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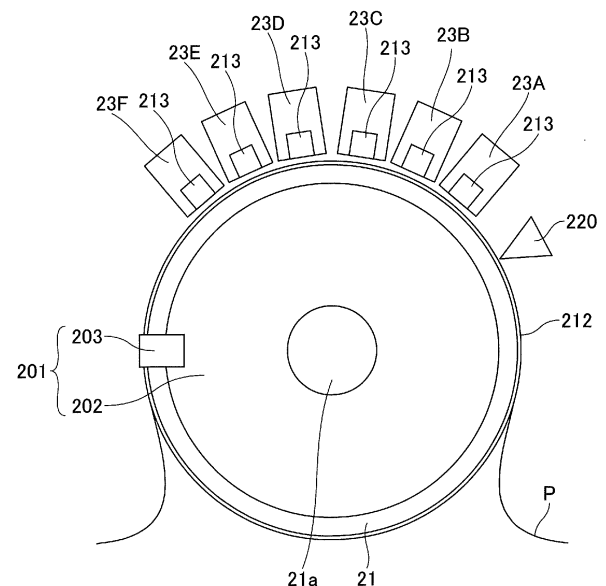
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(54) **LIQUID DISCHARGE APPARATUS AND IMAGE FORMING APPARATUS**

(57) A liquid discharge apparatus includes a rotating member (21) that conveys a sheet material (P) by holding the sheet material on a peripheral surface of the rotating member, a liquid discharge device (23A to 23F) that discharges liquid on the sheet material, a sheet material position detecting unit (220) that detects a position of the sheet material, a first signal output unit (201) that outputs a first signal in accordance with a rotation amount of the rotating member, a second signal output unit that outputs a second signal that is correlated with a movement amount of the sheet material on the peripheral surface of the rotating member, a correction data storage unit that stores correction data, which corrects the second signal, obtained based on the first signal and the second signal, and a discharge timing generating unit that generates a discharge timing of the liquid discharge device based on the second signal and the correction data.

FIG.3



Description**BACKGROUND OF THE INVENTION**

1. Field of the Invention

[0001] The present invention relates to a liquid discharge apparatus and an image forming apparatus.

2. Description of the Related Art

[0002] As a liquid discharge apparatus, an apparatus that discharges liquid on a sheet material and forms an image by a liquid discharge device with holding a sheet material on a rotating member such as a conveyor drum and conveying the sheet material, is known.

[0003] In a liquid discharge apparatus that controls a discharge timing based on an output of a sensor such as an encoder to read a scale attached on a peripheral surface of a rotating member, a technique to correct a detection error of a sheet material position caused by eccentricity of a rotating member or the like is disclosed (e.g., Patent Document 1).

[0004] However, a scale cycle (or a pitch) attached on a peripheral surface of a rotating member may include an accumulated error, and an attachment error may be caused when a scale is attached to a peripheral surface of a rotating member. In the technology of Patent Document 1, there is a case that a detecting error of a sheet material position cannot be appropriately corrected because of the accumulated error or the attachment error.

[0005] The present invention is made in view of the above point, and aims to appropriately correct a detecting error of a sheet material position.

SUMMARY OF THE INVENTION

[0006] According to an aspect of the disclosure, a liquid discharge apparatus includes a rotating member configured to convey a sheet material by holding the sheet material on a peripheral surface of the rotating member, a liquid discharge device configured to discharge liquid on the sheet material, a sheet material position detecting unit configured to detect a position of the sheet material, a first signal output unit configured to output a first signal in accordance with a rotation amount of the rotating member, a second signal output unit configured to output a second signal that is correlated with a movement amount of the sheet material on the peripheral surface of the rotating member, a correction data storage unit configured to store correction data, which corrects the second signal, obtained based on the first signal and the second signal, and a discharge timing generating unit configured to generate a discharge timing of the liquid discharge device based on the second signal and the correction data.

[0007] According to an aspect of the embodiment, a detecting error of a sheet material position can be appropriately corrected.

BRIEF DESCRIPTION OF THE DRAWINGS**[0008]**

Fig. 1 is a drawing illustrating an example of a configuration of an image forming apparatus according to an embodiment;

Fig. 2 is a plan view illustrating an example of a configuration of a liquid discharge unit according to an embodiment;

Fig. 3 is a front view illustrating an example of a configuration around a conveying drum according to an embodiment;

Fig. 4 is a plan view illustrating an example of a configuration around a conveying drum according to an embodiment;

Fig. 5 is a block diagram illustrating an example of a hardware configuration of an image forming apparatus according to an embodiment;

Fig. 6 is a block diagram illustrating an example of a functional configuration of an image forming apparatus according to a first embodiment;

Fig. 7 is a graph illustrating an example of an obtaining method of correction data according to an embodiment;

Fig. 8 is a flowchart illustrating an example of a process performed by a correction data obtaining unit according to an embodiment;

Fig. 9 is a timing chart illustrating an example of a discharge timing generation method according to an embodiment;

Fig. 10 is a flowchart illustrating an example of an image forming process of an image forming apparatus according to an embodiment; and

Fig. 11 is a block diagram illustrating an example of a functional configuration of an image forming apparatus according to a second embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0009] Embodiments of the present invention are described below with reference to the accompanying drawings. The same reference number is assigned to the same component throughout the drawings, and repeated descriptions of the same component may be omitted.

[0010] In the description of embodiments, the terms "image formation", "recording", "printing", "shaping", and the like are all used synonymously.

[0011] Also in the embodiments, "an apparatus that discharges liquid" is an apparatus that includes a liquid discharge head or a liquid discharge unit, and discharges liquid by driving the liquid discharge head. An apparatus that discharges liquid is synonymous with a liquid discharge apparatus.

[0012] "The apparatus that discharges liquid" may include a means for feeding, conveying, and paper ejection of a material to which liquid can adhere, and in addition, may include a pre-processing apparatus and a post-

processing apparatus.

[0013] For example, "the apparatus that discharges liquid" may be an image forming apparatus that is an apparatus discharging liquid such as ink to form an image on paper.

[0014] The term "a material to which liquid can adhere" described above indicates a material to which liquid can adhere at least temporarily such as a material to which liquid adhered and is fixed, and a material into which liquid adhered and permeated.

[0015] "The liquid" is not particularly limited as long as the liquid has sufficient viscosity and surface tension to be discharged from a head, but viscosity is preferably 30 Pa·s or less in normal temperature and normal pressure or in a condition caused by heating or cooling. More specifically, "the liquid" is a solution, a suspension, or an emulsion including a solvent such as water and an organic solvent, a colorant such as a dye and a pigment, a functional material such as a polymerizable compound, a resin, and a surfactant, a biocompatible material, such as DNA, amino acid, protein, and calcium, an edible material, such as a natural colorant, and the like, and these can be used, for example, for inkjet ink, surface treatment liquid, liquid for forming components of an electronic element and a light-emitting element, a resist pattern of an electronic circuit, and a material solution for three-dimensional fabrication.

[0016] "An apparatus that discharges liquid" may be an apparatus in which a liquid discharge head and a material to which liquid can adhere move relatively, but is not limited to such an apparatus. For example, a serial head apparatus that moves a liquid discharge head or a line head apparatus that does not move a liquid discharge head are included.

[0017] "The liquid discharge unit" is a unit in which a functional part and a mechanism are integrated with a liquid discharge head and is an assembly of parts relating to liquid discharge. For example, "the liquid discharge unit" includes a unit in which at least one structure of a head tank, a carriage, a supply mechanism, a maintenance and restore mechanism, and a main scanning moving mechanism, is integrated with a liquid discharge head.

[0018] Here, the term "integrated" includes, for example, a state in which a liquid discharge head, a functional part, a mechanism are fixed to each other by fastening, bonding and engaging, and a state in which one of a liquid discharge head, a functional part, and a mechanism is held movably to other. Additionally, a liquid discharge head, a functional part, a mechanism may be configured to be removable.

[0019] As a liquid discharge unit, for example, a liquid discharge head and a head tank may be integrated. A liquid discharge head and a head tank may be integrated by connecting to each other through a tube for example. Here, a unit including a filter may be added between a liquid discharge head and a head tank of these liquid discharge units.

[0020] As a liquid discharge unit, a liquid discharge head and a carriage may be integrated.

[0021] As a liquid discharge unit, a liquid discharge head and a scanning moving mechanism may be integrated such that a liquid discharge head is movably held by a guide constituting a part of a scanning moving mechanism. Additionally, a liquid discharge head, a carriage, and a main scanning moving structure may be integrated.

[0022] As a liquid discharge unit, a liquid discharge head, a carriage, and a maintenance and restore mechanism may be integrated such that a cap component, which is a part of a maintenance and restore mechanism, is fixed to a carriage to which a liquid discharge head is attached

[0023] As a liquid discharge unit, a liquid discharge head and a supply mechanism are integrated by connecting a tube to a liquid discharge head to which a head tank or a flow path part is attached. Liquid in a liquid storage source is provided to a liquid discharge head by the tube.

[0024] A main scanning moving mechanism includes a single guide component. A supply mechanism includes a single tube and a single load unit.

[0025] "The liquid discharge head" is a functional part that discharges and injects liquid from a nozzle.

[0026] An energy generation source to discharge liquid includes a piezoelectric actuator (a laminated piezoelectric element or a thin-film piezoelectric element), a thermal actuator that uses a thermoelectric conversion element such as a heating resistor, and an electrostatic actuator including a diaphragm and opposed electrodes.

[0027] In the following, an embodiment will be described by an example that a material to which liquid can adhere is a sheet material, and an apparatus that discharges liquid is an on-demand inkjet image forming apparatus with line scanning.

[First embodiment]

<A configuration of an image forming apparatus according to a first embodiment>

[0028] Fig. 1 is a drawing illustrating an example of a configuration of an image forming apparatus according to an embodiment. Fig. 2 is a plan view illustrating an example of a configuration of a liquid discharge unit 23 in Fig. 1.

[0029] An image forming apparatus 1 includes a feeder 10, an image forming unit 20, a drying unit 30 and an ejecting unit 40. The image forming apparatus 1 forms an image as required by applying liquid on a sheet material P that is a sheet material fed from the feeder 10 at the image forming unit 20, and ejects the sheet material P to the ejecting unit 40 after drying liquid attached to the sheet material P at the drying unit 30.

[0030] The feeder 10 includes a feeding tray 11 in which multiple sheet materials P are loaded, a feeding unit 12 that separately transfers the sheet material P from

the feeding tray 11 one by one, and a pair of registration rollers 13 that conveys the sheet material P to the image forming unit 20.

[0031] For the feeding unit 12, any feeding device such as a device using a roller or a round bar, and a device using air suction, can be used. The sheet material P fed from the feeding tray 11 by the feeding unit 12 is conveyed to the image forming unit 20 by the pair of registration rollers 13 being driven at a predetermined timing after a front edge of the sheet material P arrives at the pair of registration rollers 13.

[0032] The image forming unit 20 includes a conveying drum 21 that is an example of a rotating member as a conveyor conveying the sheet material P held on a peripheral surface, and a liquid discharge device 22 that discharges liquid to the sheet material P held by the conveying drum 21.

[0033] In addition, the image forming unit 20 includes a transfer cylinder 24 that receives and transfers the conveyed sheet material P to the conveying drum 21, and a transfer cylinder 25 that receives and transfers the sheet material P conveyed by the conveying drum 21 to the drying unit 30.

[0034] The front edge of the sheet material P conveyed from the feeder 10 to the image forming unit 20 is held by a sheet gripper provided on a surface of the transfer cylinder 24, and the sheet material P is conveyed by rotation of the transfer cylinder 24. The sheet material P conveyed by the transfer cylinder 24 is transferred to the conveying drum 21 at a position facing the conveying drum 21.

[0035] A sheet gripper is also provided on a surface of the conveying drum 21, and the front edge of the sheet material P is held by the sheet gripper. On a surface of the conveying drum 21, multiple suction holes are formed dispersedly. A suction air flow directed from the suction holes of the conveying drum 21 to the inside is caused by a suction device 26 as a suction unit.

[0036] The sheet material P transferred from the transfer cylinder 24 to the conveying drum 21 is held at the front edge by the sheet gripper, and is suctioned on the conveying drum 21 by a suction air flow of the suction device 26, and is conveyed with rotation of the conveying drum 21.

[0037] The liquid discharge device 22 includes a liquid discharge unit 23 (23A to 23F). For example, a liquid discharge unit 23A discharges cyan (C) liquid, a liquid discharge unit 23B discharges magenta (M) liquid, a liquid discharge unit 23C discharges yellow (Y) liquid, and a liquid discharge unit 23D discharges black (K) liquid. In addition, liquid discharge units 23E and 23F are used to discharge any of Y, M, C, and K, or discharge special liquid such as white and gold (or silver). Furthermore, a liquid discharge unit that discharges treatment liquid such as surface coating liquid, can be provided.

[0038] As illustrated in Fig. 2, the liquid discharge unit 23 is, for example, a full line head in which multiple liquid discharge heads (which will be hereinafter simply re-

ferred to as the heads) 100, each including a nozzle array 101 in which multiple nozzles are arranged, are disposed on a base member 52.

[0039] In each liquid discharge unit 23 of the liquid discharge device 22, each discharge is controlled by a driving signal in accordance with printing information. When the sheet material P held by the conveying drum is passed through an area facing the liquid discharge device 22, the liquid discharge unit 23 discharges liquid of each color, and forms an image on the sheet material P in accordance with image data.

[0040] The drying unit 30 includes a drying mechanism part 31 for drying liquid attached on the sheet material P at the image forming unit 20, and a suction conveying mechanism part 32 that conveys in a state that the sheet material P conveyed from the image forming unit 20 is suctioned (i.e., conveys with suctioning).

[0041] After the sheet material P conveyed from the image forming unit 20 is received by the suction conveying mechanism part 32, the sheet material P is conveyed to the ejecting unit 40 with being passed through a drying mechanism part 31. When the sheet material P is passed through the drying mechanism part 31, drying is performed to liquid on the sheet material P. This evaporates a liquid component such as water in the liquid, and fixes a colorant included in the liquid on the sheet material P, and suppresses a curl of the sheet material P.

[0042] The ejecting unit 40 includes an ejecting tray 41 in which multiple sheet materials P are stacked. The sheet materials P conveyed from the drying unit 30 are sequentially stacked and held in the ejecting tray 41. In the image forming apparatus 1, a pre-processing unit that performs pre-processing to the sheet material P can be disposed on an upstream side of the image forming unit 20, and a post-processing unit that performs post-processing to the sheet material P to which liquid adheres can be disposed between the drying unit 30 and the ejecting unit 40.

[0043] The pre-processing unit may be a unit of a pre-applying process that applies treatment liquid on the sheet material P in order to suppress a blur by reacting with the liquid, for example. The post-processing unit may be a unit for a sheet inverting and conveying process for printing to both sides of the sheet material P by inverting a sheet printed by the image forming unit 20 and transferring the sheet to the image forming unit 20 again, and a unit for a process to fasten multiple sheets, for example.

<Configuration of a first signal output unit and a second signal output unit>

[0044] Next, a part with respect to detection for controlling a discharge timing in the present embodiment will be described with reference to Fig. 3 and Fig. 4. Fig. 3 is a front view illustrating an example of a configuration around a conveying drum according to the present embodiment. Fig. 4 is a plan view illustrating the same example. For simplicity, one discharge unit is illustrated in

Fig. 4.

[0045] An encoder wheel 202 is provided to a shaft 21a of the conveying drum 21, and an encoder sensor 203 for reading the encoder wheel 202 is disposed. The encoder wheel 202 and the encoder sensor 203 are included in a first encoder 201 that is an example of the first signal output unit. The first encoder 201 is a rotary encoder, and outputs a first signal (i.e., an output pulse) in accordance with a rotation amount (i.e. rotation-drive amount) of the conveying drum 21.

[0046] An encoder scale 212 is attached on a peripheral surface of the conveying drum 21, and an encoder sensor 213 to read the encoder scale 212 is disposed. The encoder scale 212 and the encoder sensor 213 are included in a second encoder 211 that is an example of the second signal output unit. The second encoder 211 is a linear encoder, and outputs a second signal (i.e., an output pulse) in accordance with a movement amount on the peripheral surface of the conveying drum 21. The second signal is a signal that is correlated with the movement amount of the sheet material P on the peripheral surface of the conveying drum 21.

[0047] A rotary encoder and a linear encoder include a scale as a ruler, and a detector that detects position information, for example. A detection signal of the scale by the detector is output as an output pulse. In the following, an interval of the scale will be referred to as a scale cycle or a pitch. A pulse cycle of the output pulse corresponds to a scale cycle, and will be referred to as an output pulse cycle in the following.

[0048] Here, the encoder sensor 213 included in the second encoder 211 is disposed near each of multiple liquid discharge units 23. In the present embodiment, the encoder sensor 213 is attached to the base member 52 of the liquid discharge unit 23. Thus, the encoder sensor 213 of each liquid discharge unit 23 and the encoder scale 212 of the conveying drum 21 are included in the second encoder 211.

[0049] Furthermore, a sheet material position sensor 220, which is a sheet material position detecting means to detect a front edge of the sheet material P, is disposed on an upstream side in a conveying direction from the liquid discharge unit 23A that is at the most upstream in a conveying direction.

[0050] In the present embodiment, the sheet material position sensor 220 detects the front edge of the sheet material P, but can be configured to read a mark (e.g., a registration mark) placed on the sheet material P. This can support to use not only a cut sheet material but also a continuous medium such as continuous form paper.

<Hardware configuration of the image forming apparatus according to the first embodiment>

[0051] Fig. 5 is a block diagram illustrating an example of a hardware configuration of the image forming apparatus according to the present embodiment. As illustrated in Fig. 5, the image forming apparatus 1 includes a CPU

(Central Processing Unit) 301, a ROM (Read Only Memory) 302, a RAM (Random Access Memory) 303, an NVRAM (Non-Volatile Random Access Memory) 304, an external device connecting I/F (interface) 308, a network I/F 309, an operating panel 330, and a bus line 310. In addition, the image forming apparatus 1 includes a conveying driver 312, a liquid discharge unit driver 322, a drying driver 332, and a sensor I/F 342. The conveying driver 312 is electrically connected to the feeder 10, the conveying drum 21 and the ejecting unit 40, the liquid discharge unit driver 322 is electrically connected to the liquid discharge unit 23, the drying driver 332 is electrically connected to the drying unit 30, and the sensor I/F 342 is electrically connected to the first encoder 201, the second encoder 211, and the sheet material position sensor 220.

[0052] Among these components, the CPU 301 controls an entire operation of the image forming apparatus 1. The ROM 302 stores, for example, a program used to drive the CPU 301 such as IPL. The RAM 303 is used as a work area of the CPU 301. The NVRAM 304 stores various data such as a program and accumulated error correction data, and maintains the various data while the image forming apparatus 1 is powered off. The external device connecting I/F 308 is coupled to an external device such as a PC (Personal Computer), and communicates a control signal or data to be printed with the external device.

[0053] The network I/F 309 is an interface for communicating data through a communication network such as the Internet. The bus line 310 is, for example, an address bus or a data bus for electrically connecting each component such as the CPU 301. The operating panel 330 displays a current setting and a selection screen for example, and includes a touch panel that accepts an input from an operator, and an alarm lamp, for example.

[0054] The conveying driver 312 is a driver that controls a roller or a motor driving a drum, included in the feeder 10, the conveying drum 21, the ejecting unit 40, and the like. The liquid discharge unit driver 322 is a driver that controls liquid discharge from the liquid discharge unit 23, and a drying driver 332 is a driver that controls an operation of the drying unit 30.

[0055] The sensor I/F 342 is an interface that sends and receives data or a signal among various sensors such as the first encoder 201, the second encoder 211, and the sheet material position sensor.

[0056] Functions of the conveying driver 312, the liquid discharge unit driver 322, the drying driver 332, and the sensor I/F 342 may be achieved by instructions of the CPU 301 in accordance with respective programs.

<Functional configuration of the image forming apparatus according to the first embodiment>

[0057] Next, a functional configuration of the image forming apparatus will be described with reference to Fig. 6.

[0058] Fig. 6 is a block diagram illustrating an example of a functional configuration of the image forming apparatus according to the present embodiment. As illustrated in Fig. 6, the image forming apparatus 1 includes a sheet material position detecting unit 110, a first signal output unit 111, a discharge start timing determining unit 112, and a second signal output unit 113. In addition, the image forming apparatus 1 includes a correction data obtaining unit 114, a correction data storage unit 115, a discharge timing generating unit 116, a discharge unit controller 117, and the liquid discharge device 22. Among these components, the correction data obtaining unit 114, the discharge start timing determining unit 112, and the discharge timing generating unit 116 are achieved by predetermined program execution of the CPU 301 in Fig. 5.

[0059] The sheet material position detecting unit 110 is implemented by the sheet material position sensor 220 for example, and detects the front edge of the sheet material P, and outputs a detection result to the discharge start timing determining unit 112.

[0060] The first signal output unit 111 is implemented by the first encoder 201 for example, and outputs an output pulse of the first encoder 201 to the discharge start timing determining unit 112 as a first signal.

[0061] The discharge start timing determining unit 112 starts counting the output pulse of the first signal input from the first signal output unit 111, when a detecting result input from the sheet material position detecting unit 110 indicates a state of detecting the front edge of the sheet material P. The discharge start timing determining unit 112 determines a timing when the number of counts reaches a predetermined number as a discharge start timing, and sends a signal indicating a discharge start timing to the discharge timing generating unit 116 and the discharge unit controller 117.

[0062] Overlapping accuracy of each color by the liquid discharge unit 23 can be controlled by determining a discharge start timing based on an output from the first signal output unit 111.

[0063] The second signal output unit 113 is implemented by the second encoder 211 for example, and can output an output pulse of the second encoder 211 to the correction data obtaining unit 114 and the discharge timing generating unit 116 as a second signal.

[0064] By generating a discharge timing after discharging at the discharge start timing based on an output of the second signal output unit 113, interval accuracy in a conveying direction and position accuracy of dots of the liquid attached on the sheet material P can be controlled in accordance with an actual position of the sheet material P on the conveying drum 21. This can determine discharge accuracy between the liquids of the same color, which requires high accuracy, based on an actual position of the sheet material P on the conveying drum 21 that is obtained based on an output of the second signal output unit 113. At this time, the second encoder 211 included in the second signal output unit 113 detects the

movement amount of the surface of the conveying drum 21, and a position detecting error of the sheet material P caused by rotation accuracy and part accuracy of the conveying drum 21 can be corrected.

[0065] Here, the output of the second signal output unit 113 is based on the encoder scale 212 attached on the peripheral surface of the conveying drum 21, however a cycle of the encoder scale 212 might include an accumulated error, and an attachment error might be caused when the encoder scale 212 is attached to the peripheral surface of the conveying drum 21. By the accumulated error and the attachment error, the position detecting error of the sheet material might not be appropriately corrected.

[0066] Thus, in the present embodiment, the correction data obtaining unit 114 that obtains correction data for correcting an influence of the accumulated error and the attachment error, is provided. The correction data obtaining unit 114 includes a function to generate correction data for correcting the second signal based on the first signal input from the first signal output unit 111 and the second signal input from the second signal output unit 113, and to output the correction data to the correction data storage unit 115. The correction data and an obtaining method of the correction data by the correction data obtaining unit 114 will be separately described in detail by using Fig. 7 and Fig. 8.

[0067] The correction data storage unit 115 is implemented by the NVRAM 304 for example, and stores the correction data input from the correction data obtaining unit 114.

[0068] The discharge timing generating unit 116 generates a discharge timing, after discharging at the discharge start timing determined by the discharge start timing determining unit 112, based on the output pulse of the second signal input from the second signal output unit 113 and the correction data stored in the correction data storage unit 115.

[0069] In other words, the discharge timing generating unit 116 corrects an influence of the accumulated error and the attachment error, which is described above, included in the second signal by adding the correction data to the output pulse of the second signal, and generates a discharge timing after discharging at the discharge start timing. A generating method of a discharge timing by the discharge timing generating unit 116 will be separately described in detail by using Fig. 9 and Fig. 10.

[0070] The discharge unit controller 117 is implemented by the liquid discharge unit driver 322 for example, and the liquid discharge device 22 is implemented by the liquid discharge unit 23 for example. The discharge unit controller 117 can cause the liquid discharge device 22 to start discharging the liquid at the discharge start timing determined by the discharge start timing determining unit 112. After starting the discharge, the discharge unit controller 117 can cause the liquid discharge device 22 to discharge the liquid at a discharge timing generated by the discharge timing generating unit 116.

<Obtaining method of the correction data according to the embodiment>

[0071] Next, an obtaining method of correction data by the correction data obtaining unit 114 will be described.

[0072] The correction data obtaining unit 114 detects the rotation amount of the conveying drum 21 based on the first signal output from the first signal output unit 111 before the liquid discharge device 22 starts discharging the liquid. At the same time, the correction data obtaining unit 114 detects the movement amount of the surface of the conveying drum 21 based on the second signal output from the second signal output unit 113. The correction data obtaining unit 114 obtains correction data by comparison of the rotation amount and the movement amount such as by difference.

[0073] A detection of the rotation amount of the conveying drum 21 and the movement amount of the surface of the conveying drum 21 is started at the timing when the conveying drum 21 rotates at a predetermined angle from a rotation origin. For more detail, the discharge start timing determining unit 112 starts counting the output pulse of the first signal output unit 111 with reference to a rotation origin signal output from the first signal output unit 111, and outputs a start trigger signal to the correction data obtaining unit 114 when the number of counts reaches a predetermined number. The correction data obtaining unit 114 starts detecting the rotation amount of the conveying drum 21 and the movement amount of the surface of the conveying drum 21 at the timing when the start trigger signal is input.

[0074] The encoder scale 212 in the second encoder 211 necessarily has one or more seams in a circumferential direction of the conveying drum 21, and if detection of the seam is included in the second signal, the rotation amount of the conveying drum 21 might not be able to be detected appropriately. Thus, the discharge start timing determining unit 112 is preferably configured to output the start trigger signal after the seam passes the encoder sensor 213. This enables the correction data obtaining unit 114 to obtain the correction data without an influence of the seam. The discharge timing generation unit 116 can generate a discharge timing by appropriately correcting the second signal with the correction data.

[0075] Fig. 7 is a graph illustrating an example of an obtaining method of the correction data according to the embodiment. The horizontal axis in Fig. 7 indicates the number of pulses of the output pulse of the first signal output unit 111 and the second signal output unit 113, and the vertical axis indicates the number of clocks. The number of clocks can be obtained by counting clock of the CPU 301 in Fig. 2. In other words, the number of clocks indicates time measured based on the clock of the CPU 301. The output pulse cycle can be measured by the number of clocks.

[0076] In Fig. 7, a curve 71 illustrated by a dotted line is a curve on which integrated values of multiplying the number of pulses of the output pulse of the first signal

output unit 111 (i.e., the first signal) by the number of clocks indicating a measured result for each output pulse cycle, are plotted. The integrated value corresponds to a detected value of the rotation amount of the conveying drum 21 by the first signal output unit 111.

[0077] A curve 72 illustrated by a dashed-dotted line is a curve on which integrated values of multiplying the number of pulses of the output pulse of the second signal output unit 113 (i.e., the second signal) by the number of clocks indicating a measured result for each output pulse cycle, are plotted. The integrated value corresponds to a detected value of the movement amount of the surface of the conveying drum 21 by the second signal output unit 113.

[0078] The curves 71 and 72 indicate an upward-sloping curve as the integrated values are plotted.

[0079] A curve 73 illustrated by a solid line is a curve on which difference values obtained by subtracting the integrated values of the output pulse cycle of the first signal output unit 111 (i.e., the curve 71) from the integrated values of the output pulse cycle of the second signal output unit 113 (i.e., the curve 72), are plotted. In this case, in synchronizing the output pulse cycle of the second signal output unit 113 with the output pulse cycle of the first signal output unit 111, the integrated values of the output pulse cycle of the first signal output unit 111 are subtracted from the integrated values of the output pulse cycle of the second signal output unit 113. The term "synchronized" in a description that the output pulse cycle of the second signal output unit 113 and the output pulse cycle of the first signal output unit 111 are synchronized, does not require complete synchronization, and it is sufficient if both correspond as described in the second embodiment in detail.

[0080] The difference value illustrated in the curve 73 indicates an influence of the accumulated error of the cycle of the encoder scale 212 and the attachment error caused when the encoder scale 212 is attached to the peripheral surface of the conveying drum 21, included in the output pulse of the second signal output unit 113 (i.e., the second signal). The correction data obtaining unit 114 obtains the difference value illustrated in the curve 73 as the correction data, and outputs the correction data to the correction data storage unit 115. The correction data storage unit 115 stores the correction data input from the correction data obtaining unit 114.

[0081] Here, because of the rotation accuracy and the part accuracy of the conveying drum 21, the rotation amount of the conveying drum 21 and the movement amount of the surface of the conveying drum 21 do not match necessarily, and detected values of the first signal output unit 111 and the second signal output unit 113 might include a margin of error. Thus the correction data obtaining unit 114 may use an average value of results of obtaining difference values illustrated in the curve 73 multiple times, as correction data. This can decrease an influence of a detected value error of the first signal output unit 111 and the second signal output unit 113.

[0082] Variations in the scale cycle of the first encoder 201 and the second encoder 211 may be caused by part accuracy. The correction data obtaining unit 114 measures the cycles of the first encoder 201 and the second encoder 211 multiple times, and performs a moving average for each cycle. Correction data may be obtained by difference value of a result of performing the moving average. This can decrease an influence of scale cycle variations of the first encoder 201 and the second encoder 211.

<Process of the correction data obtaining unit according to the embodiment>

[0083] The correction data obtaining unit 114 performs a correction data obtaining process described below as an example when the image forming apparatus 1 is shipped from a factory, and stores the correction data in the correction data storage unit 115. Alternatively, the correction data obtaining unit 114 may perform regular calibration in a predetermined period (e.g., one year), and update the correction data stored in the correction data storage unit 115. But a timing when the correction data obtaining unit 114 performs a correction data obtaining process is not limited to these, and may be any timing as long as it is before the liquid discharge device 22 starts discharging the liquid.

[0084] Fig. 8 is a flowchart illustrating an example of a process performed by the correction data obtaining unit 114.

[0085] In step S81, the output pulse from the first signal output unit 111 (i.e., the first signal) is input to the correction data obtaining unit 114, and the output pulse from the second signal output unit 113 (i.e., the second signal) is input to the correction data obtaining unit 114 at the same time.

[0086] In step S82, the correction data obtaining unit 114 obtains an integrated value of the first signal cycle.

[0087] In step S83, the correction data obtaining unit 114 obtains an integrated value of the second signal cycle.

[0088] The processes from step S82 to step S83 can be appropriately changed, and both processes can be performed in parallel.

[0089] In step S84, the correction data obtaining unit 114 subtracts the integrated value of the first signal cycle from the integrated value of the second signal cycle, and obtains the correction data.

[0090] In step S85, the correction data obtaining unit 114 outputs the obtained correction data to the correction data storage unit 115, and stores the correction data in the correction data storage unit 115.

[0091] As described, the correction data obtaining unit 114 can obtain the correction data for correcting the second signal.

[0092] In step S81 in Fig. 8, an example that the first signal and the second signal are input to the correction data obtaining unit 114 at the same time is described,

but the embodiment is not limited to this. As described in Fig. 7, the first signal and the second signal are not required to be input at the same time necessarily if the output pulse cycle of the second signal output unit 113 is synchronized with the output pulse cycle of the first signal output unit 111, and subtraction of both the integrated values can be performed. The first signal and the second signal may be input to the correction data obtaining unit 114 in parallel, or the second signal may be input after the first signal is input, or the first signal may be input after the second signal is input.

<Discharge timing generation method according to the embodiment>

[0093] Next, a discharge timing generation method by the discharge timing generation unit 116 will be described.

[0094] Fig. 9 is a timing chart illustrating an example of a discharge timing generation method according to the embodiment.

[0095] The discharge timing generation unit 116 starts a discharge timing generation process in response to an input of the start trigger signal (which is illustrated in Fig. 9(a)) output from the discharge start timing determining unit 112. The discharge timing generation unit 116 obtains the correction data corresponding to the output pulse of the second signal by referring to the correction data storage unit 115 based on the second signal (which is illustrated in Fig. 9(b)) output from the second signal output unit 113.

[0096] The discharge timing generation unit 116 generates a discharge timing by a discharge timing generating means 502 in response to the discharge start timing (which is illustrated in Fig. 9(e)) output from the discharge start timing determining unit 112. In this case, a discharge timing is a timing when the number of counting the clocks (which is illustrated in Fig. 9(d)) reaches the number of counts obtained by subtracting a value of the correction data from a reference count value.

[0097] More specifically, in the example illustrated in Fig. 9, a rise of the second signal pulse is a base timing, and counting the clocks is started from the rise of the second signal pulse.

[0098] First, at starting the discharge, a discharge timing signal f1 that matches the discharge start timing output from the discharge start timing determining unit 112, is generated. In subsequent discharges, a difference value "4" obtained by subtracting a value of the correction data "+1" from the number of counts at the discharge start timing, is used as a reference.

[0099] Thus, in a next discharge timing, a discharge timing signal f2 is generated at a timing of third count, which is obtained by adding a value of the correction data "-1" to the number of counts "4" described above, after the rise of the output pulse of the second signal subsequent to the first discharge timing signal f1 generation.

[0100] Similarly, in a next discharge timing, a discharge

timing signal f3 is generated at a timing of second count, which is obtained by adding a value of the correction data "-2" to the number of counts 4 described above, after the next rise of the output pulse of the second signal.

[0101] As correction data can be generated for each pulse of the output pulse of the second signal, by generating a discharge timing by adding the corresponding correction data to the output pulse of the second signal, the second signal can be corrected, and an influence of the accumulated error of the cycle of the encoder scale 212 and the attachment error caused when the encoder scale 212 is attached on the peripheral surface of the conveying drum 21, can be eliminated.

[0102] The example in which the number of counts "4" is used as a reference is described in the present embodiment. Correction accuracy can be improved by increasing the number of counts with a higher frequency of the clock.

[0103] In the present embodiment, the clock is counted from a base timing that is a rise of the output pulse of the second signal, but a base timing may be a fall or both edges of a rise and a fall, for example. In this case, the correction data is generated in accordance with a base timing.

[0104] Furthermore, the second encoder 211 might cause variations in the scale cycle because of part accuracy. By measuring the cycle of the second encoder 211 multiple times, and calculating average movement, a difference of variations can be removed. In this case, a difference between the cycle obtained by the average movement result and the preceding cycle of the second encoder 211, is subtracted from the number of counts described above.

[0105] In the present embodiment, as described by using Fig. 2 and Fig. 4, the multiple heads 100, each including a nozzle array 101 in which multiple nozzles are arranged, are disposed on the base member 52 in the liquid discharge unit 23. The multiple heads 100 are arranged in a zigzag alignment in a conveying direction. A "zigzag alignment in a conveying direction" indicates that among six heads 100 in Fig. 4, head arrays of three heads 100 on the left and head arrays of three heads 100 on the right are shifted in a direction orthogonal to a conveying direction. As the multiple heads 100 are arranged in a zigzag alignment in a conveying direction, the nozzle arrays 101 included in the head 100 are arranged in a zigzag alignment in a conveying direction in accordance with the heads 100. In such an arrangement, the discharge timing generation unit 116 generates a discharge timing for each of the nozzle arrays 101.

[0106] In this case, the second encoder 211 may be provided to each liquid discharge unit 23, for example. The correction data is commonly used by all nozzle arrays 101 in the liquid discharge unit 23, which can decrease the number of the encoder sensors 213.

<Image forming process by the image forming apparatus according to the embodiment>

[0107] Next, an image forming process by the image forming apparatus 1 will be described.

[0108] Fig. 10 is a flowchart illustrating an example of an image forming process by the image forming apparatus according to the embodiment.

[0109] In response to the sheet material P being transferred to the conveying drum 21 by the transfer cylinder 24, the suction device 26 starts applying suction to the sheet material P, and the sheet material P is conveyed by rotation of the conveying drum 21.

[0110] In step S101, the sheet material position detecting unit 110 detects the front edge of the sheet material P, and outputs a detected result to the discharge start timing determining unit 112.

[0111] In step S102, the discharge start timing determining unit 112 starts counting the output pulse of the first signal output unit 111 at the timing the detected result from the sheet material position detecting unit 110 is input, and determines a discharge start timing of each color from each liquid discharge unit 23 at the timing of reaching a predetermined number of counts. By this, each liquid discharge unit 23 starts discharging.

[0112] In step 103, after the liquid discharge unit 23 starts discharging, the discharge timing generating unit 116 adds the correction data to the output pulse of the second signal output unit 113, and generates a discharge timing with correcting the second signal, and outputs the discharge timing signal to the discharge unit controller 117.

[0113] In step S104, the discharge unit controller 117 controls the liquid discharge unit 23 in accordance with the discharge timing signal that is input, and causes the liquid discharge unit 23 to discharge the liquid and form an image on the sheet material P.

<Effect>

[0114] As described above, in the present embodiment, the correction data obtaining unit 114 obtains correction data that corrects the second signal output from the second signal output unit 113. The discharge timing generation unit 116 generates a discharge timing of the liquid discharge unit 23 based on the second signal and the correction data. This can appropriately correct a position detection error of the sheet material by removing an influence of the accumulated error and the attachment error, when accumulated error is included in the cycle of the encoder scale 212, and when attachment error is caused when the encoder scale 212 is attached on the peripheral surface of the conveying drum 21.

[0115] By determining a discharge start timing based on the first signal, overlapping accuracy of each color can be obtained. Furthermore, by generating a discharge timing after discharging at the discharge start timing based on the second signal, the liquid can be discharged

with respect to an actual position of the sheet material P on the conveying drum 21. This can obtain discharge accuracy of the same color that requires high accuracy, and interval accuracy in a conveying direction and position accuracy of dots of the same color.

[0116] Without using a high precision encoder for the first encoder 201 of the first signal output unit 111, high landing position accuracy can be achieved, and the quality of image forming can be improved.

[Second embodiment]

[0117] Next, an image forming apparatus according to a second embodiment will be described. Descriptions about the same component of the embodiment already described will be omitted.

[0118] Fig. 11 is a block diagram illustrating an example of a functional configuration of an image forming apparatus according to the present embodiment. As illustrated in Fig. 11, an image forming apparatus 1a includes a correction data obtaining unit 114a, and the correction data obtaining unit 114a includes a cycle adjustment unit 118.

[0119] Here, a scale cycle of the encoder wheel 202 for detecting the rotation amount of the conveying drum 21 might mismatch a scale cycle of the encoder scale 212 for detecting the movement amount of the surface of the conveying drum 21. Because of such a difference of the cycle, when correction data is obtained, an integrated value of the output pulse cycle of the first signal output unit 111 (i.e., the curve 71) cannot be subtracted from an integrated value of the output pulse cycle of the second signal output unit 113 (i.e., the curve 72) by synchronization, and accurate correction data cannot be obtained in some cases.

[0120] Thus, the cycle adjustment unit 118 performs an adjustment process that causes the output pulse cycle of the first signal output unit 111 (i.e., the first signal) to correspond to the output pulse cycle of the second signal output unit 113 (i.e., the second signal).

[0121] For an example of such an adjustment process, the cycle adjustment unit 118 can perform a process that adjusts the cycle of the first encoder 201 to the same as or an integral multiple of the cycle of the second encoder 211 by multiplying or dividing the output pulse of the first encoder 201.

[0122] Alternatively, for another example, the cycle adjustment unit 118 obtains an approximate equation that interpolates discrete obtained data of integrated values of the cycle of the first encoder 201 (See the curve 71 in Fig. 7). Integrated values of the cycle of the first encoder 201 corresponding to each cycle of the second encoder 211 are calculated by substituting each cycle of the second encoder 211 in the approximate equation. By this way, the output pulse cycle of the first signal output unit 111 (i.e., the first signal) may be caused to correspond to the output pulse cycle of the second signal output unit 113 (i.e., the second signal).

[0123] As a result, an integrated value of the output pulse cycle of the first signal output unit 111 (i.e., the curve 71) can be subtracted from an integrated value of the output pulse cycle of the second signal output unit 113 (i.e., the curve 72) by synchronization, and accurate correction data can be obtained.

[0124] The effects other than those described above are the same as those described in the first embodiment.

[0125] Although the embodiments are described above, the present invention is not limited to the embodiments disclosed above specifically, and various changes and alternations can be made without departing from the scope of the claims.

[0126] Each function of the embodiments described above can be implemented by one or more processing circuits. Here, a "processing circuit" in the specification includes a programmed processor configured to execute each function by software as a processor implemented on an electronic circuit and a device such as an ASIC (application specific integrated circuit), DSP (digital signal processor), FPGA (field programmable gate array), and a conventional circuit module, designed to execute each function describe above.

RELATED-ART DOCUMENT

PATENT DOCUMENT

[0127] Patent Document 1: Japanese Unexamined Patent Application Publication No. 2016-074101

Claims

1. A liquid discharge apparatus, comprising:

a rotating member configured to convey a sheet material by holding the sheet material on a peripheral surface of the rotating member;
a liquid discharge device configured to discharge liquid on the sheet material;
a sheet material position detecting unit configured to detect a position of the sheet material;
a first signal output unit configured to output a first signal in accordance with a rotation amount of the rotating member;
a second signal output unit configured to output a second signal that is correlated with a movement amount of the sheet material on the peripheral surface of the rotating member;
a correction data storage unit configured to store correction data, which corrects the second signal, obtained based on the first signal and the second signal; and
a discharge timing generating unit configured to generate a discharge timing of the liquid discharge device based on the second signal and the correction data.

2. The liquid discharge apparatus as claimed in claim 1, wherein the second signal output unit includes:

an encoder scale that is provided on the peripheral surface of the rotating member; and
an encoder sensor that is disposed near the liquid discharge device and configured to read the encoder scale.

3. The liquid discharge apparatus as claimed in claim 1 or 2, comprising:

a correction data obtaining unit configured to obtain the correction data based on the movement amount of the sheet material obtained from an integrated value of a cycle of the second signal and the rotation amount of the rotating member obtained from an integrated value of a cycle of the first signal.

4. The liquid discharge apparatus as claimed in claim 3, wherein the correction data obtaining unit performs an obtaining process of the correction data a plurality of times, and obtains the correction data by calculating an average of results of performing the obtaining process of the correction data a plurality of times.

5. The liquid discharge apparatus as claimed in claim 3 or 4, wherein the correction data obtaining unit obtains the correction data based on a result of performing a moving average of the movement amount of the sheet material obtained from the integrated value of the cycle of the second signal and a result of performing a moving average of the rotation amount of the rotating member obtained from the integrated value of the cycle of the first signal.

6. The liquid discharge apparatus as claimed in any one of claims 1 to 5, wherein the liquid discharge device includes a plurality of nozzle arrays that are disposed in a zigzag alignment in a conveying direction of the sheet material and configured to discharge the liquid, and the discharge timing generating unit generates the discharge timing for each of the nozzle arrays.

7. The liquid discharge apparatus as claimed in any one of claims 1 to 6, wherein the liquid discharge device includes a plurality of liquid discharge units for each color of the liquid in a conveying direction, and the second signal output unit is disposed near each of the plurality of the liquid discharge units.

8. The liquid discharge apparatus as claimed in any one of claims 3 to 7, comprising a cycle adjustment unit configured to perform an adjustment process to cause the cycle of the first signal to correspond to the cycle of the second signal.

9. The liquid discharge apparatus as claimed in claim 8, wherein the cycle adjustment unit adjusts the cycle of the first signal by multiplying or dividing the first signal so that the cycle of the first signal is the same as or an integral multiple of the cycle of the second signal.

10. The liquid discharge apparatus as claimed in claim 8, wherein the cycle adjustment unit obtains an approximate equation that interpolates the integrated values of the cycle of the first signal, and calculates integrated values of the cycle of the first signal by substituting the cycle of the second signal in the approximate equation.

11. An image forming apparatus, comprising:

a rotating member configured to convey a sheet material by holding the sheet material on a peripheral surface of the rotating member;
a liquid discharge device configured to discharge liquid on the sheet material;
a sheet material position detecting unit configured to detect a position of the sheet material;
a first signal output unit configured to output a first signal in accordance with a rotation amount of the rotating member;
a second signal output unit configured to output a second signal that is correlated with a movement amount of the sheet material on the peripheral surface of the rotating member;
a correction data storage unit configured to store correction data, which corrects the second signal, obtained based on the first signal and the second signal; and
a discharge timing generating unit configured to generate a discharge timing of the liquid discharge device based on the second signal and the correction data.

FIG.1

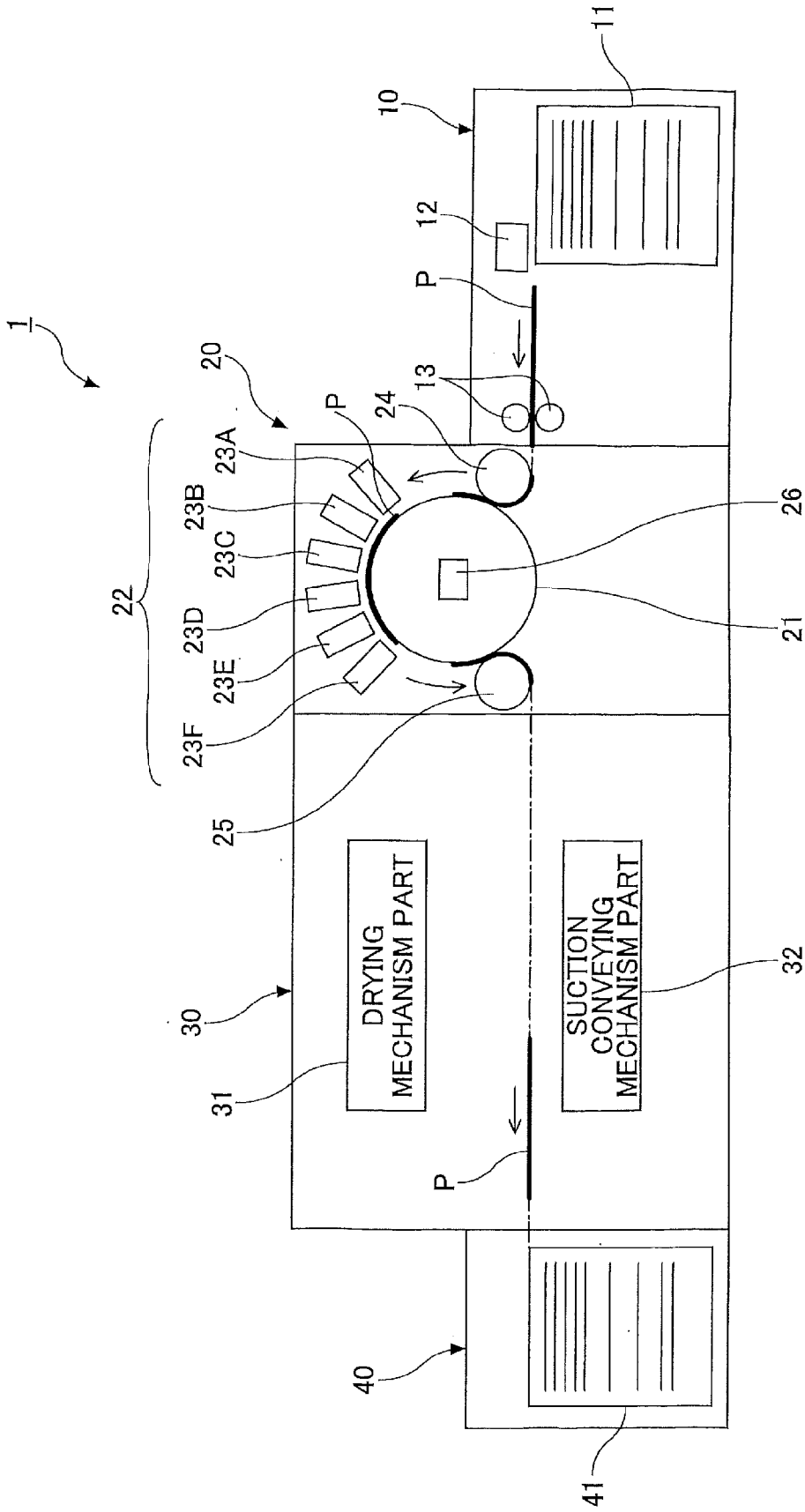


FIG.2

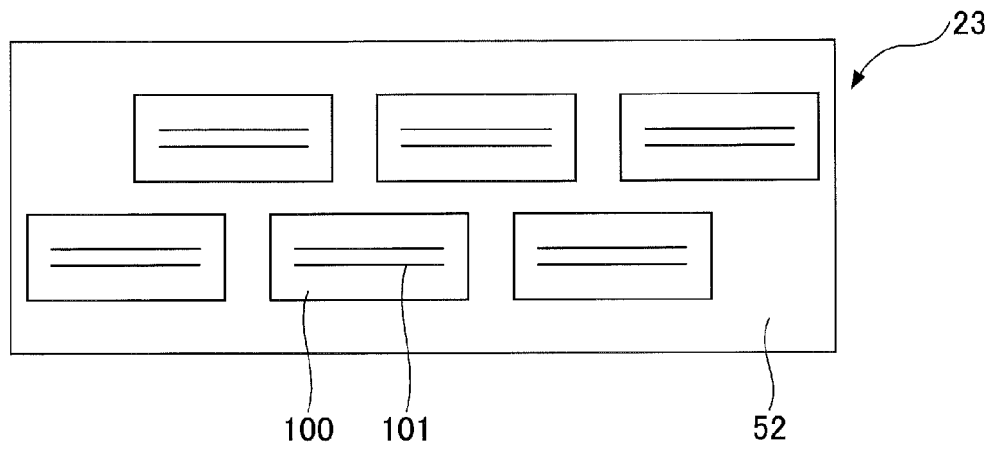


FIG.3

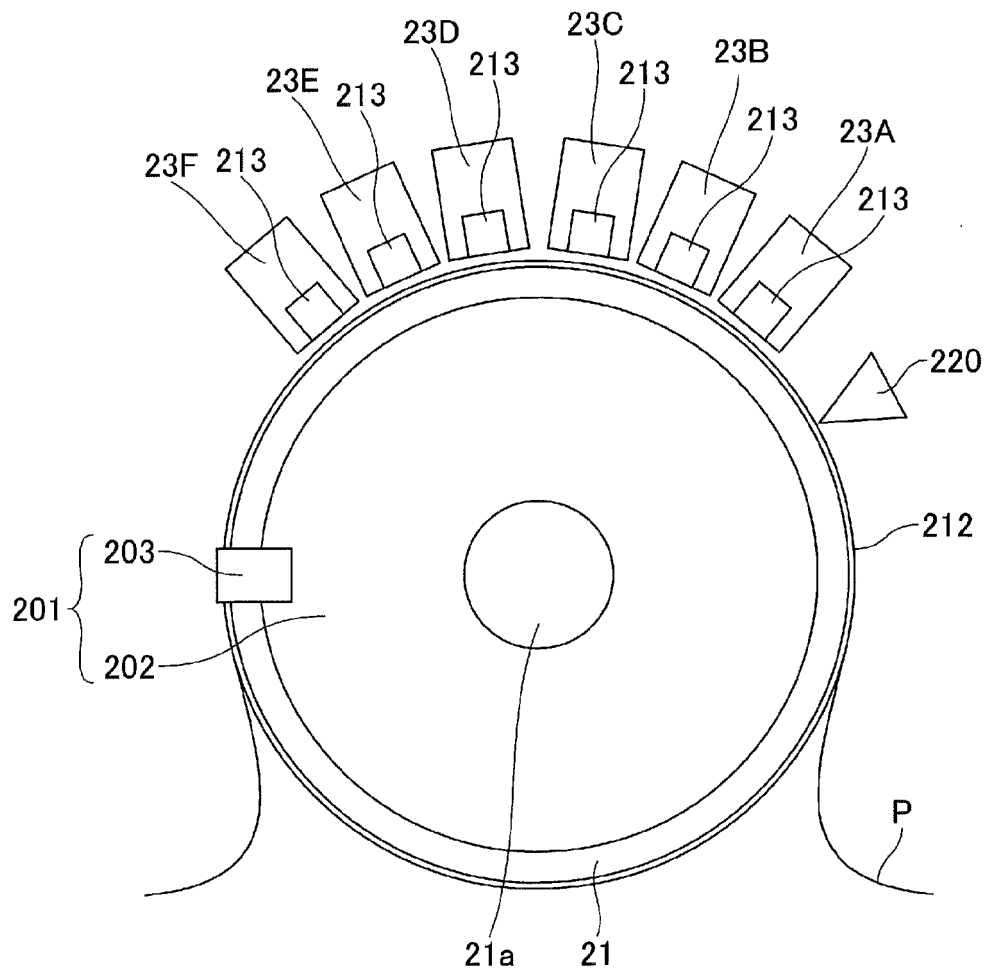


FIG.4

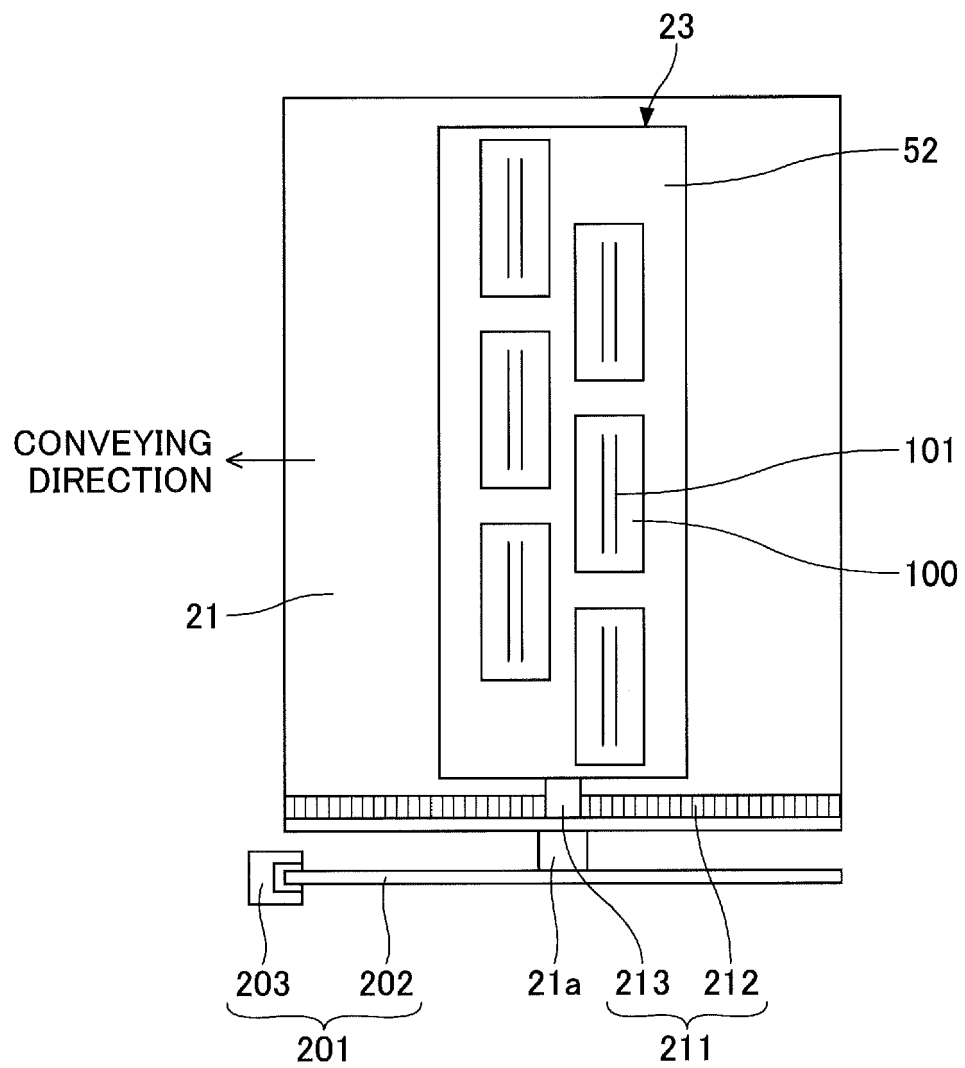


FIG.5

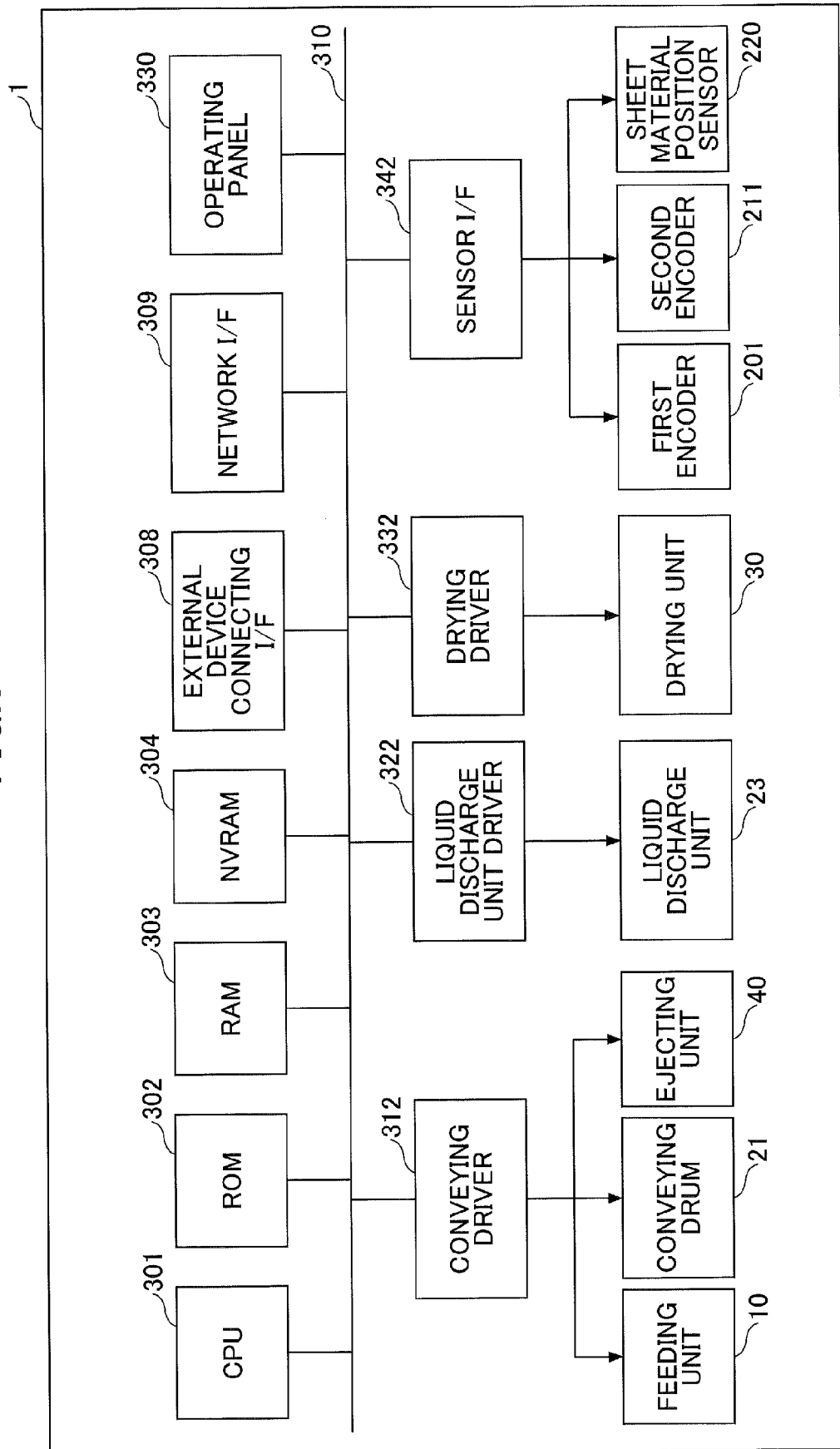


FIG.6

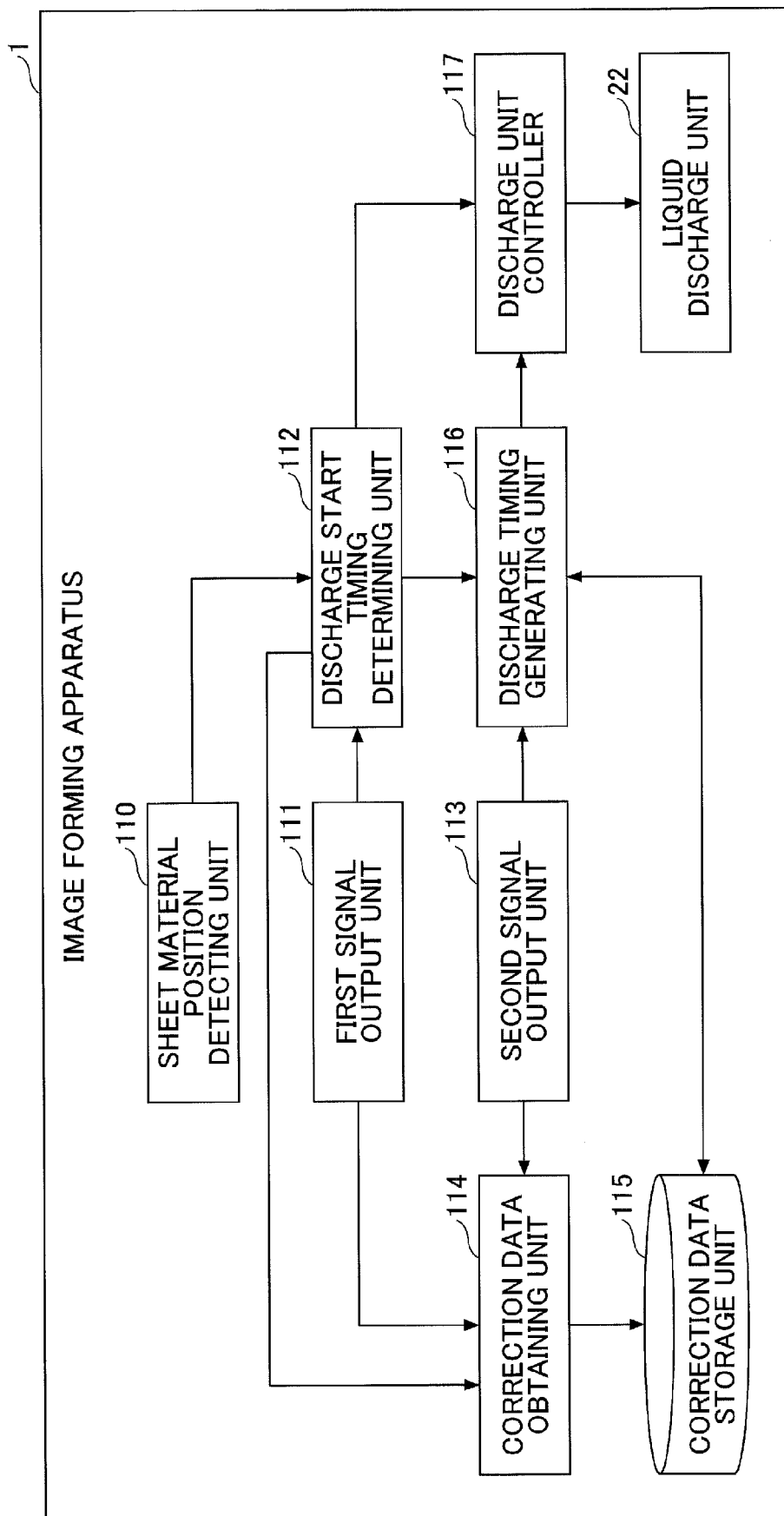


FIG.7

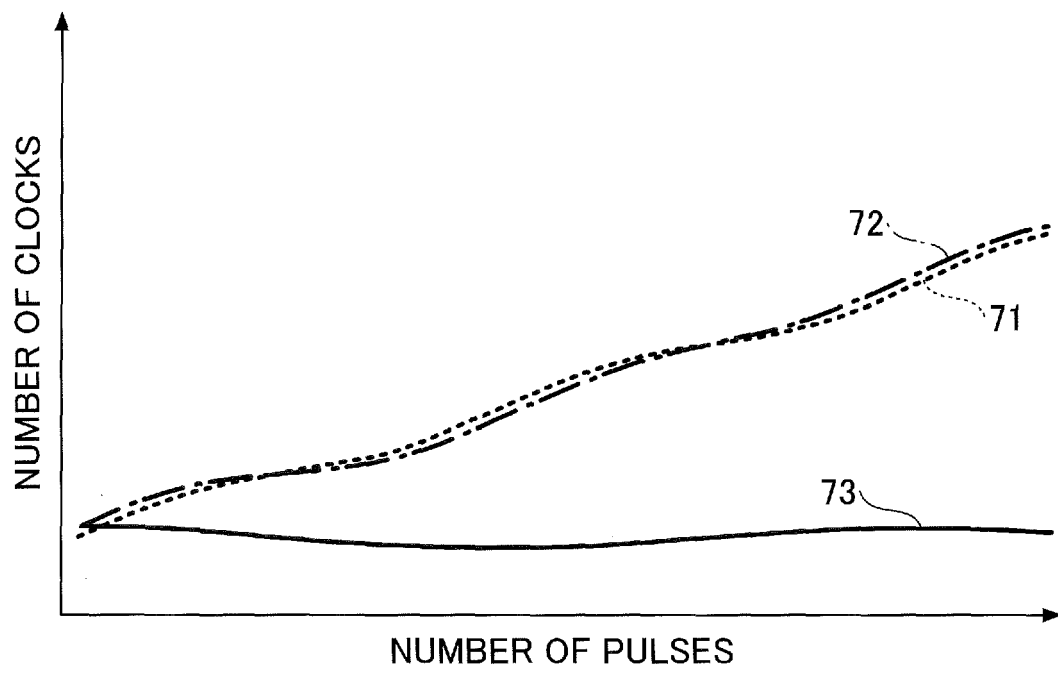


FIG.8

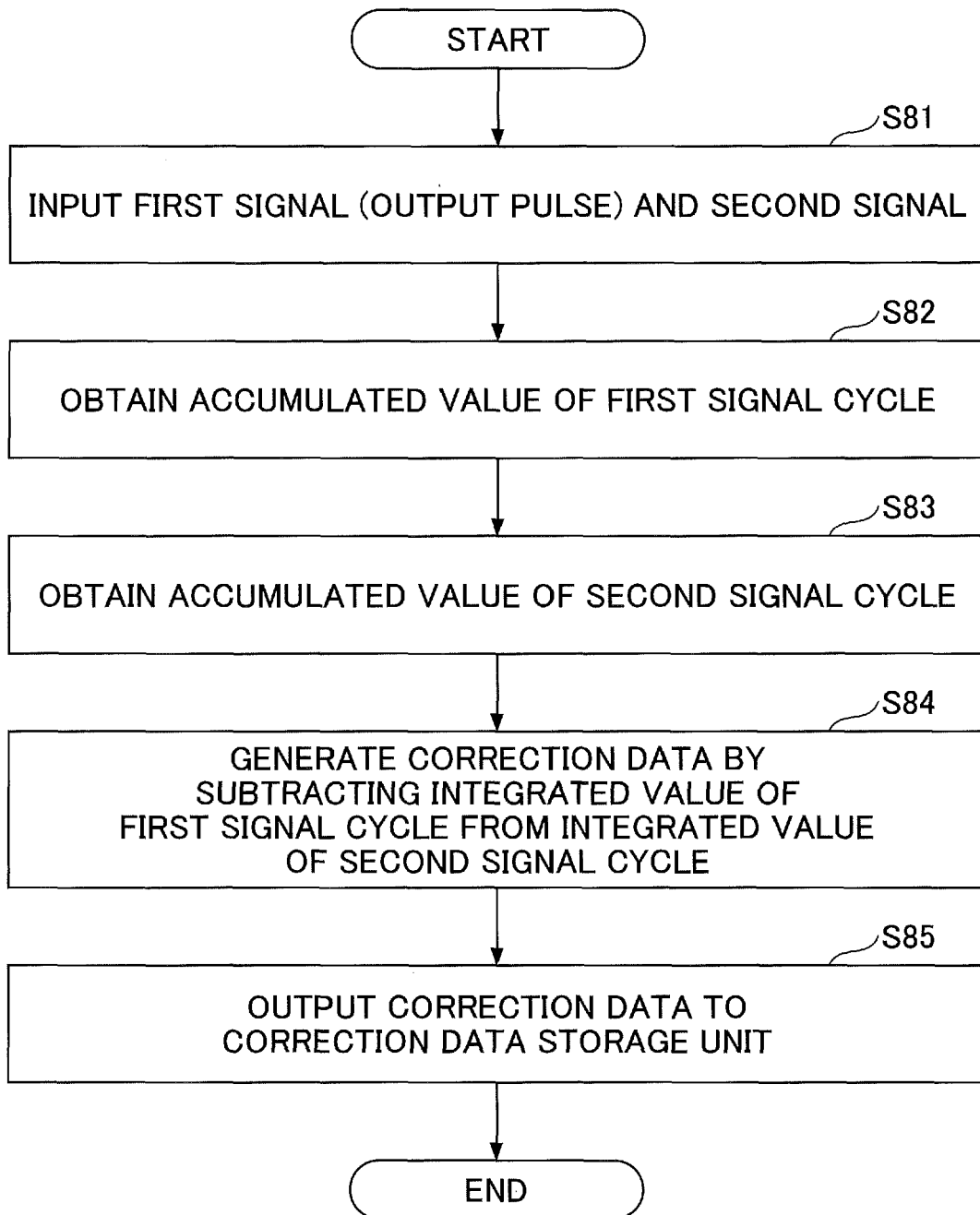


FIG.9

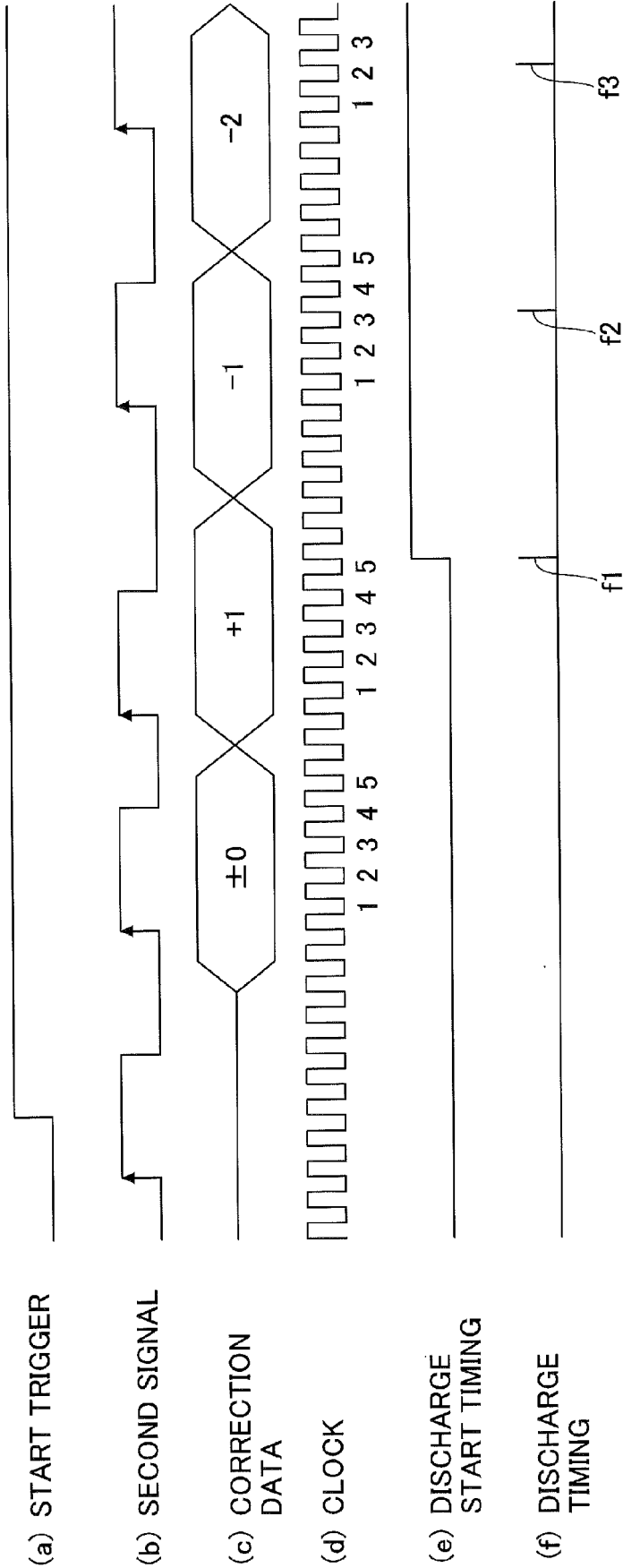


FIG.10

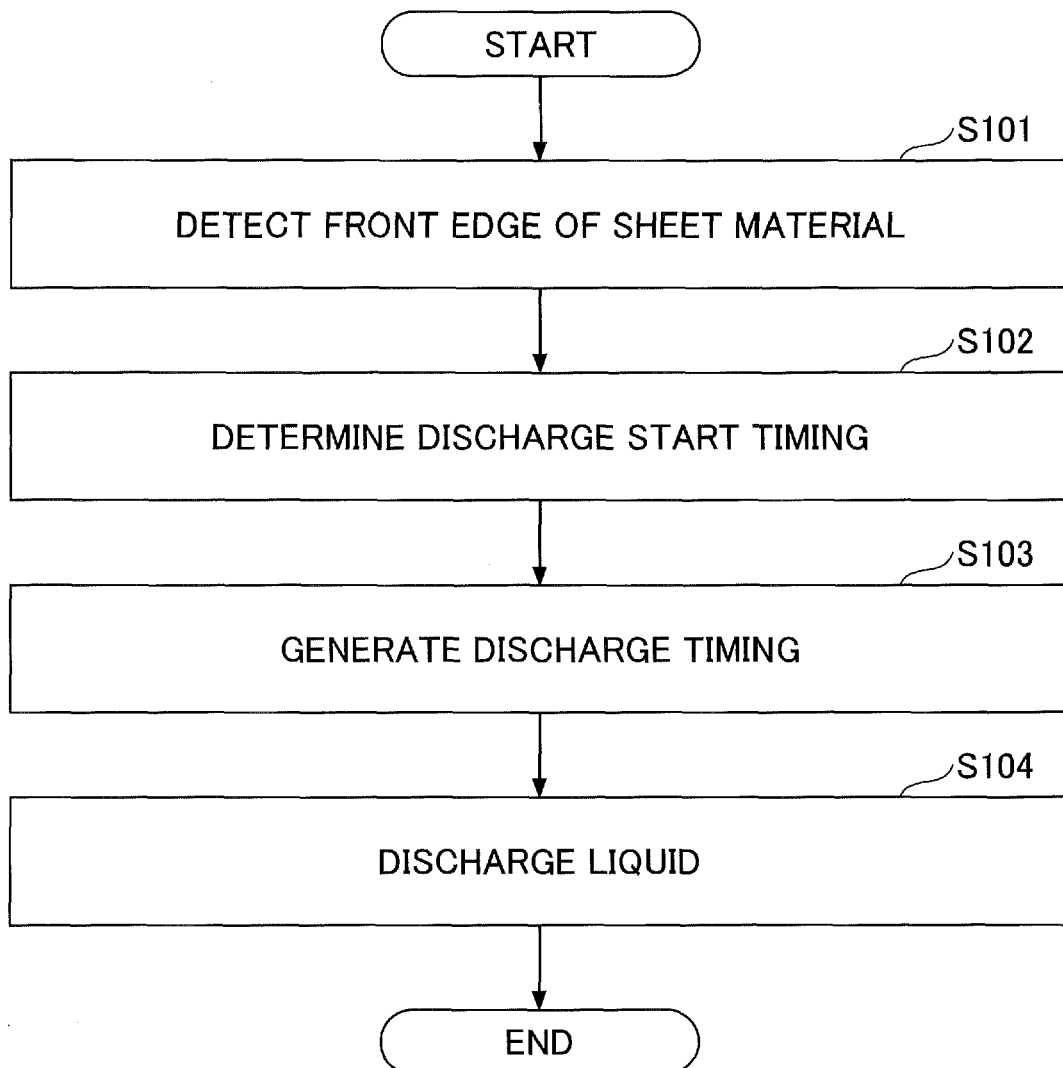
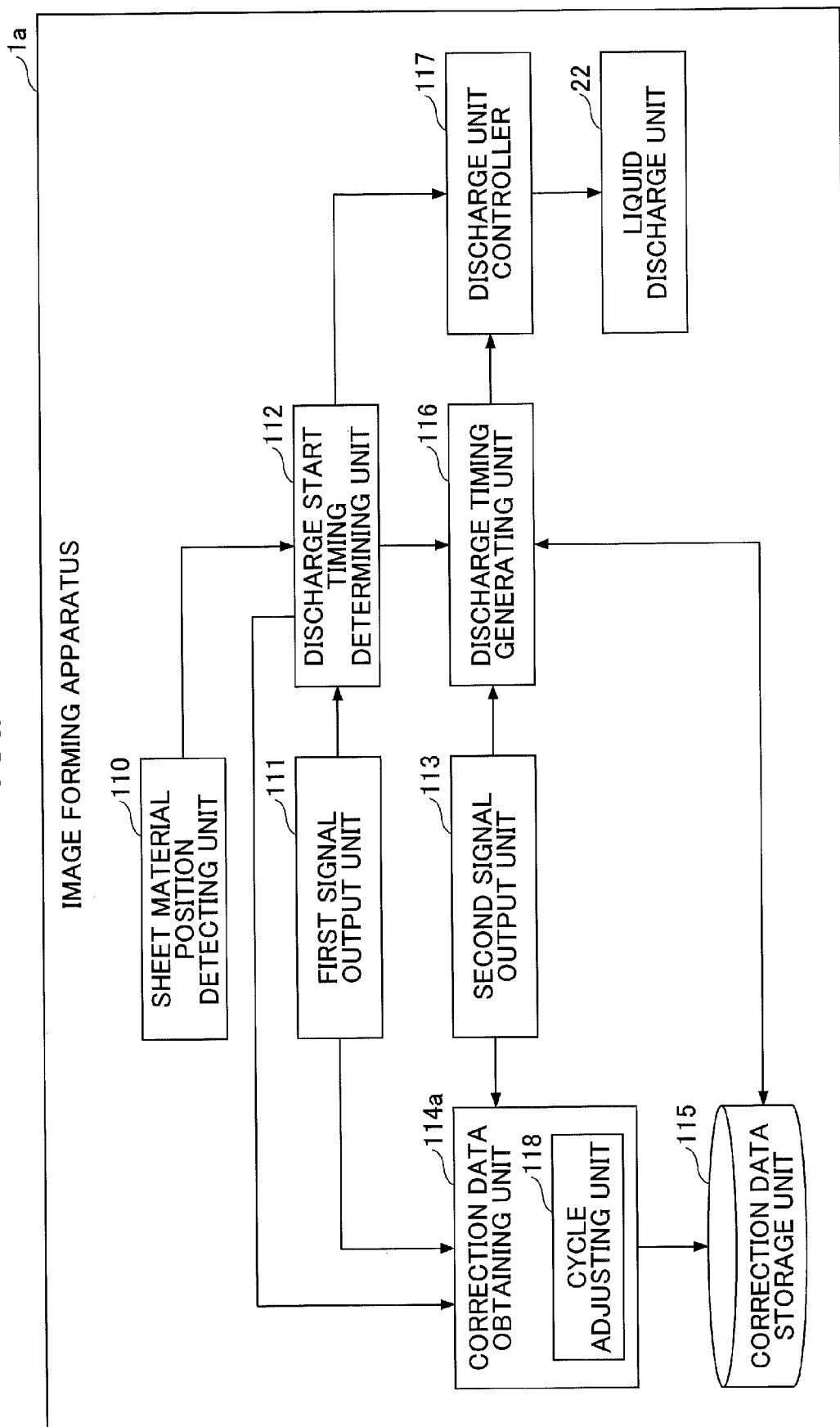


FIG.11





EUROPEAN SEARCH REPORT

Application Number
EP 20 15 5017

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	JP 2012 162051 A (SEIKO EPSON CORP) 30 August 2012 (2012-08-30) * abstract *	1-11	INV. B41J13/22 B41J11/46 B41J11/00
A,D	JP 2016 074101 A (SEIKO EPSON CORP) 12 May 2016 (2016-05-12) * abstract *	1-11	ADD. B41J15/04
			TECHNICAL FIELDS SEARCHED (IPC)
			B41J
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		22 July 2020	Wehr, Wolfhard
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