When the count value D is below the number of "n" nozzles (NO in step S309), the process returns to step S304. Then, as the next detection operation, it is determined, based on the encoder signal, whether the subsequent droplet on the thread has reached the timing to reach immediately below the photosensor 107. When the subsequent droplet on the thread has reached the timing (YES in step S304), then in step S305, the signal from the photosensor 107 is compared with the encoder signal and it is determined whether the signal from the photosensor 107 is synchronized with the encoder signal to detect the droplet. Then, according to the result of comparison, the process repeats that: the nozzle that should have discharged liquid is detected as a missing nozzle (step S306); the detection in step S306 is informed to the host controller 400 (step S307); and the count value D is incremented by 1 (step S308). The operations in steps S304 to S308 are repeated until the count value D reaches the number of "n" nozzles in one nozzle row in step S309.

[0199] When the count value D has reached the number of "n" nozzles in one nozzle row (YES in step S309), the photosensor 107 finishes monitoring the thread in step S310. Finishing monitoring of the thread indicates stopping light emission from the light emitting part of the photosensor 107.

[0200] With this operation, the detection by the photosensor 107 is completed.

[0201] Note that, in step S307 in the above-described flow, each time a missing nozzle is detected, the detection is informed to the host controller 400. However, the head controller 401 may temporarily store the nozzle number of the missing nozzle and, after completion of detection of each nozzle of one nozzle row, the head controller 401 may inform the nozzle numbers of the missing nozzles altogether, to the host controller 400.

[0202] As the above-described control, the photosensor 107 performs automatic detection and feedback of a missing nozzle or missing nozzles in the test pattern.

[0203] In addition, since light emission of the photosensor 107 achieves continuous monitoring of the thread, the photosensor 107 is not turned on and off depending on the position of the landing droplet on the thread.

(Test Flowchart (Control Example 2))

[0204] FIG. 22 is a flowchart of test pattern formation in Control Example 2 detected with the photosensor 107.

[0205] The flow of the flowchart of FIG. 22 is basically the same as the flow of the flowchart of FIG. 21, except that the setting in step S401 and the detection timing in step S404 in the flowchart of FIG. 22 are different from the flowchart of FIG. 21.

[0206] In Control Example 2, in step S401, the head controller 401 calculates the positions of the landing droplets on the thread, where the respective positions are associated with the nozzle numbers of respective liquid discharges used for this time, and then calculates the timings at which the landing droplets on the thread reach the position immediately below the photosensor. The information of each calculated timing is used in step S404.

[0207] Further, while the timing in step S304 in Control Example 1 is the detection timing that is synchronized with the discharge timing, since the plurality of droplets is simultaneously discharged at one discharge in Control Example 2, the synchronization is detected at the timing when each droplet on the thread reaches the position immediately below the photosensor 107, at the timing adjusted to the position of each droplet in step S404.

[0208] As in the present embodiment, by detecting the test pattern with the photosensor, even when the discharge interval of the test pattern or the nozzle interval is relatively short, when compared with visual detection, a missing nozzle, that is, a nozzle that does not discharge liquid, is detected on the thread more smoothly. Further, since the photosensor is connected to the host controller, even though the state of discharge is not input by a user, for example, the operation is shifted to the maintenance.

[0209] Further, in a case in which the test pattern is detected by the photosensor, the detection is made along with the conveyance of the thread, without stopping the conveyance of the thread and the monitoring operation of the thread each time the test pattern is detected.

(Embodiment 3)

[0210] In Embodiment 3, a liquid discharge apparatus 100C includes an image sensor 500 that functions as a sensor to detect the test pattern. Note that the image sensor 500 is installed at the same position as the installation position of

the sensor 107 illustrated in FIG. 18A or the sensor 107B illustrated in FIG. 18B, on the thread conveyance passage.

[0211] Note that the image sensor 500 is a two-dimensional image sensor that captures an image at the detection timing while conveyance of the thread is stopped.

[0212] FIG. 23 including FIGS. 23A and 23B is a control block diagram of a liquid discharge part provided with the image sensor 500 in the liquid discharge apparatus 100C according to Embodiment 3 of the present disclosure.

[0213] The image sensor 500 includes an illumination light source 510, a data storage memory 520, a sensor unit 530, an in-sensor image processing unit 540, and an interface unit 550.

[0214] The illumination light source 510 serves as a light source or a flashlight source at the time of image capturing. The data storage memory 520 serves as a storage area for captured images.

[0215] The sensor unit 530 serves as an image reading unit (image capturing unit) for the image of the test pattern on the thread.

[0216] The in-sensor image processing unit 540 includes an AD (analog-digital) converter 541, a shading corrector 542, a gamma corrector 543, and an image format converter 544.

[0217] The AD converter 541 converts the analog signal transmitted from the sensor unit 530 into a digital signal. The shading corrector 542 corrects the unevenness of the image. The gamma corrector 543 is a correction unit for the brightness of image. The image format converter 544 converts the image into a format for transmitting to the host system.

[0218] The interface unit 550 is connected to a host central processing unit (CPU) 400A, a host central processing unit (CPU) 400B, and an image processing unit 300A.

[0219] The image sensor 500 is connected to the image processing unit 300A. Different from the image processing unit 300 illustrated in FIG. 16, the image processing unit 300A includes an image capturing data calculator 308.

[0220] When checking the test pattern automatically by the image sensor 500, the mark pattern needs to be previously stored in the host CPU (image processing unit) 300A.

[0221] Here, when the image sensor 500 examines each landing droplet of the test pattern, the image is captured by the number of landing droplets. Therefore, the image capturing needs to be synchronized with cycle of liquid discharge.

When examining the test pattern formed by the method of Control Example 1, the images of landing droplets of the test pattern are captured with intervals at timings synchronized with the encoder, similar to the control of discharge timing in FIG. 8A.

[0222] In other words, the image sensor 500 detects the test pattern formed on the thread 101, and the head controller 401 of the controller 200A determines whether the head 1 has a missing nozzle, based on a timing of conveyance of the thread 101 on the conveyor including the thread feed reel 102 and the rollers 108 and 109 and a timing of each detection of the plurality of "n" intermittent landing droplets of the test pattern.

[0223] The detection process may be performed by the host CPU 400A around the two-dimensional image sensor or may be performed by the in-sensor image processing unit 540 inside the image sensor 500.

(Test Flow by Image Sensor)

[0224] FIG. 24 is a flowchart of the detection process for the test pattern by the image sensor.

[0225] Note that this flow explains detection of yellow (Y) patterns as an example. However, the same flow as this flow is executed for detection of each of the other colors.

[0226] First, in step S501, the host CPU 400A or the image sensor 500 calculates the position of each droplet to be discharged onto the thread at the liquid discharge C.

[0227] In step S502, the liquid discharge C is read to specify the nozzle of the image to be detected. The reading is performed subsequently from the liquid discharge C = 1.

[0228] In step S503, the position of the landing droplet of the test pattern on the thread corresponding to the liquid discharge C is captured.

[0229] In step S504, the data storage memory 520 reads out the image captured in step S503.

[0230] In step S505, the measured colorimetric value at the corresponding portion in the read image is scanned. The corresponding portion is a portion in which color is read on the image, which is previously set to the center of the image, for example. The parameter of the measured colorimetric value may be RGB, Lab, or any other parameter.

[0231] In step S506, it is determined whether the measured colorimetric value scanned in step S505 corresponds to Y. When the measured colorimetric value does not correspond to Y (NO in step S506), the process goes to step S507.

[0232] Then, the missing nozzle is confirmed in step S507, and the confirmation result is informed to the host system to recover the clogging of the nozzle, for example, by cleaning the head in step S508.

[0233] On the other hand, when the measured colorimetric value corresponds to Y (YES in step S506), it is determined whether the count value C is "n" (C = n) in step S509. When the count value C is not "n" (NO in step S509), the process goes back to step S502 and repeats steps S502, S503, S504, S505, S506, S507, and S508 in this order until the count value C is "n".

[0234] Then, when the count value C is "n" (YES in step S509), the detection process of the test pattern is completed.

[0235] As in the present embodiment, by detecting the test pattern with the image sensor, even when the liquid discharge interval of the test pattern or the nozzle interval is relatively short, a missing nozzle on the thread is detected more smoothly when compared with visual detection. Further, since the image sensor is connected to the host controller, even though the state of discharge is not input by a user, for example, the operation is shifted to the maintenance.

[0236] In addition, the image sensor has a color measuring function. Therefore, the image sensor is capable of confirming blurring of the landing droplet and the color change state of the landing droplet as well as confirming that there is the landing droplet of the test pattern.

(Another Liquid Discharge Apparatus)

[0237] Next, a description is given of an example of a liquid discharge apparatus according to an embodiment of the present disclosure, with reference to FIG. 25.

[0238] FIG. 25 is a schematic view illustrating an example of a coloring system incorporating a liquid discharge apparatus according to an embodiment of the present disclosure.

[0239] A coloring system 2000 has the configuration basically the same as the configuration of the thread coloring-embroidering apparatus 1000 illustrated in FIG. 1, except that the coloring system 2000 includes a thread take-up reel 110 that takes up the colored thread 101 while the thread coloring-embroidering apparatus 1000 of FIG. 1 includes the embroidery head 106.

[0240] In the coloring system 2000, the thread feed reel 102 feeds the thread 101, the liquid applying device 103 discharges and supplies liquid of a specified color to the thread 101 to color the thread 101 to the specified color, and the thread take-up reel 110 takes up the colored thread 101.

[0241] The coloring system 2000 may be connected to an information processing device 9 that functions as a host computer (PC).

[0242] In the coloring system 2000, an intermittent test pattern is formed on the thread by the method of Control Example 1 or the method of Control Example 2 as described above. By so doing, even on a thread having a relatively small discharge target area, a missing nozzle or missing nozzles in the nozzle row may be checked.

[0243] Further, in the liquid discharge apparatus according to the present disclosure, the test pattern may be detected automatically with the above-described photosensor or image sensor.

[0244] Note that the liquid discharge apparatus according to the above-described embodiments includes the liquid discharge head that discharges liquid toward downward, the cap is disposed below the liquid discharge head, and the face of the nozzle plate is covered from below. However, the discharge direction of ink droplets by the liquid discharge head is not limited to the downward direction. For example, ink droplets may be discharged in the upward direction or in the horizontal (lateral) direction. Alternatively, a plurality of liquid discharge heads is disposed on the drum to discharge liquid (ink) in a direction outwardly away from the center of rotation. In any configuration, the cap is disposed at a position facing the liquid discharge direction of the liquid discharge head or at a position facing the position to which the liquid discharge head is moved from the liquid discharge position. In such a configuration, a photosensor or an image sensor may be disposed downstream from the liquid discharge head in the thread conveyance direction, at a position at which the landing droplet that lands on the surface of the thread is detected.

[0245] Although the present disclosure makes reference to specific embodiments, it is to be noted that the present disclosure is not limited to the details of the embodiments and examples described above. For example, elements and/or features of different embodiments and examples may be combined with each other and/or substituted for each other within the scope of the present disclosure. The number of constituent elements and their locations, shapes, and so forth are not limited to any of the structure for performing the methodology illustrated in the drawings. Further, the present disclosure is not limited to the embodiments and examples described above. Thus, various modifications and enhancements are possible in light of the above teachings, without departing from the scope of the present disclosure.

[0246] The above-described embodiments are illustrative and do not limit this disclosure. Thus, numerous additional modifications and variations are possible in light of the above teachings. For example, elements at least one of features of different illustrative and exemplary embodiments herein may be combined with each other at least one of substituted for each other within the scope of this disclosure and appended claims. Further, features of components of the embodiments, such as the number, the position, and the shape are not limited the embodiments and thus may be preferably set.

[0247] The present disclosure is not limited to specific embodiments described above, and numerous additional modifications and variations are possible in light of the teachings within the technical scope of the appended claims. It is therefore to be understood that, the disclosure of this patent specification may be practiced otherwise by those skilled in the art than as specifically described herein, and such, modifications, alternatives are within the technical scope of the appended claims. Such embodiments and variations thereof are included in the scope and gist of the embodiments of the present disclosure and are included in the embodiments described in claims and the equivalent scope thereof.

[0248] The above-described embodiments are illustrative and do not limit the present disclosure. Thus, numerous additional modifications and variations are possible in light of the above teachings. For example, elements and/or features

of different illustrative embodiments may be combined with each other and/or substituted for each other within the scope of this disclosure.

[0249] Any one of the above-described operations may be performed in various other ways, for example, in an order different from the one described above.

Claims

1. A liquid discharge apparatus (100, 100A, 100B) comprising:

a head (1a, 1b, 1c, 1d) having a nozzle row with nozzles aligned in line, the nozzles each being configured to discharge a color liquid;
 a conveyor (102, 108, 109) configured to convey a discharge target medium (101) in parallel with a direction of alignment of the nozzle row of the head (1a, 1b, 1c, 1d); and
 a controller (200, 200A) configured to control a liquid discharge from each of the nozzles of the head (1a, 1b, 1c, 1d) in association with a state of conveyance of the discharge target medium (101), the controller (200, 200A) being configured to form a test pattern and perform a test to determine whether each of the nozzles of the head (1a, 1b, 1c, 1d) discharges the color liquid with the test pattern, wherein the controller (200, 200A) is configured to:

when forming the test pattern without discharging droplets of the color liquid from adjacent nozzles of the nozzle row of the head (1a, 1b, 1c, 1d) simultaneously,
 discharge a droplet of the color liquid from a first nozzle of the adjacent nozzles;
 suspend the liquid discharge of the color liquid to the discharge target medium (101) for a predetermined discharge suspension period while the discharge target medium (101) is conveyed; and
 discharge a droplet of the color liquid from a second nozzle of the adjacent nozzles after the predetermined discharge suspension period.

2. The liquid discharge apparatus (100, 100A, 100B) according to claim 1, wherein the nozzles of the nozzle row of the head (1a, 1b, 1c, 1d) are n nozzles aligned in line, wherein the controller (200, 200A) is configured to:

discharge a droplet of the color liquid from one nozzle of the nozzle row of the head (1a, 1b, 1c, 1d);
 suspend the liquid discharge of the color liquid in the predetermined discharge suspension period while the discharge target medium (101) is conveyed;
 change the one nozzle of the nozzle row to another nozzle of the nozzle row; and
 repeat discharging a droplet of the color liquid and suspending the liquid discharge to form the test pattern on the discharge target medium (101); and

wherein the test pattern includes n intermittent landing droplets on the discharge target medium (101) in a conveyance direction of the discharge target medium (101).

3. The liquid discharge apparatus (100, 100A, 100B) according to claim 2, wherein, when repeating discharging a droplet of the color liquid and suspending the liquid discharge for n times, the controller (200, 200A) is configured to cause the head (1a, 1b, 1c, 1d) to discharge droplets of the color liquid in an order from a downstream nozzle to an upstream nozzle of the nozzle row of the head (1a, 1b, 1c, 1d) in the conveyance direction of the discharge target medium (101), and wherein the controller (200, 200A) is configured to set a conveying distance of the discharge target medium (101) to be equal to or greater than a value obtained by dividing a diameter of a droplet by a conveying speed of the discharge target medium in the predetermined discharge suspension period.

4. The liquid discharge apparatus (100, 100A, 100B) according to claim 1, wherein the nozzles of the nozzle row of the head (1a, 1b, 1c, 1d) are n nozzles aligned in line, wherein the controller (200, 200A) includes a memory (307) configured to store a correlation table in which a total of discharges based on a discharge interval corresponding to a number m of non-discharge nozzle between adjacent discharge nozzles, where m represents a positive number more than one and less than n/2, is associated with a nozzle number at each discharge when a plurality of nozzles discharge droplets of the color liquid simultaneously, wherein the controller (200, 200A) is configured to:

discharge droplets of the color liquid at every m nozzle from the plurality of nozzles;
 suspend the liquid discharge of the color liquid in the predetermined discharge suspension period while the
 discharge target medium (101) is conveyed;
 change the one nozzle of the nozzle row to another nozzle of the nozzle row; and
 5 repeat discharging one droplet and suspending the liquid discharge for the total of discharges to form the test
 pattern on the discharge target medium (101); and

wherein the test pattern includes n intermittent landing droplets on the discharge target medium (101) in a conveyance
 10 direction of the discharge target medium (101).

5. The liquid discharge apparatus (100, 100A, 100B) according to claim 4,
 wherein the controller (200, 200A) is configured to set a conveying distance of the discharge target medium (101)
 from a last landing droplet of a current discharge to a first landing droplet of a subsequent discharge, to be equal
 to or greater than a distance between adjacent discharge nozzles across m non-discharge nozzles in the predeter-
 15 mined discharge suspension period.

6. The liquid discharge apparatus (100, 100A, 100B) according to any one of claims 1 to 5, further comprising a
 photosensor (107, 107B) on a conveyance passage of the discharge target medium (101), the photosensor (107,
 107B) being configured to detect the test pattern on the discharge target medium (101),
 20 wherein the controller (200A) is configured to determine whether the head (1a, 1b, 1c, 1d) has a missing nozzle,
 based on a timing of conveyance of the discharge target medium (101) on the conveyor (102, 108, 109) and a timing
 of each detection of a plurality of intermittent landing droplets of the test pattern detected by the photosensor (107,
 107B).

7. The liquid discharge apparatus (100, 100A, 100B) according to any one of claims 1 to 5, further comprising an image
 sensor (500) on a conveyance passage of the discharge target medium (101), the image sensor (500) being con-
 figured to detect the test pattern on the discharge target medium (101),
 wherein the controller (200A) is configured to determine whether the head (1a, 1b, 1c, 1d) has a missing nozzle,
 based on a timing of conveyance of the discharge target medium (101) on the conveyor (102, 108, 109) and a timing
 30 of each detection of the plurality of "n" intermittent landing droplets of the test pattern detected by the image sensor
 (500).

8. The liquid discharge apparatus (100, 100A, 100B) according to any one of claims 1 to 7,
 wherein the controller (200, 200A) is configured to discharge, as a mark pattern indicating a start of a test pattern
 35 formation, droplets of the color liquid having a color same as the droplet of the color liquid from the head (1a, 1b,
 1c, 1d) immediately before forming the test pattern by the head (1a, 1b, 1c, 1d) to be tested, to form a group of
 droplets different from the plurality of intermittent landing droplets of the test pattern.

9. The liquid discharge apparatus (100, 100A, 100B) according to any one of claims 1 to 7, further comprising a plurality
 40 of heads (1a, 1b, 1c, 1d) configured to discharge color liquids of colors different from each other, the plurality of
 heads (1a, 1b, 1c, 1d) including the head,
 wherein the controller (200, 200A) is configured to discharge, as a mark pattern indicating a start of a test pattern
 formation, droplets of a color liquid from another head of the plurality of heads for a color different from a color of
 the color liquid of the head (1a, 1b, 1c, 1d) to be tested, on the discharge target medium (101) at a position immediately
 45 before the test pattern formed by the head (1a, 1b, 1c, 1d) to be tested.

10. The liquid discharge apparatus (100, 100A, 100B) according to any one of claims 1 to 9,
 wherein the controller (200, 200A) is configured to discharge droplets of the color liquid having a color same as the
 droplet of the color liquid from the head (1a, 1b, 1c, 1d), as a mark pattern indicating an end of a test pattern formation,
 50 at a position immediately after the test pattern formed by the head (1a, 1b, 1c, 1d) to be tested, to form a group of
 droplets different from the plurality of intermittent landing droplets of the test pattern.

11. The liquid discharge apparatus (100, 100A, 100B) according to any one of claims 1 to 9, further comprising a plurality
 55 of heads (1a, 1b, 1c, 1d) configured to discharge color liquids of colors different from each other, the plurality of
 heads (1a, 1b, 1c, 1d) including the head,
 wherein the controller (200, 200A) is configured to discharge, as a mark pattern indicating a start of the test pattern
 formation, a droplet of the color liquid from another head of the plurality of heads for a color different from a color
 of the color liquid of the head (1a, 1b, 1c, 1d) to be tested, on the discharge target medium (101) at a position

immediately after the test pattern formed by the head (1a, 1b, 1c, 1d) to be tested.

12. The liquid discharge apparatus according to any one of claims 1 to 11, further comprising a maintenance unit (20a, 20b, 20c, 20d) configured to maintain and recover an ability of a missing nozzle of the head (1a, 1b, 1c, 1d).

13. A method for forming a test pattern in a liquid discharge apparatus including a head (1a, 1b, 1c, 1d) having a nozzle row with nozzles aligned in line, the nozzles each being configured to discharge a color liquid and a conveyor (102, 108, 109) configured to convey a discharge target medium (101) in parallel with a direction of alignment of the nozzle row of the head (1a, 1b, 1c, 1d),
the method comprising:

discharging a droplet of the color liquid from a first nozzle of adjacent nozzles of the nozzle row of the head (1a, 1b, 1c, 1d) without discharging droplets of the color liquid from the adjacent nozzles simultaneously;
suspending a liquid discharge of the color liquid to the discharge target medium (101) for a predetermined discharge suspension period while the discharge target medium (101) is conveyed after the discharging; and
discharging a droplet of the color liquid from a second nozzle of the adjacent nozzles after the predetermined discharge suspension period.

FIG. 1

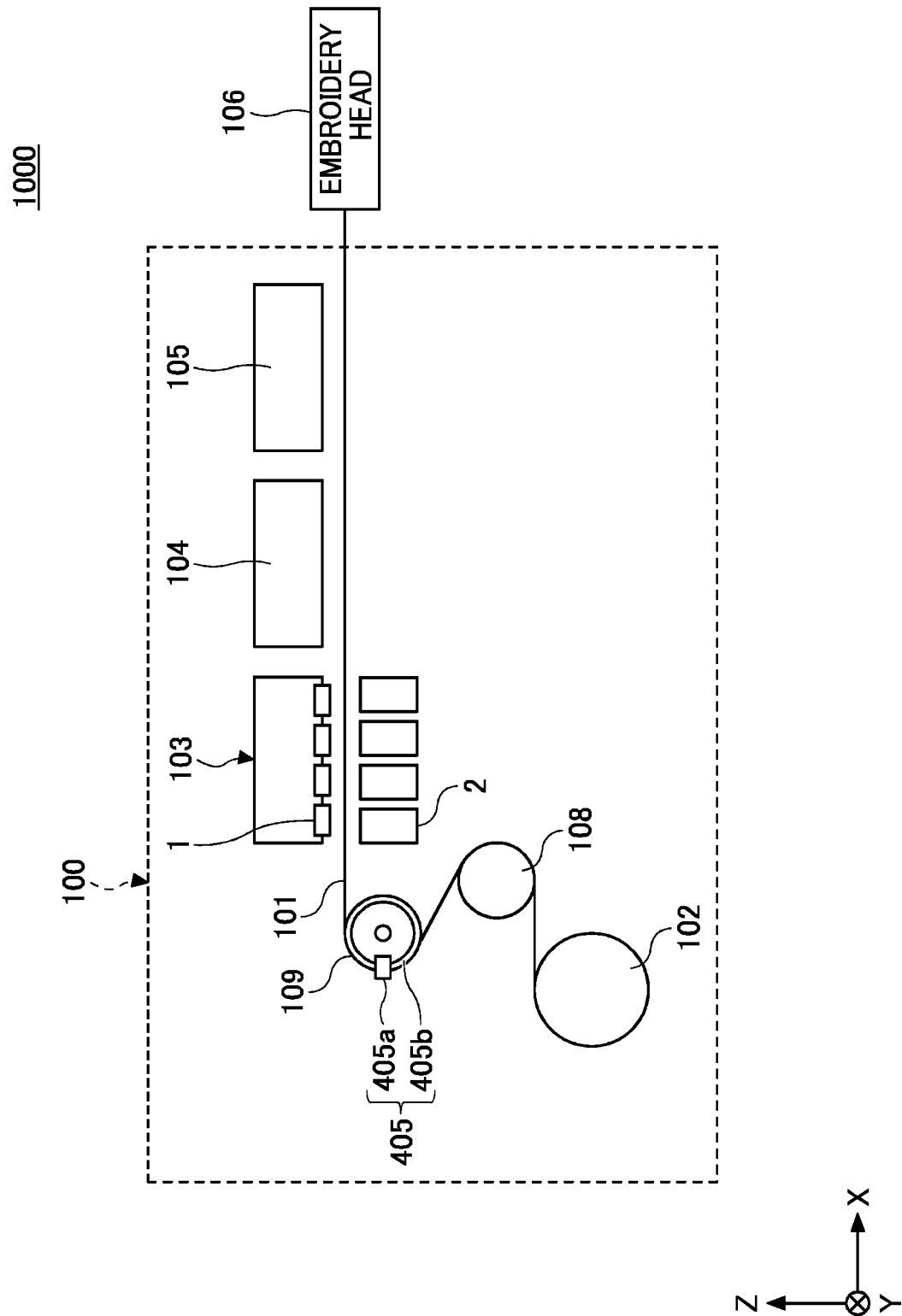


FIG. 2

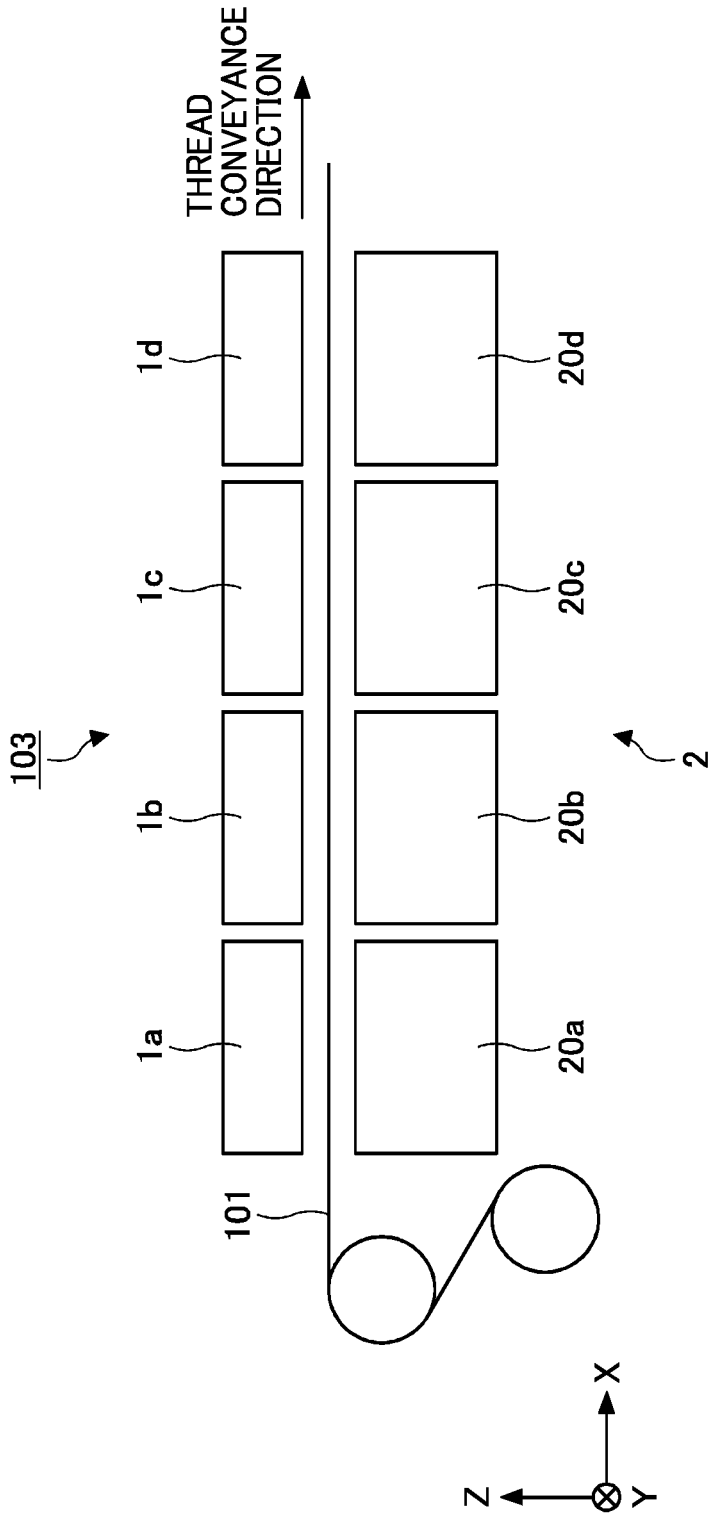


FIG. 3

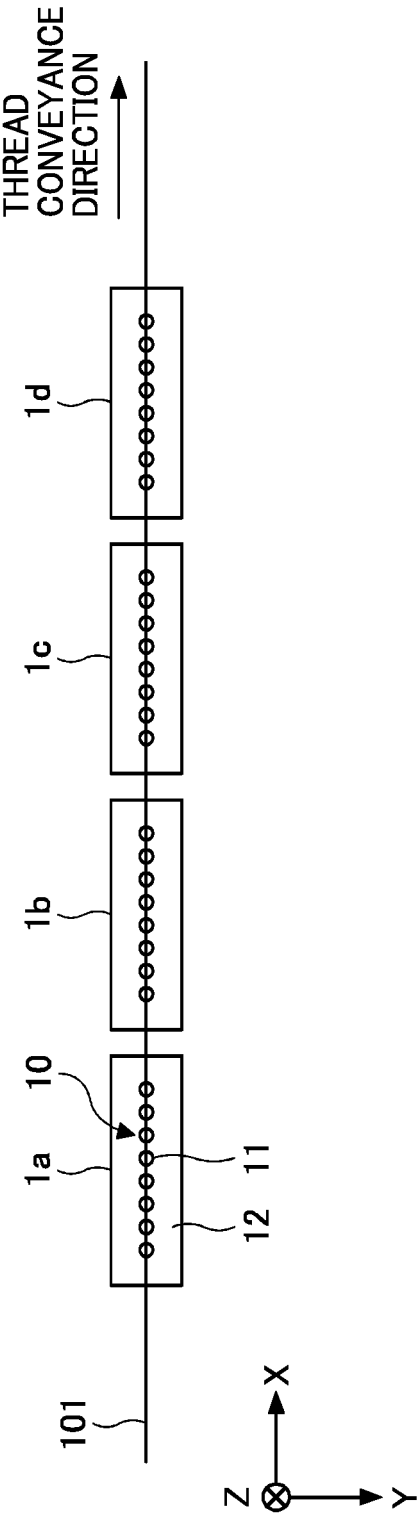


FIG. 4

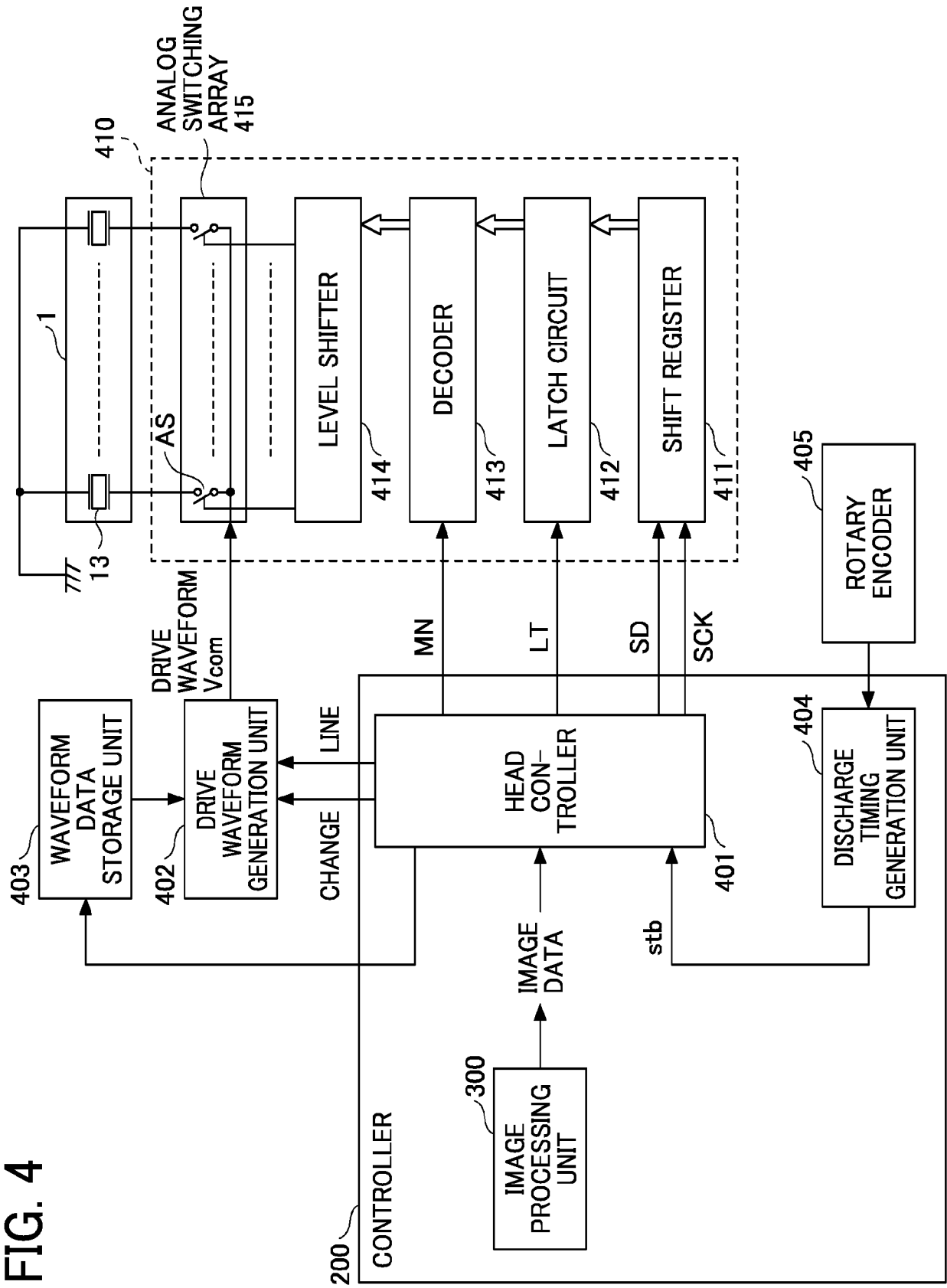


FIG. 5

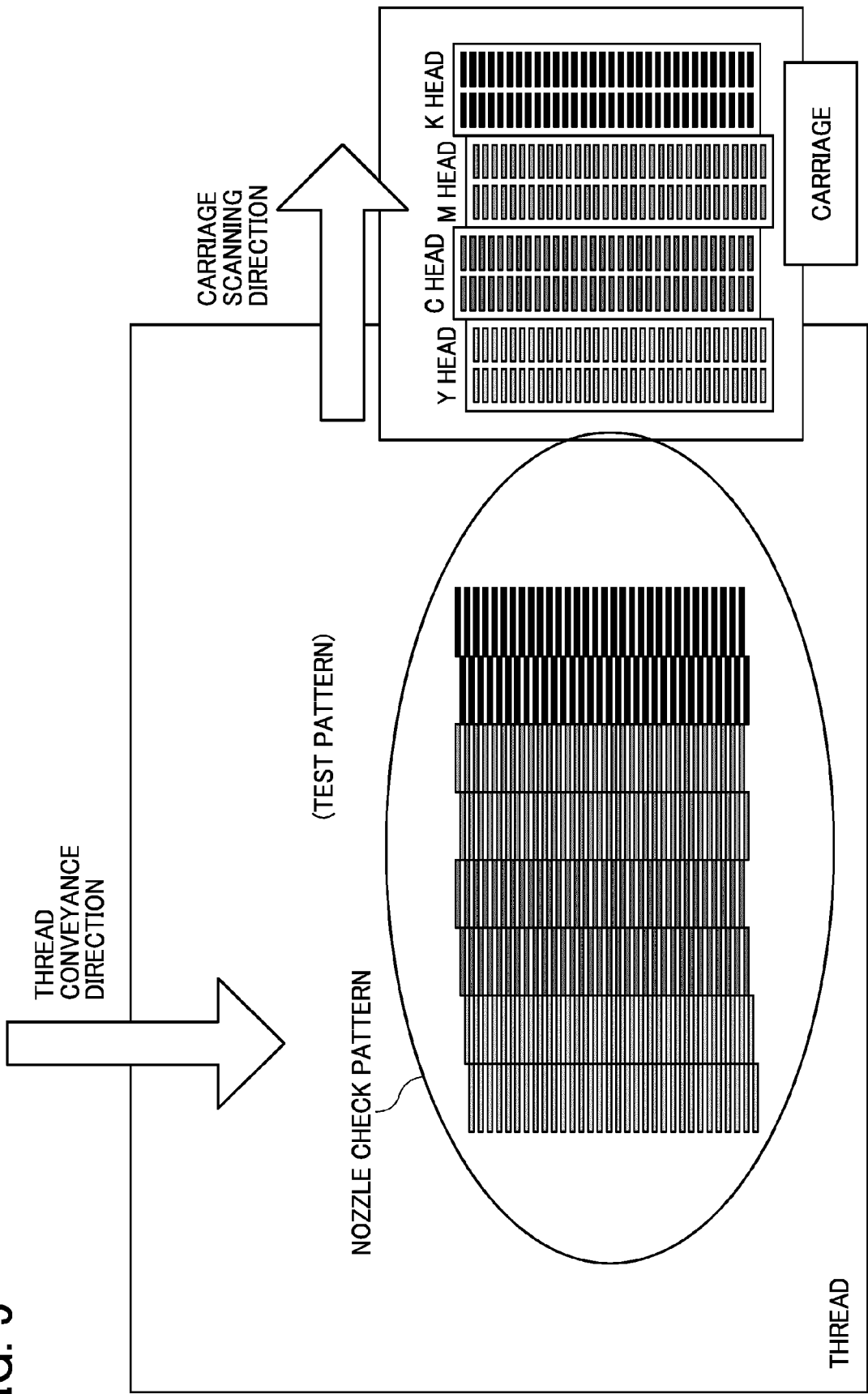


FIG. 6A

COMPARATIVE EXAMPLE

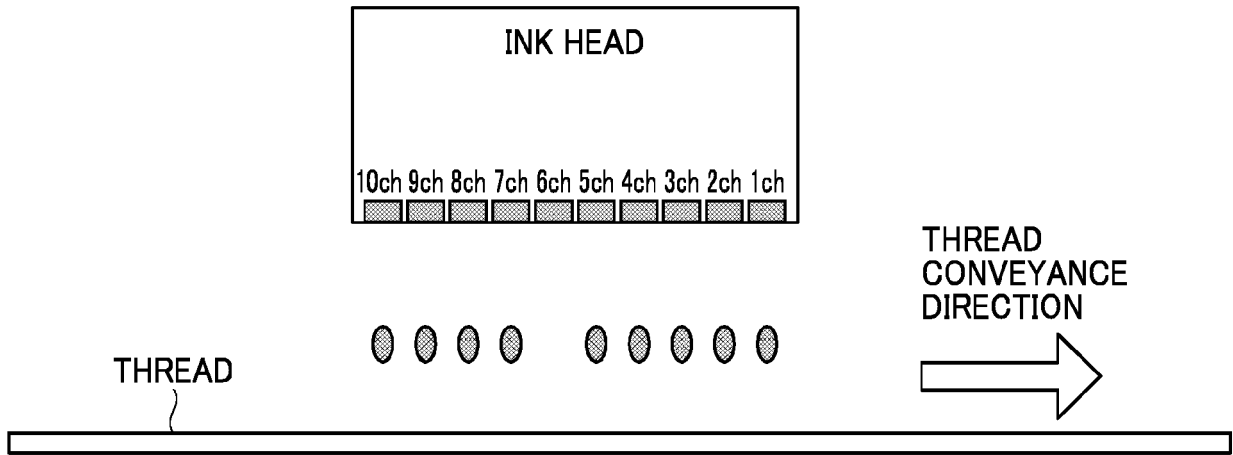


FIG. 6B

COMPARATIVE EXAMPLE

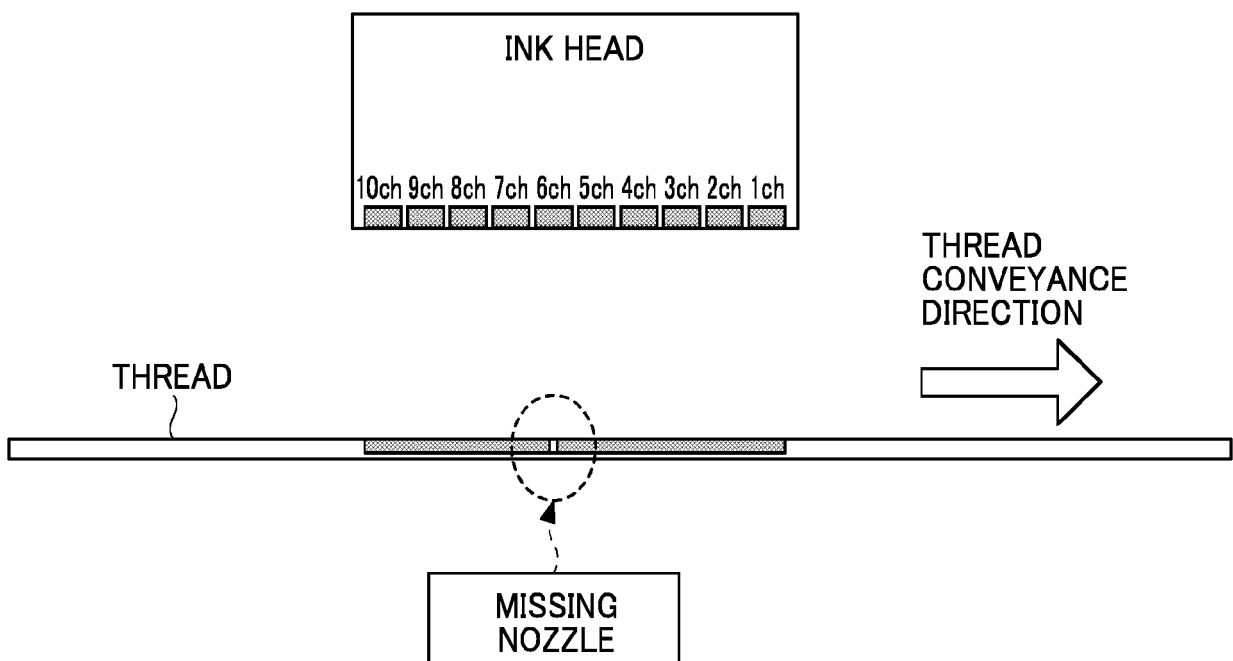


FIG. 7A

<CONTROL EXAMPLE 1>

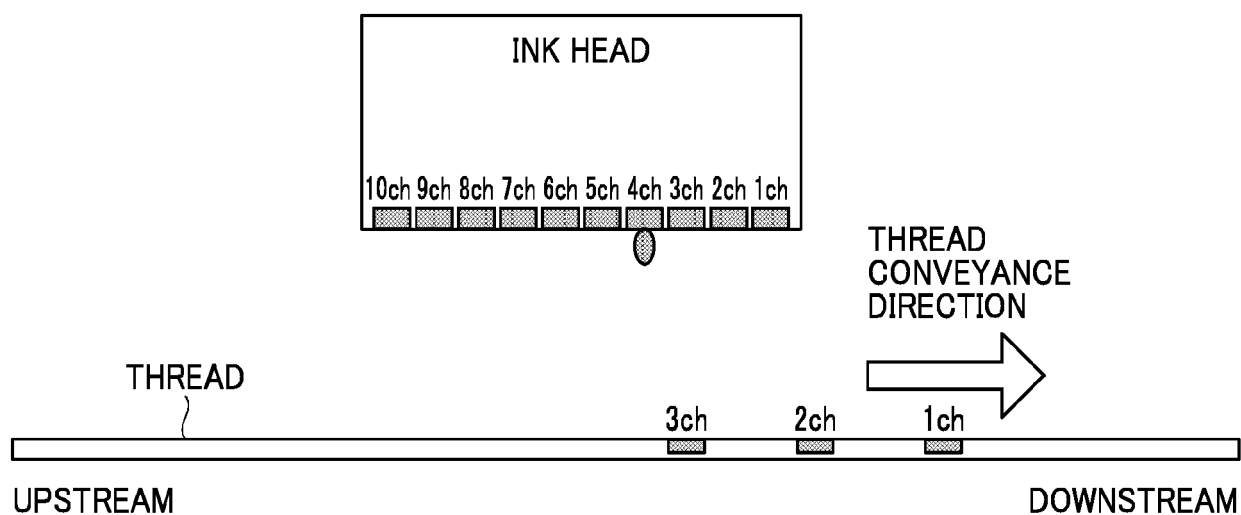


FIG. 7B

<CONTROL EXAMPLE 1>

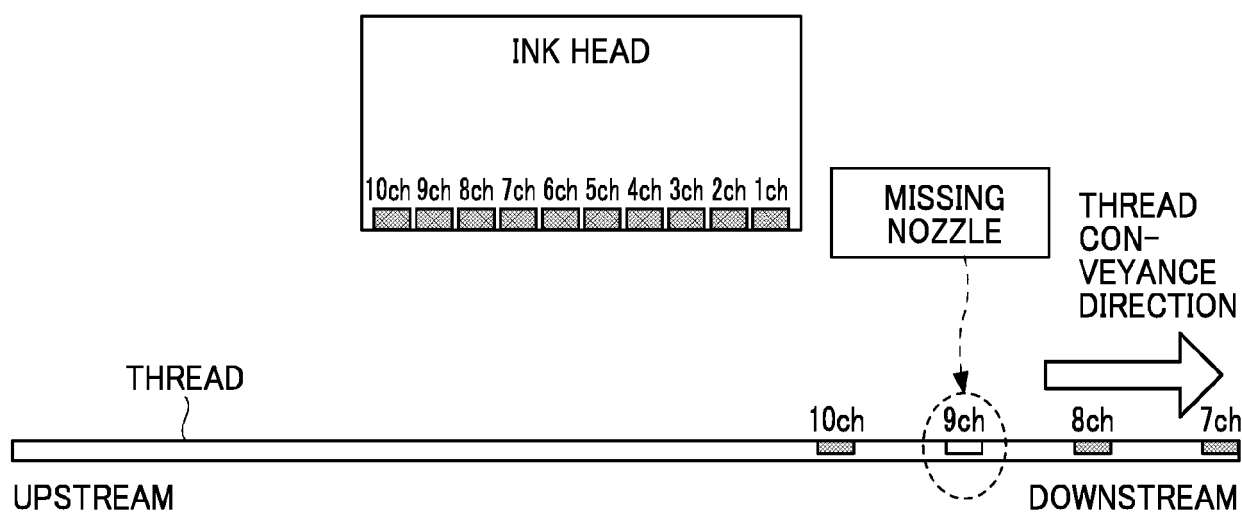


FIG. 8A

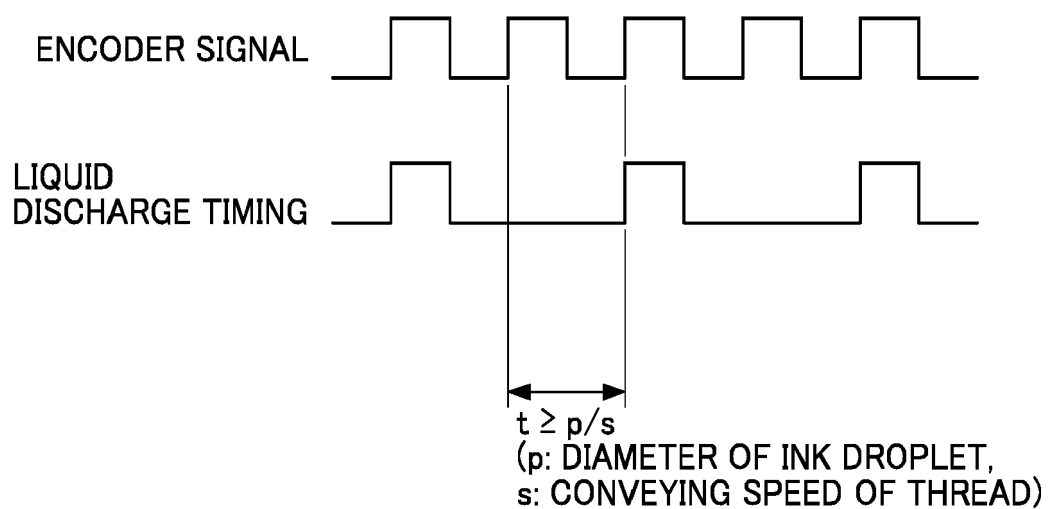


FIG. 8B

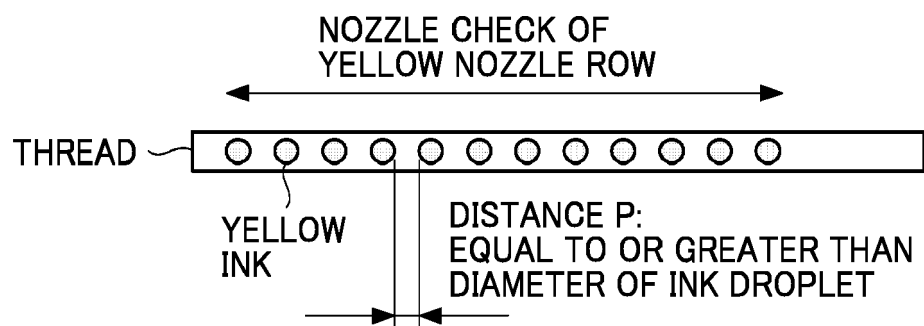


FIG. 9

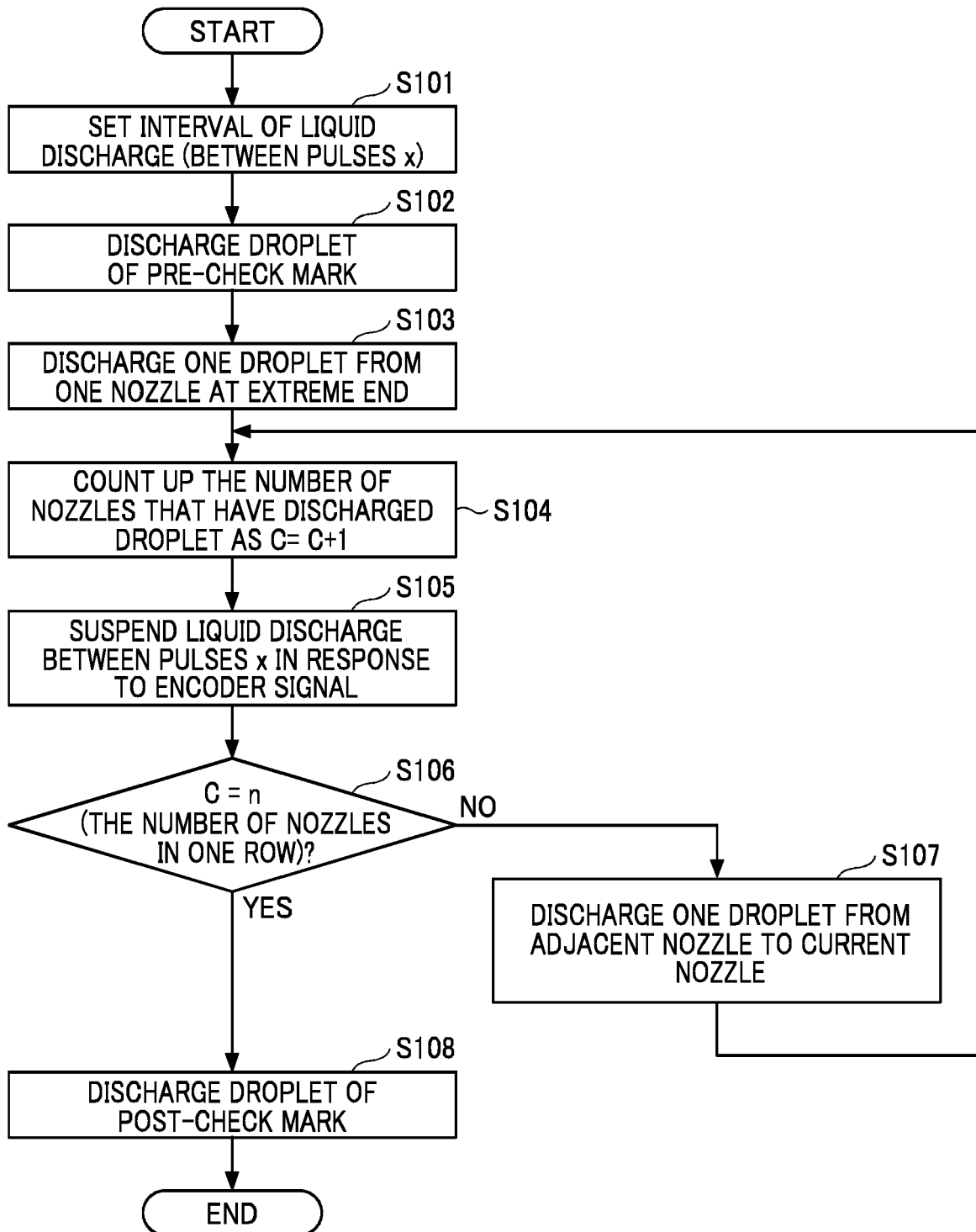


FIG. 10

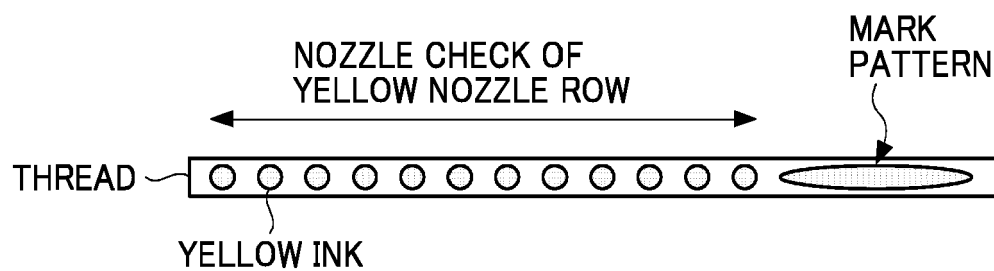


FIG. 11

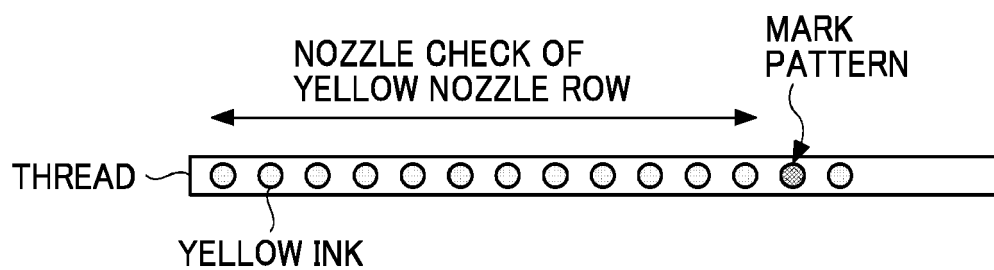


FIG. 12

COLOR FOR NOZZLE CHECK	COLOR FOR MARK PATTERN
C (CYAN)	M (MAGENTA)
M (MAGENTA)	C (CYAN)
Y (YELLOW)	K (BLACK)
K (BLACK)	M (MAGENTA)

FIG. 13

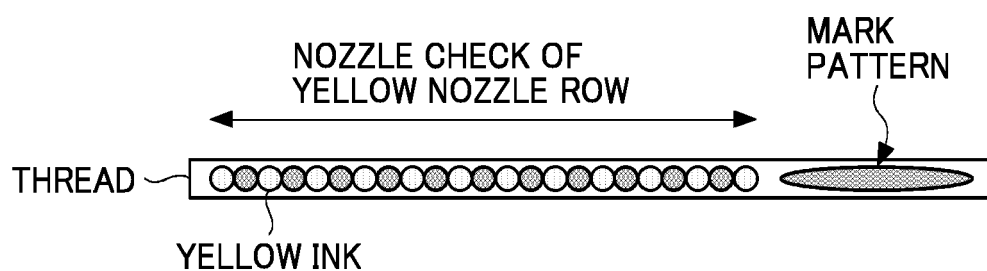


FIG. 14A

<CONTROL EXAMPLE 2>

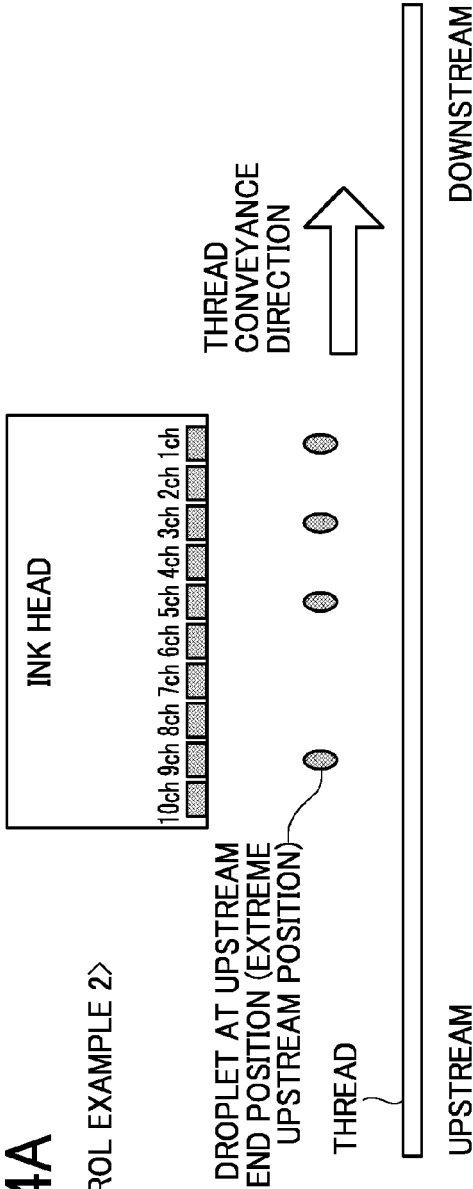


FIG. 14B

THREAD CONVEYANCE DIRECTION

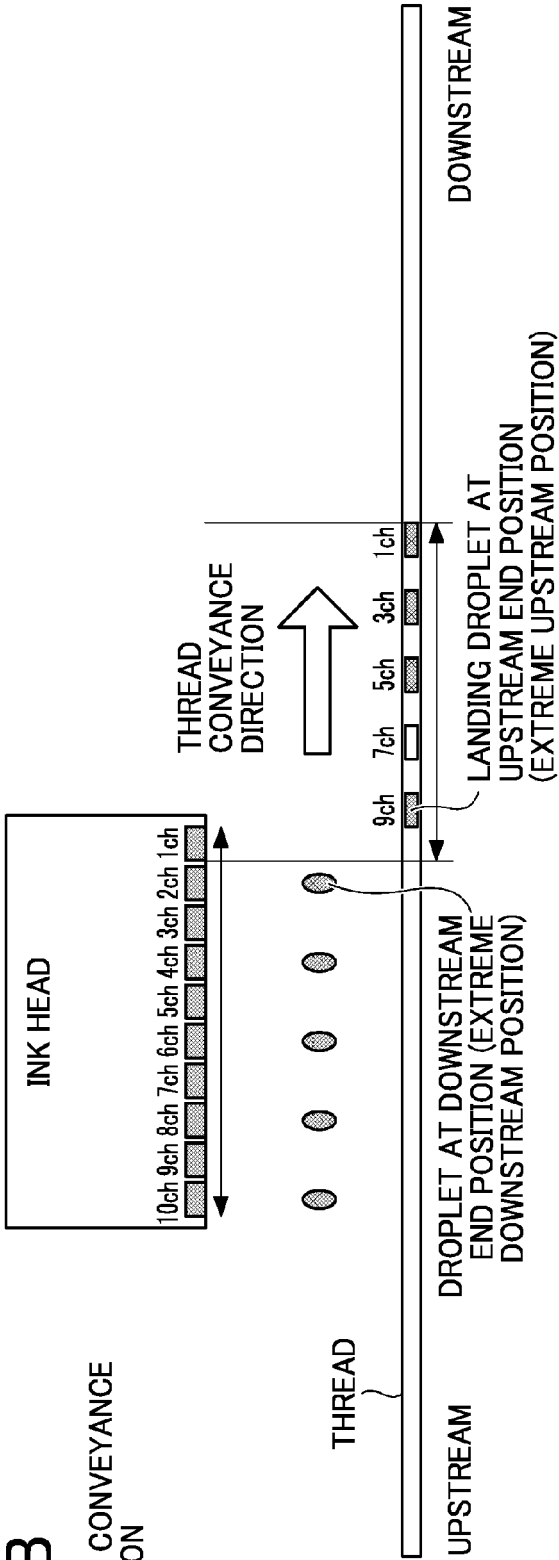


FIG. 15

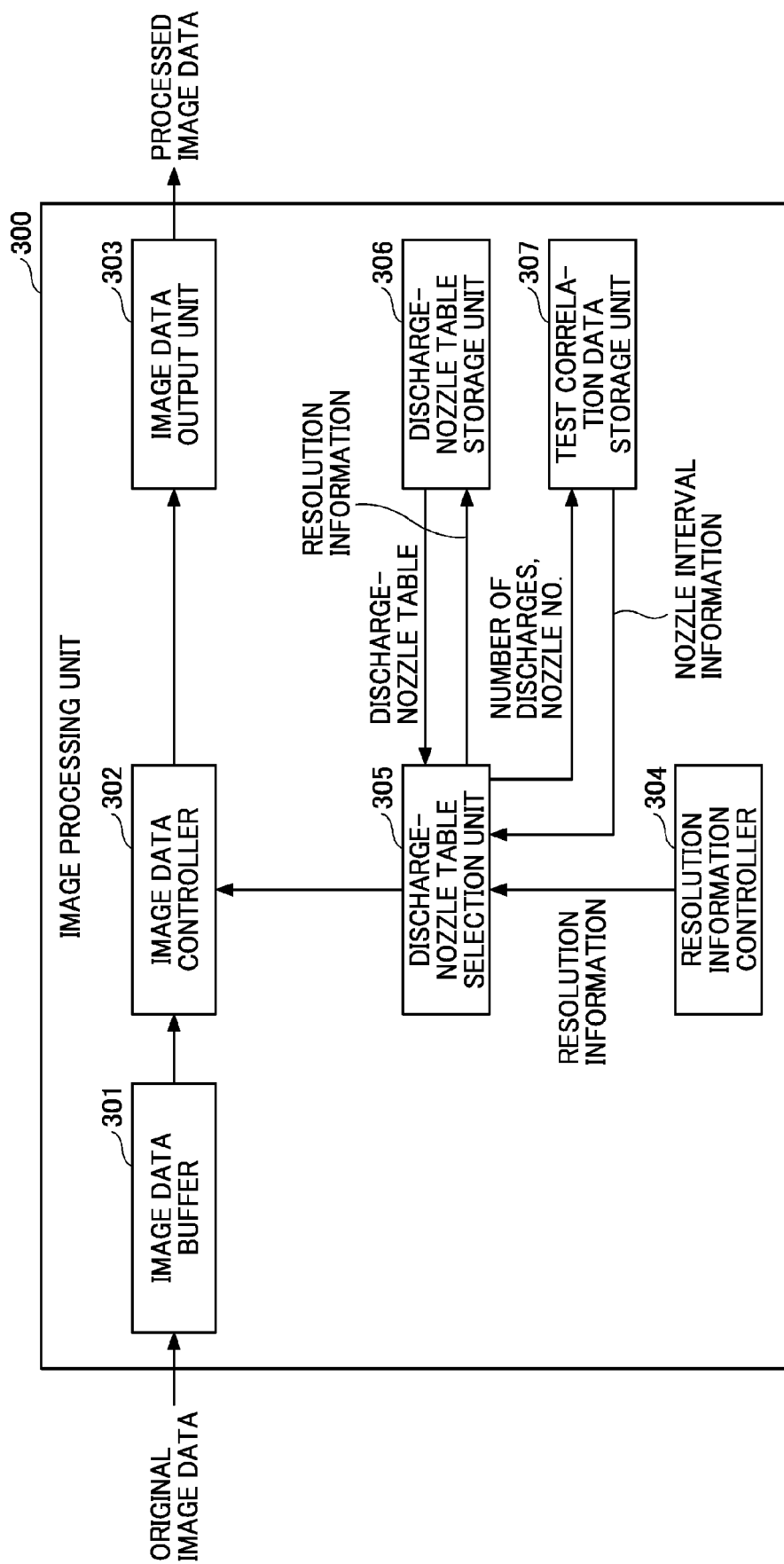


FIG. 16A

	NOZZLE INTERVAL AT SIMULTANEOUS DISCHARGES _m	NUMBER OF DROPLETS PER DISCHARGE _a	TOTAL OF DISCHARGES _b
COMPARATIVE EXAMPLE	0	10	1
CONTROL EXAMPLE 2	1	5	2
	2	3 OR 4	3
	3	2 OR 3	4
	4	2	5
CONTROL EXAMPLE 1	NOT SPECIFIED	1	10

FIG. 16B

NOZZLE INTERVAL AT SIMULTANEOUS DISCHARGES _m	NOZZLE NOS. FOR FIRST DISCHARGE	CONVEYANCE DISTANCE BETWEEN DISCHARGES _T	NOZZLE NOS. FOR SECOND DISCHARGE	CONVEYANCE DISTANCE BETWEEN DISCHARGES _T	NOZZLE NOS. FOR THIRD DISCHARGE	CONVEYANCE DISTANCE BETWEEN DISCHARGES _T	NOZZLE NOS. FOR FOURTH DISCHARGE	CONVEYANCE DISTANCE BETWEEN DISCHARGES _T	NOZZLE NOS. FOR FIFTH DISCHARGE
1	1,3,5,7,9ch	9/10 NOZZLE ROW	2,4,6,8,10ch						
2	1,4,7,10ch	11/10 NOZZLE ROW	2,5,8ch	8/10 NOZZLE ROW	3,6,9ch				
3	1,5,9ch	11/10 NOZZLE ROW	2,6,10ch	11/10 NOZZLE ROW	3,7ch	7/10 NOZZLE ROW	4,8ch		
4	1,6ch	9/10 NOZZLE ROW	2,7ch	9/10 NOZZLE ROW	3,8ch	9/10 NOZZLE ROW	4,9ch	9/10 NOZZLE ROW	5,10ch

FIG. 17

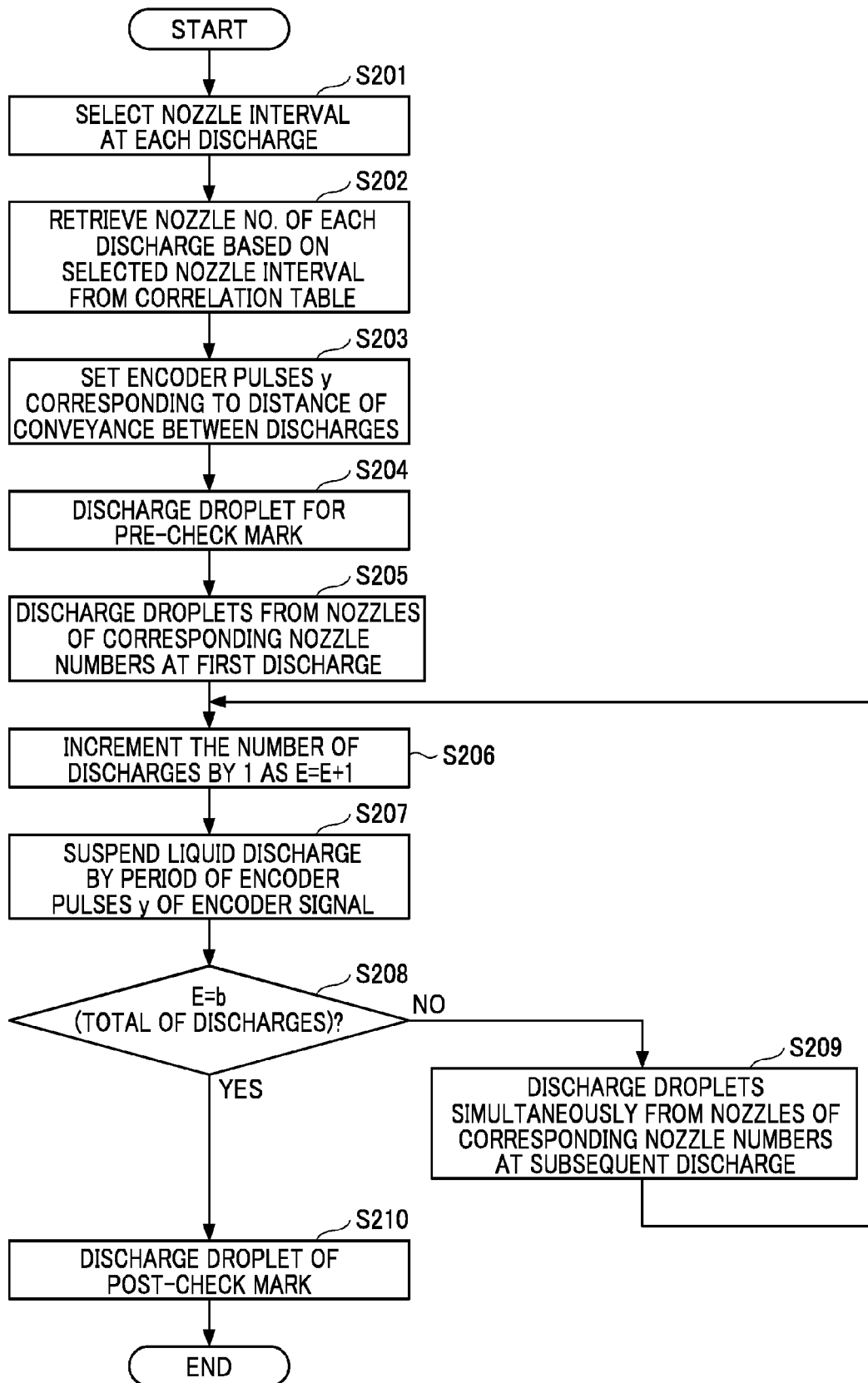


FIG. 18A

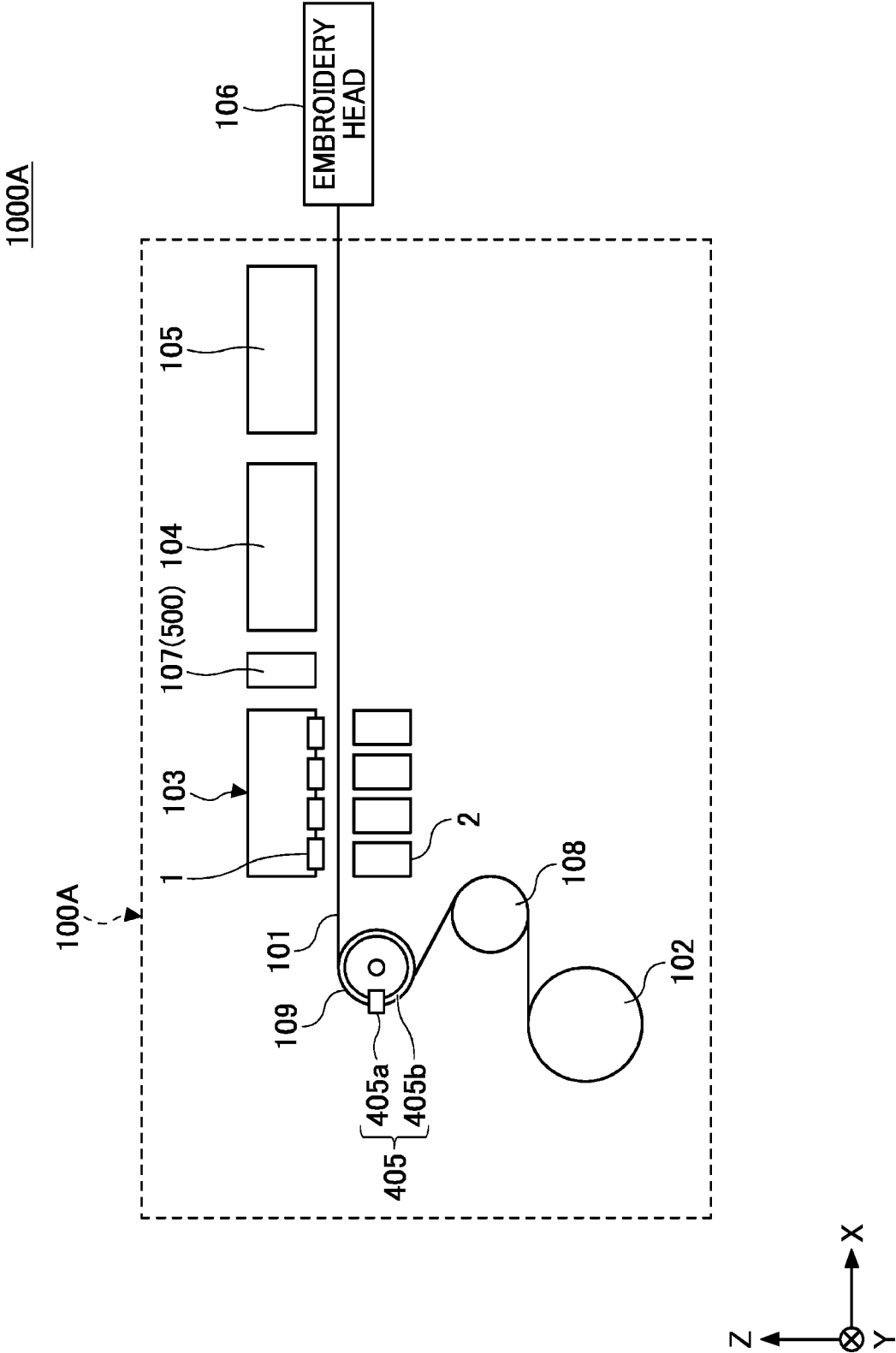
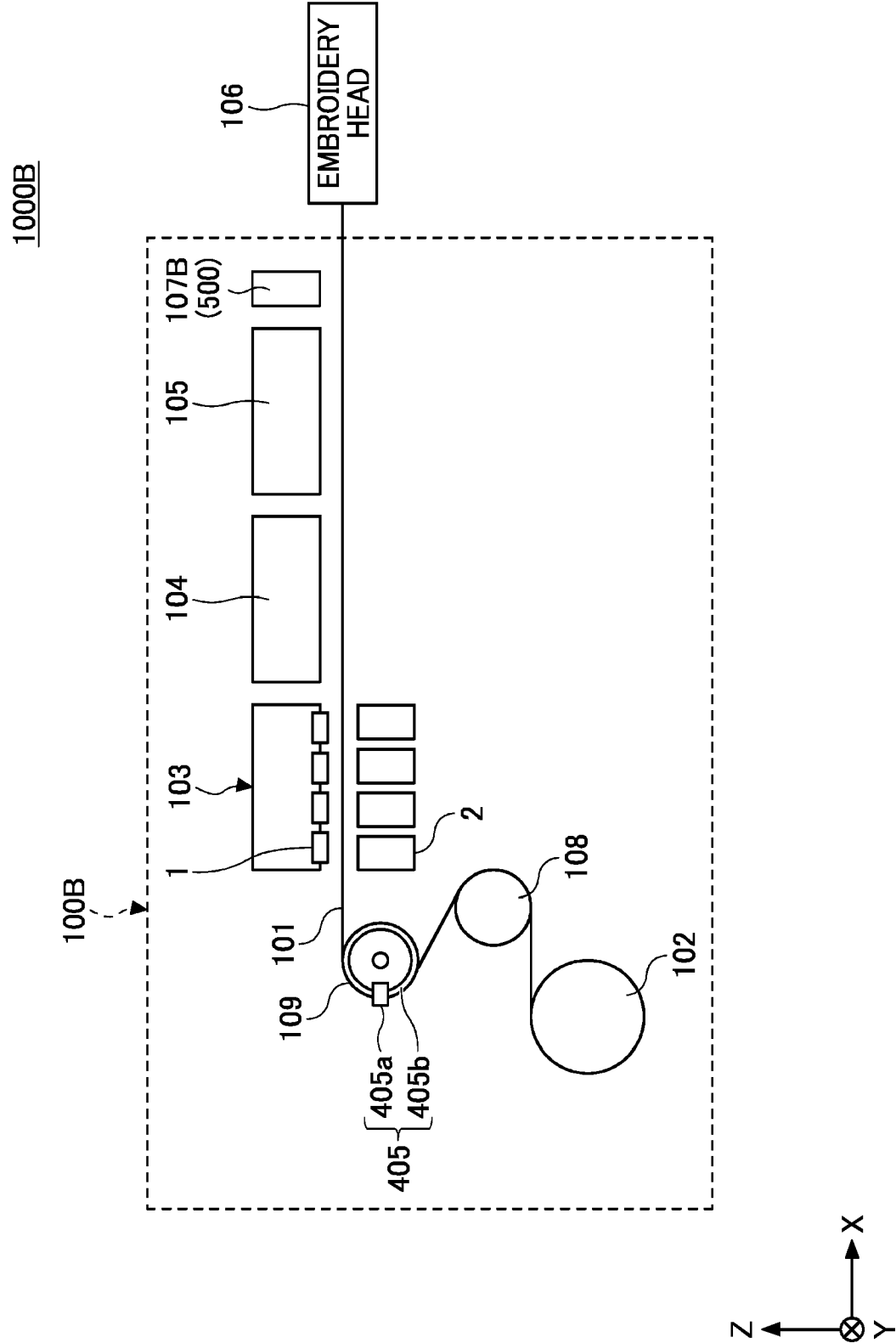


FIG. 18B



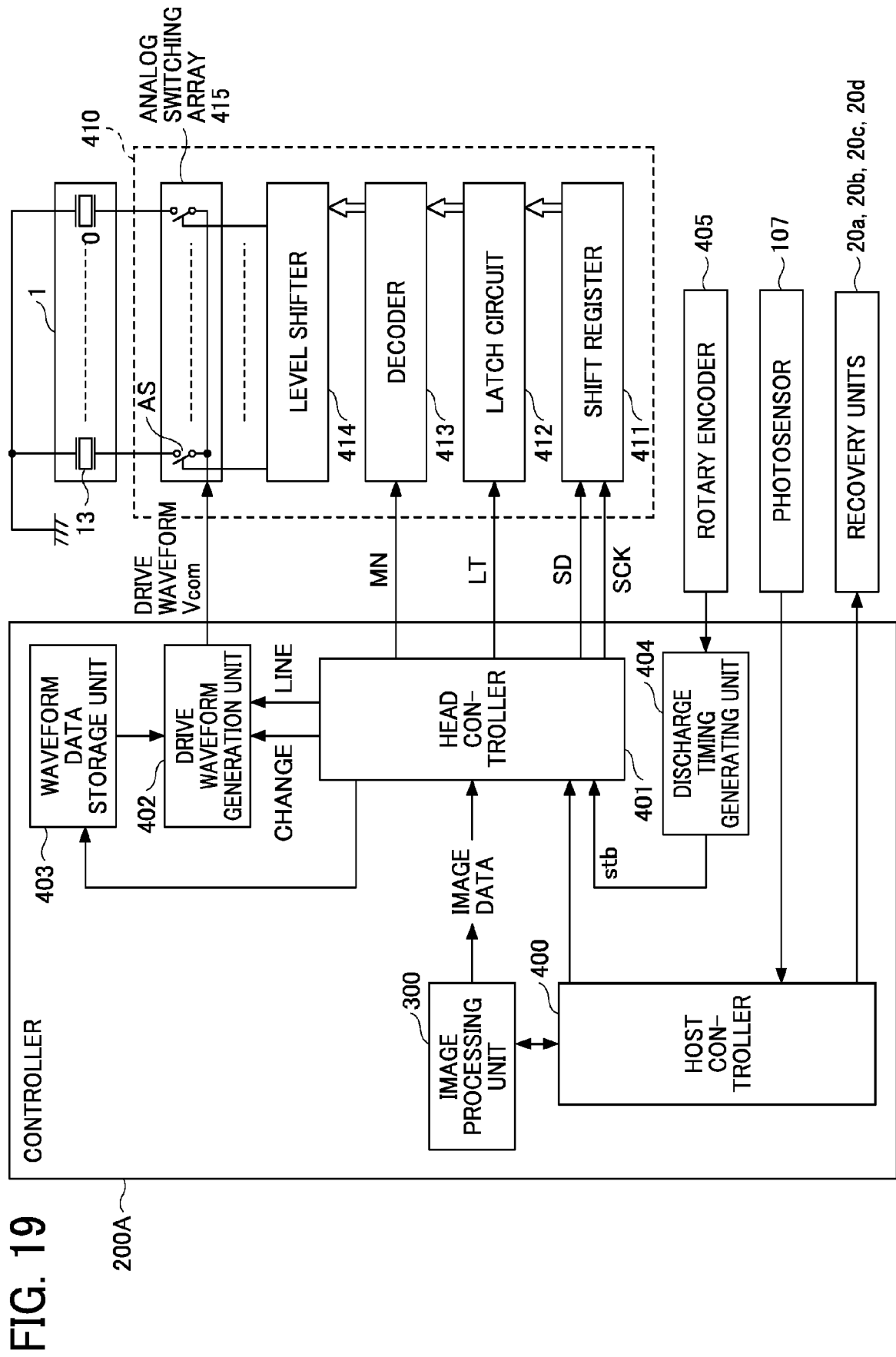


FIG. 20

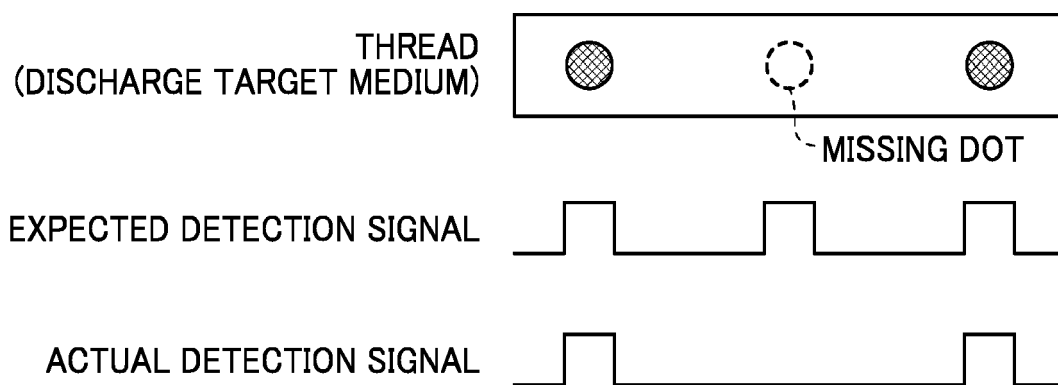


FIG. 21

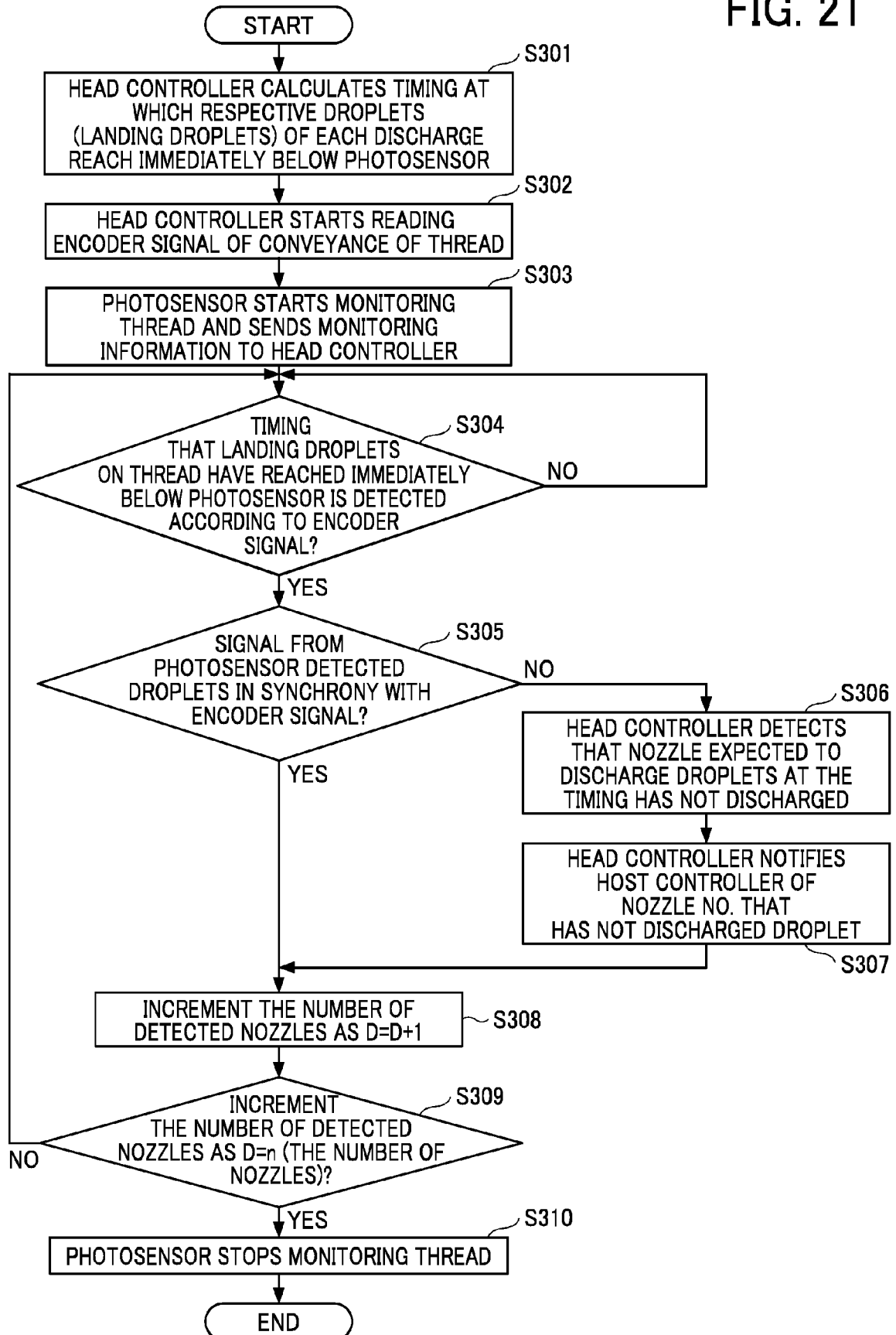


FIG. 22

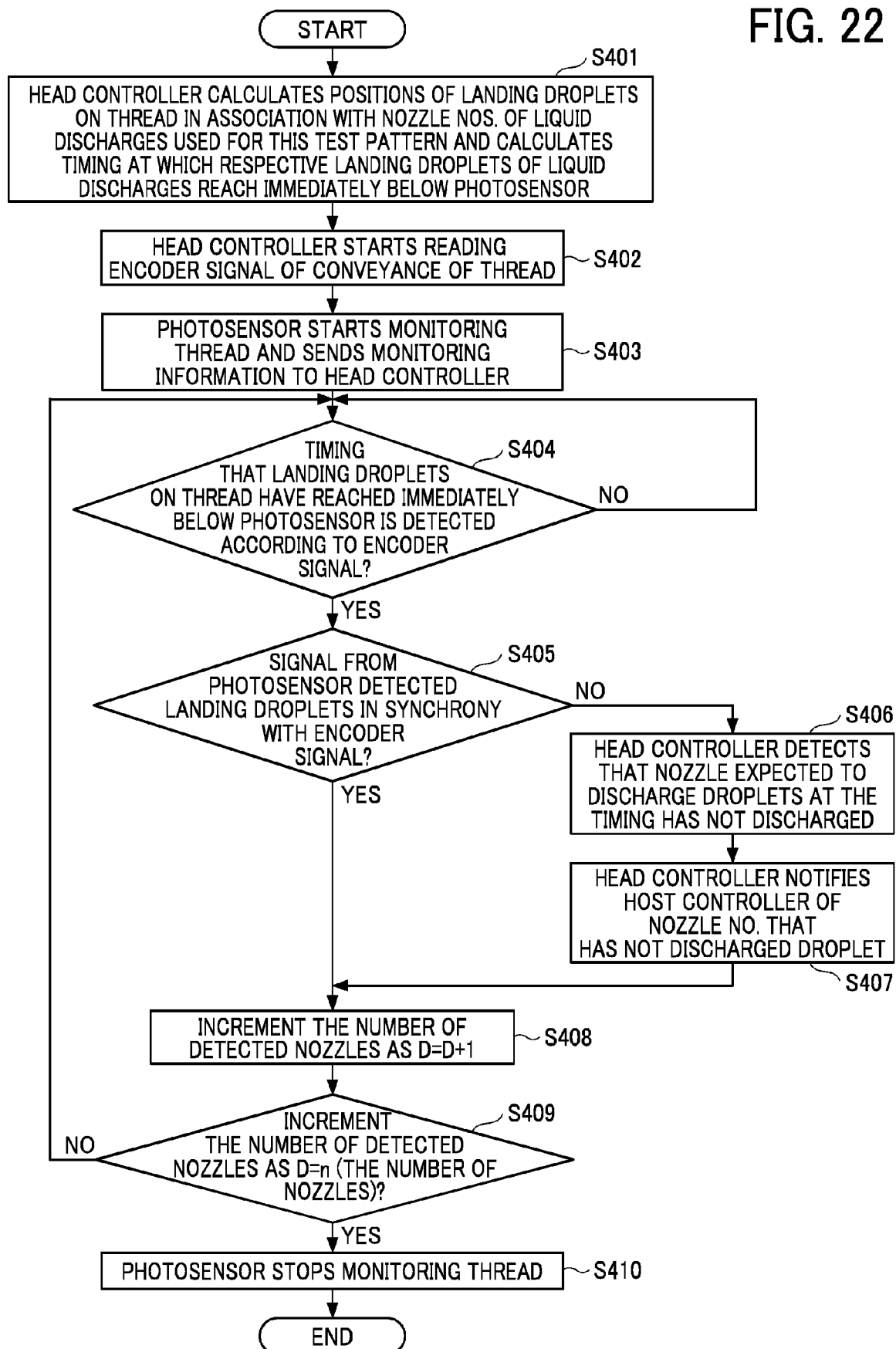


FIG. 23A FIG. 23 FIG. 23A FIG. 23B

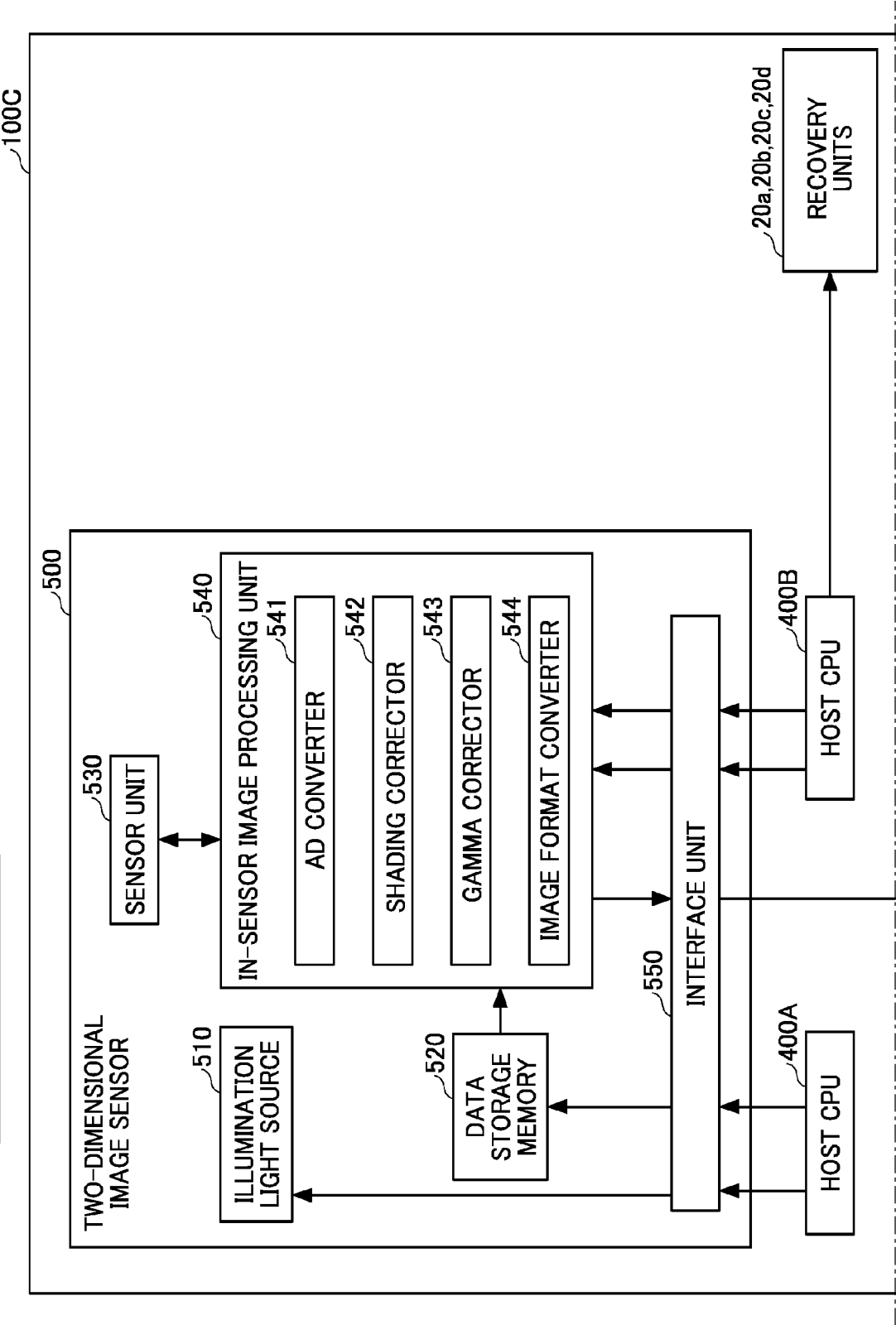


FIG. 23B

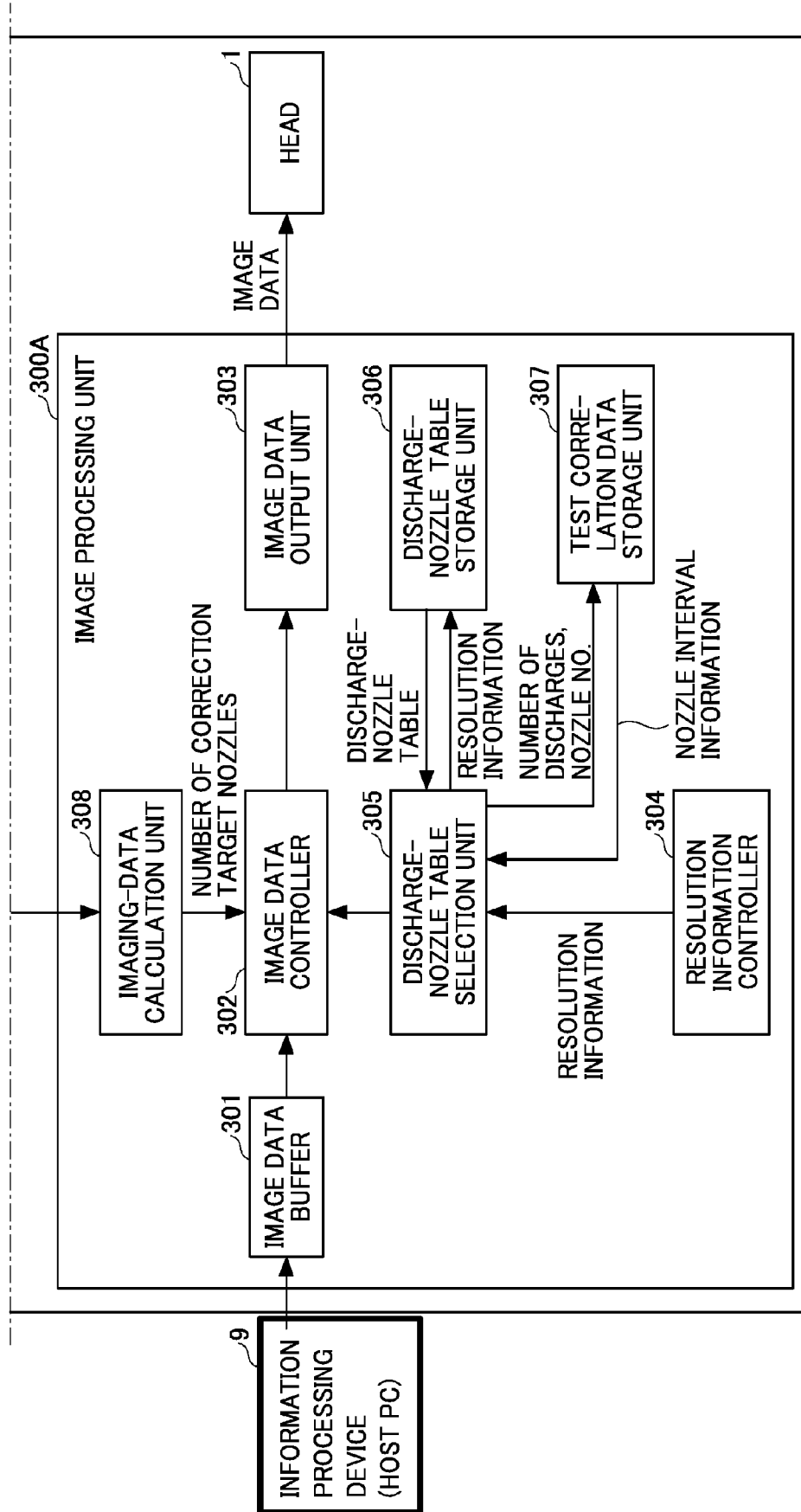


FIG. 24

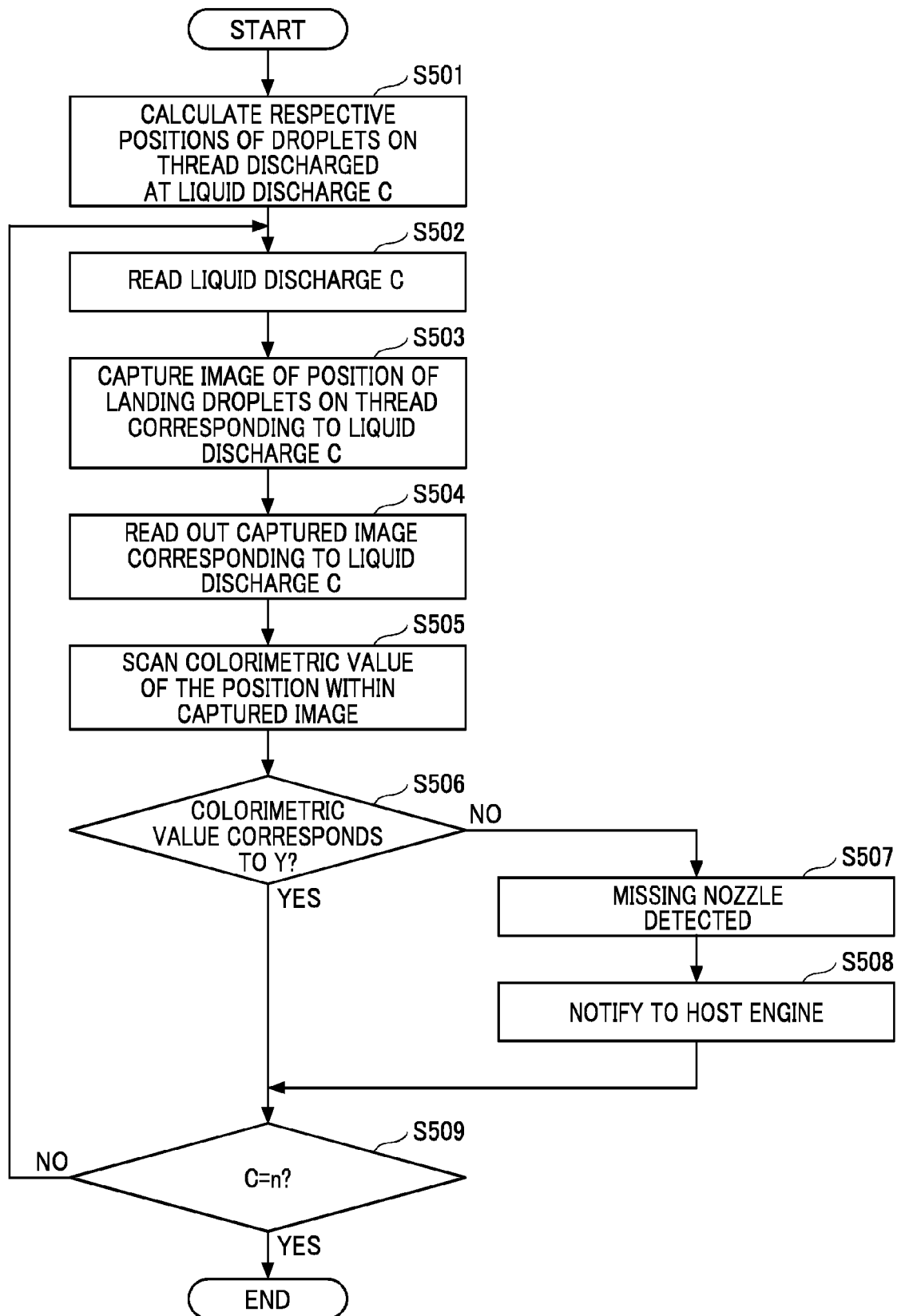
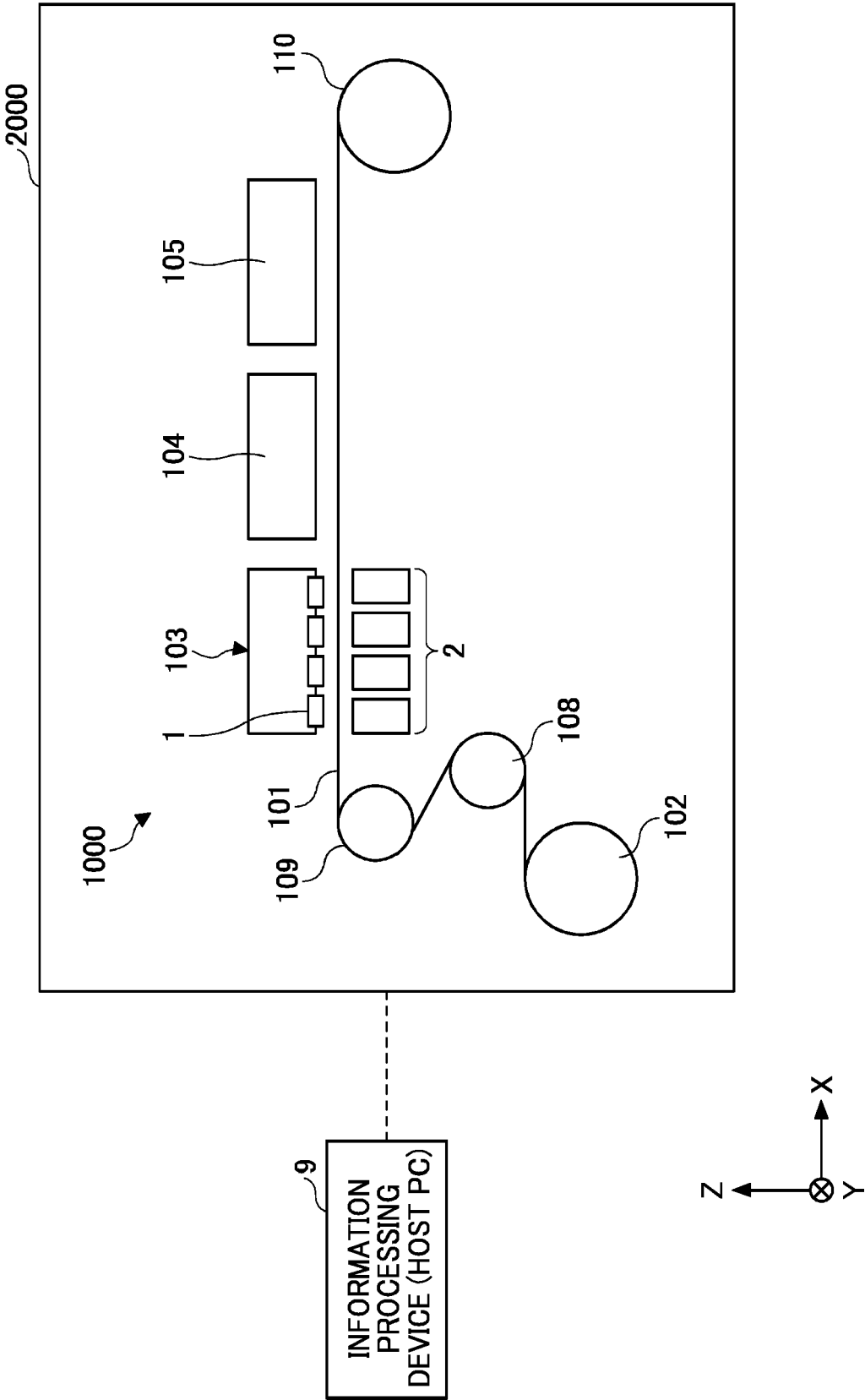


FIG. 25





EUROPEAN SEARCH REPORT

Application Number
EP 20 20 9183

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X	IT 2017 0004 6089 A1 (TECHNORES S R L) 4 November 2018 (2018-11-04)	13	INV. B41J3/407
Y	* paragraphs [0022], [0024], [0025], [0045], [0046]; figures 1, 2 *	1-12	D06B11/00 D06P5/30 B41J2/165 B41J29/393
Y	US 2017/066262 A1 (KIMURA YOSUKE [JP]) 9 March 2017 (2017-03-09) * figures 8, 9B *	1-12	
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			B41J D06Q D06B D06P
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 10 March 2021	Examiner 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			

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