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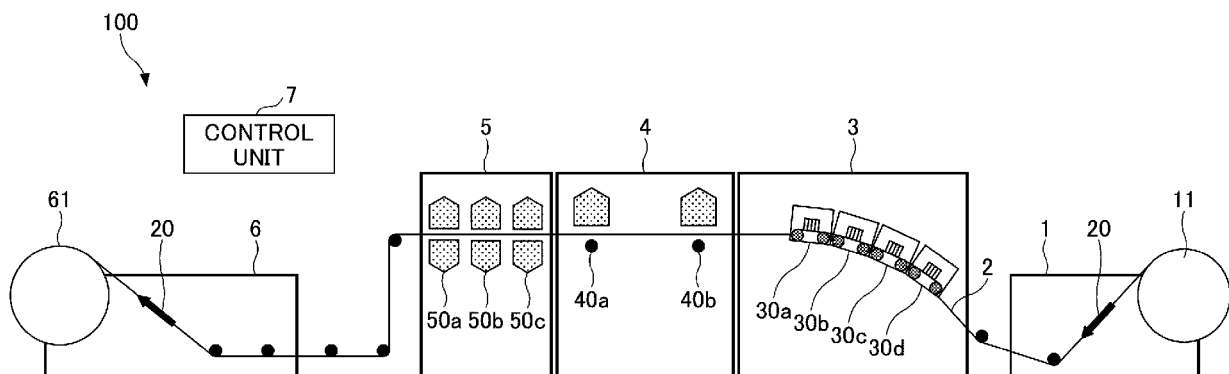
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(54) **LIQUID DISCHARGE DEVICE, LIQUID DISCHARGE METHOD, AND LIQUID DISCHARGE DEVICE FOR BATTERY MEMBER**

(57) A liquid discharge device (100) for discharging and applying liquid to a target discharging medium (2) conveyed in a predetermined conveying direction (20) to form a discharged region, includes a plurality of liquid discharge units (30, 30a, 30b, 30c, 30d) configured to discharge the liquid based on a drive waveform (33, 34); an output unit (74) configured to output the drive waveform to the liquid discharge unit; an acquisition unit (71) configured to acquire information representing a characteristic of the liquid; and a switching unit (75) configured

to switch the drive waveform based on the characteristic. The plurality of liquid discharge units includes first and second liquid discharge units (30a, 30b), disposed at position separated from each other in the conveying direction. When the characteristic satisfies a predetermined condition, positions at which the liquid is applied by the first and second liquid discharge units on the target discharging medium are separated from each other in the conveying direction.

FIG.1



Description

Background of the invention

1. Field of the invention

[0001] The disclosures herein generally relate to a liquid discharge device, a liquid discharge method, and a liquid discharge device for a battery member.

2. Description of the related art

[0002] Conventionally, a liquid discharge device has been known which discharges and applies liquid to a target discharging medium conveyed in a predetermined conveying direction to form a discharged region.

[0003] Further, for example, Patent Document 1 discloses applying to a recording head a drive signal with a waveform for test, in which at least one of a voltage, a frequency, and a waveform is different from that of a drive signal with a waveform for recording applied to the recording head when a desired image is drawn and recorded on a recording medium, to perform discharging with a discharge force that is made greater than that of applying the drive signal with a waveform for recording, to form a test pattern, in order to reduce an amount of liquid consumed in maintenance or the like.

SUMMARY OF INVENTION

Problem to be solved by the invention

[0004] However, Patent Document 1 has a problem that when the drive signal is switched during the formation of an image on a recording medium, the quality of the discharged region formed by the liquid discharge device may be degraded.

[0005] The present invention aims at providing a liquid discharge device that suppresses degradation of quality of a discharged region formed by the liquid discharge device, and a method of discharging liquid.

Means for Solving Problems

[0006] According to an aspect of the present disclosure, a liquid discharge device for discharging and applying liquid to a target discharging medium conveyed in a predetermined conveying direction to form a discharged region, includes a plurality of liquid discharge units configured to discharge the liquid based on a drive waveform; an output unit configured to output the drive waveform to each of the plurality of liquid discharge units; an acquisition unit configured to acquire information representing a characteristic of the liquid; and a switching unit configured to switch the drive waveform based on the characteristic, the plurality of liquid discharge units including a first liquid discharge unit and a second liquid discharge unit that is disposed at a position separated

from the first liquid discharge unit in the conveying direction, and when the characteristic satisfies a predetermined condition, a position at which the liquid is applied by the first liquid discharge unit and a position at which the liquid is applied by the second liquid discharge unit on the target discharging medium are separated from each other in the conveying direction.

Effects of the Invention

[0007] According to the present invention, degradation of quality of a formed discharged region can be suppressed.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

FIG. 1 is a diagram illustrating an example of a film formation device according to an embodiment of the present application;

FIG. 2 is a diagram illustrating an example of an ink discharge unit according to the embodiment;

FIG. 3 is a block diagram illustrating an example of a functional configuration of a control unit according to the embodiment;

FIG. 4 is a flowchart illustrating an example of a process performed by the control unit according to the embodiment;

FIG. 5 is a diagram illustrating an example of a temperature variation of ink with respect to a film formation time;

FIG. 6 is a diagram depicting an example of a drive waveform, FIG. 6(a) illustrates the drive waveform before switching, and FIG. 6(b) is a diagram illustrates the drive waveform after switching; and

FIG. 7 is a diagram depicting an example of a change in an ink application state by switching the drive waveform, for comparative example (FIG. 7(a)) and the embodiment of the present application (FIG. 7(b)).

Mode for Carrying Out the Invention

[0009] In the following, with reference to the drawings an embodiment for carrying out the invention will be described. In each drawing, the same components are denoted by the same reference numerals, and overlapping descriptions are omitted accordingly.

[0010] The following embodiments are exemplary of a liquid discharge device for embodying the technical concept of the present invention, and the present invention is not limited to the following embodiments. The dimensions, materials, shapes, relative arrangements thereof, and the like of components described below are not intended to limit the scope of the invention to the embodiments, unless otherwise specified, but are intended to be exemplary. In addition, the size and positional rela-

tionship of the members illustrated in the drawings may be exaggerated for the purpose of clarification.

[0011] The liquid discharge device according to the embodiment applies liquid by discharging the liquid onto a target discharging medium conveyed in a predetermined conveying direction to form a discharged region.

[0012] The target discharging medium includes, for example, an electrode substrate (current collector) used in a power storage device such as a battery, a power generation device such as a fuel cell, and a photovoltaic device. The target discharging medium further includes an electrode in which an electrode material layer, such as an active material, is formed on the electrode substrate. The liquid discharge device applies a liquid, in which various materials, such as a powder-like active material or a catalyst composition, are dispersed, to the target discharging medium, fixes and dries the liquid, and thereby forms a discharged region of an electrode or the like having a film containing the various materials on the target discharging medium.

[0013] In such a liquid discharge device, when liquid is discharged continuously for a long time, the characteristic of the liquid may change due to a change in the temperature of the discharged liquid. The characteristic of liquid refers to a property or condition of the liquid. The property of a liquid includes a physical property of the liquid such as viscosity or surface tension of the liquid.

[0014] A drive waveform for driving a liquid discharge unit provided in the liquid discharge device is often adjusted according to the characteristics of the liquid so that the liquid is discharged appropriately without any discharge abnormality such as a non-discharge or a discharge curve. However, if the characteristics of the liquid are changed due to continuous discharge for a long time, the drive waveform may not match the characteristics and the liquid may not be discharged appropriately.

[0015] In this case, a plurality of drive waveform data adjusted for different characteristics of the liquid are preferably stored in a storage unit or the like in advance so that the drive waveform can be switched in accordance with the change in the characteristics of the liquid, to use the stored drive waveform data.

[0016] However, when the drive waveform is switched while the discharged region is formed, an abnormal area is generated due to a transient change in the discharge characteristic, and the quality of the discharged region to be formed may deteriorate. The abnormal area includes a stripe region in which an area with an amount of discharged liquid different from the surrounding area extends in a stripe shape.

[0017] For example, when the liquid discharge device includes the plurality of liquid discharge units disposed in a conveying direction and the drive waveforms that cause the plurality of liquid discharge units to discharge the liquid are switched, the abnormal area becomes more prominent because the liquid discharged in a state where the discharge characteristics are transiently changed is concentrated in a specific area along the target discharg-

ing medium in the conveying direction. As a result, the quality of the formed discharged region decreases.

[0018] In the embodiment of the present application, the liquid discharge device includes a plurality of liquid discharge units capable of discharging liquid based on a drive waveform, an output unit capable of outputting a drive waveform to each of the plurality of liquid discharge units, an acquisition unit for acquiring information indicating the characteristics of the liquid, and a switching unit for switching the drive waveform based on the characteristics of the liquid.

[0019] The plurality of liquid discharge units include a first liquid discharge unit and a second liquid discharge unit that is disposed at a position separated from the first liquid discharge unit in the conveying direction, and when the characteristic of the liquid satisfies a predetermined condition, a position at which the liquid is applied by the first liquid discharge unit and a position at which the liquid is applied by the second liquid discharge unit on the target discharging medium being separated from each other in the conveying direction.

[0020] For example, the above-described switching unit switches the drive waveform output to the first liquid discharge unit and the drive waveform output to the second liquid discharge unit when the liquid characteristic satisfies the predetermined condition. The characteristic of liquid is, for example, a temperature of the liquid, and the predetermined condition is satisfied when the temperature of the liquid changes by a predetermined threshold or more.

[0021] The term "separated" means that centers of the liquids are spaced apart and, in the embodiment of the present application, in particular means that the centers are not adjacent. However, if the centers of the liquids are separated apart, a portion of the liquids do not need to be spaced apart from each other.

[0022] As described above, liquid discharged in a state where the discharge characteristics of the first liquid discharge unit and the second liquid discharge unit are transiently changed when the drive waveform is switched, is dispersed separately in the conveying direction. As a result, since an abnormal area that is formed becomes inconspicuous, degradation of the quality of the discharged region can be suppressed.

[0023] Hereinafter, an embodiment will be described with reference to a film formation device, as an example, which discharges an ink onto a non-permeable target coating material to form a film on the target coating material. Here, the target coating material is an example of a target discharging medium, the ink is an example of a liquid, the film is an example of a discharged region, and the film formation device is an example of a liquid discharge device.

[Embodiment]

<Example of overall configuration of the film formation device 100>

[0024] First, an overall configuration of the film formation device 100 will be described with reference to FIG. 1. FIG. 1 is a diagram illustrating an example of the overall configuration of the film formation device 100. FIG. 1 illustrates inside of the film formation device 100 viewed from a direction substantially perpendicular to a conveying direction 20 of a target coating material 2.

[0025] As illustrated in FIG. 1, the film formation device 100 includes an unwinding unit 1, an application unit 3, a curing unit 4, a drying unit 5, a winding unit 6, and a control unit 7. The application unit 3 includes ink discharge units 30a, 30b, 30c, and 30d.

[0026] The film formation device 100 applies ink discharged from each of the ink discharge units 30a, 30b, 30c, and 30d included in the application unit 3 onto the target coating material 2 while conveying the target coating material 2 in the conveying direction 20 by the unwinding unit 1 and the winding unit 6. The film formation device 100 forms a continuous uniform film on the target coating material 2 by irradiating the ink applied on the target coating material 2 with ultraviolet light to cure the ink by the curing unit 4 and blowing a hot air to dry the ink by the drying unit 5.

[0027] The unwinding unit 1 rotates an unwinding roll 11 that is rotatable in a state where the target coating material 2 is wound, to unwind the target coating material 2 wound on the roll, and thereby conveys the target coating material 2 from the unwinding unit 1 toward the application unit 3. The winding unit 6 winds the target coating material 2 onto the rotating winding roll 61, and thereby conveys the target coating material 2 from the drying unit 5 to the winding unit 6.

[0028] In addition to the unwinding unit 1 and the winding unit 6, a conveying roller or the like, to which a reference numeral is not assigned, is also used as a conveying means for conveying the target coating material 2. The conveying roller, the unwinding unit 1, and the winding unit 6 form the conveying means for the target coating material 2.

[0029] The target coating material 2 is continuous in the conveying direction 20. The film formation device 100 conveys the target coating material 2 along a conveying path between the unwinding unit 1 and the winding unit 6. A length of the target coating material 2 in the conveying direction 20 is at least greater than a length of the conveying path between the unwinding unit 1 and the winding unit 6. The film formation device 100 is capable of continuously performing the film formation on the target coating material 2 that is continuous in the conveying direction 20.

[0030] The ink is composed of a liquid that achieves a function of film. The ink may be provided with a viscosity or surface tension so that the ink discharge unit can dis-

charge the ink. The ink discharge unit is not particularly limited. However, the viscosity of the ink discharge unit is preferably 30 mPa·s or less at a normal temperature and under normal pressure, or by heating or cooling.

[0031] More specifically, examples of the liquids include a solution, a suspension, an emulsion, and the like, the solution containing: water; a solvent such as an organic solvent; a dye; a pigment; an electrode material such as an active substance; a polymerizable compound; a resin; a functionality-imparting material such as a surfactant; a biocompatible material such as DNA, an amino acid, a protein, or calcium; an edible material such as a natural pigment; or the like. For example, the above-described materials can be used in applications such as printing inks; surface treatment liquids; and liquids for forming various devices such as components of electronic elements or light emitting elements, or electronic circuit resist patterns.

[0032] The application unit 3 applies ink discharged by each of the ink discharge units 30a, 30b, 30c, and 30d onto the target coating material 2. The application unit 3 is provided with the ink discharge units 30a, 30b, 30c, and 30d along the target coating material 2 in the conveying direction 20. However, the present invention is not limited to the above-described configuration, and the application unit 3 may be provided with two or more ink discharge units in the conveying direction 20.

[0033] Since the ink discharge units 30a, 30b, 30c, and 30d have the same configuration, the ink discharge units 30a, 30b, 30c, and 30d are collectively referred to as the ink discharge units 30 when not particularly distinguished. In the present embodiment, the ink discharge units 30a, 30b, 30c, and 30d discharge the same type of ink.

[0034] The ink discharge unit 30 has a plurality of nozzle arrays in which a plurality of nozzles are arranged. In the film formation device 100, the ink discharge unit 30 is disposed such that the discharge direction of the ink discharged from the nozzle is directed to the target coating material 2. The ink discharge units 30a, 30b, 30c, and 30d are examples of a plurality of liquid discharge units capable of discharging ink based on a drive waveform.

[0035] The target coating material 2 may be a non-permeable substrate, such as a metal sheet, on which a layer having particles as a main component is disposed. The layer having particles as a main component disposed on the non-permeable substrate is, for example, a graphite layer.

[0036] Suitable non-permeable substrates include, for example, sheets of metal, such as aluminum, copper, stainless steel, nickel, or platinum; or resin films, such as polypropylene films, polyethylene terephthalate films, or nylon films.

[0037] The curing unit 4 includes light sources 40a and 40b. When the light sources 40a and 40b are not distinguished, they are collectively referred to as light sources 40. The light source 40 has a function of curing an ink layer to form a resin layer by irradiating the ink applied

onto the target coating material 2 with ultraviolet light.

[0038] The light source 40 includes, for example, a mercury lamp such as a low-, medium-, and high-pressure mercury lamp, a tungsten lamp, an arc lamp, an excimer lamp, an excimer laser, a semiconductor laser, a high-power UV-LED, a YAG laser, a laser system combining a laser and a nonlinear optical crystal, a high-frequency induced ultraviolet ray generating device, an electron beam irradiation device such as an electron beam (EB) curing device, or an X-ray radiation device. Particularly, a high-frequency induced ultraviolet ray generating device, a high- or low-pressure mercury lamp, or semiconductor laser, is preferably used, to simplify the system. Also, the light source 40 may be provided with a condensing mirror or a sweeping optical system.

[0039] The drying unit 5 includes heaters 50a, 50b and 50c. When the heaters 50a, 50b, and 50c are not distinguished, they are collectively referred to as heaters 50. The heater 50 functions as a curing or drying means or a heating means or heating mechanism that heats the ink formed on the target coating material 2 to dry the residual solvent in the ink to facilitate the curing or dry the ink.

[0040] The heater 50 includes, for example, an infrared lamp, a roller (a hot roller) incorporating a heating element, a blower blowing hot wind or hot air, or a furnace introducing boiler-type hot air using steam or the like.

[0041] The control unit 7 is a control device that controls the entirety of the film formation device 100. The position at which the control unit 7 is disposed is not particularly limited, and can be determined accordingly.

<Example of configuration of ink discharge unit 30>

[0042] Next, FIG. 2 is a diagram illustrating an example of the configuration of the ink discharge unit 30. FIG. 2 illustrates the ink discharge units 30a, 30b, 30c, and 30d viewed from the ink discharge direction side. The target coating material 2 is conveyed in the conveying direction 20 in a state facing the ink discharge units 30a, 30b, 30c, and 30d.

[0043] The ink discharge unit 30 is a line type ink discharge unit. The "line-type ink discharge unit" means that nozzles for discharging ink are arranged over the entire width of the target coating material 2 in the width direction (direction perpendicular to the conveying direction 20) of the target coating material 2.

[0044] As illustrated in FIG. 2, each of the ink discharge units 30a, 30b, 30c, and 30d has four ink jet heads 9 disposed in a direction substantially perpendicular to the conveying direction 20. The ink jet head 9 is an example of a liquid discharge head. Four ink jet heads are collectively referred to as the ink jet head 9. The ink jet head 9 has a plurality of nozzles 10 arranged in a direction substantially perpendicular to the conveying direction 20, and discharges ink from each of the plurality of nozzles 10.

[0045] Four ink jet heads 9 having a plurality of nozzles

10 are disposed in the direction substantially perpendicular to the conveying direction 20, so that ink can be discharged over the entire width of the target coating material 2 in the width direction. Although FIG. 2 illustrates a configuration in which one ink discharge unit 30 consists of four ink jet heads 9, the ink discharge unit 30 may include at least one ink jet head 9. The width of the ink discharge unit 30 may not necessarily be the entire width of the target coating material 2, and the width may be appropriately determined.

[0046] In the ink jet head 9, the means for applying a stimulus to ink to discharge the ink can be appropriately selected depending on the purpose. The means includes, for example, a pressurizing device, a piezoelectric element, a vibration generator, an ultrasonic oscillator, or a light. Specifically, the means includes a piezoelectric actuator such as piezoelectric element, a shape-memory alloy actuator using metal phase change due to temperature change, an electrostatic actuator using electrostatic force, or the like.

[0047] Among the above-described means, the means that applies a voltage to a piezoelectric element which is bonded to a position called a pressure chamber (also referred to as a liquid chamber or the like) in the ink flow passage in the ink jet head 9 is preferably used. In this ink jet head 9, the piezoelectric element bends according to the application of a voltage, and a volume of the pressure chamber is reduced, thereby pressurizing ink in the pressure chamber and causing the ink to be discharged as droplets from the nozzle.

[0048] The ink discharge unit 30 includes an ink jet ejection unit. The ink jet ejection unit is a collection of functional components and mechanisms associated with ink discharge from the ink discharge unit 30. The ink jet ejection unit includes, for example, a combination of the discharge unit 30 and at least one of a supply mechanism, a maintenance and recovery mechanism, and a liquid ejection head transfer mechanism.

<Example of function configuration of control unit 7>

[0049] Next, the function configuration of the control unit 7 will be described with reference to FIG. 3. The control unit 7 performs the process of switching a drive waveform based on a temperature of the ink to be discharged that is retained inside the ink discharge unit 30.

[0050] As illustrated in FIG. 3, the control unit 7 includes an acquisition unit 71, a drive waveform storage unit 72, a drive waveform retention unit 73, an output unit 74, a switching unit 75, and an amplification unit 76. From among the above-described units, the functions of the output unit 74, the switching unit 75, and the amplification unit 76 are implemented in an electrical circuit, and a portion of the above-described functions can be implemented in software (Central Processing Unit (CPU)). The above-described functions may also be implemented by a plurality of circuits or a plurality of pieces of software.

[0051] The function of the drive waveform storage unit

72 is implemented by a non-volatile storage device such as a hard disk drive (HDD), and the function of the drive waveform retention unit 73 is implemented by a volatile storage device such as a random access memory (RAM).

[0052] The acquisition unit 71 acquires temperature information of the ink discharged by the ink discharge unit 30 based on a resistance value input from a thermistor 31 provided in the ink discharge unit 30. The temperature of the ink is an example of a liquid characteristic. The thermistor 31 is an example of a detector for detecting a temperature of a liquid.

[0053] The thermistor 31 is arranged in each of the four ink jet heads 9 provided in the ink discharge unit 30, and the resistance value varies according to the temperature of the ink jet head 9. The temperature of the ink jet head 9 is approximately equal to the temperature of the ink contained in the ink jet head 9, and the temperature information of the ink can be obtained from the resistance value output from the thermistor 31.

[0054] The acquisition unit 71 acquires the ink temperature information from the resistance value output from at least one of the thermistors 31 provided in each of the four ink jet heads 9. In addition, the temperature information of the ink may be acquired from an average value of resistance values output from two or more thermistors 31.

[0055] The drive waveform storage unit 72 stores drive waveform data that is adjusted in advance so that the ink discharge unit 30 can discharge ink appropriately. The drive waveform is a driving voltage signal including a waveform that is applied to the ink discharge unit 30 to cause the ink discharge unit 30 to discharge the ink. The drive waveform data is data representing the drive waveform.

[0056] Since the drive waveform for causing the ink discharge unit 30 to appropriately discharge ink changes in accordance with the temperature of the ink, the drive waveform storage unit 72 stores drive waveform data of a plurality of drive waveforms adjusted in advance for each temperature of the ink.

[0057] The drive waveform retention unit 73 functions as a buffer for retaining a portion of the plurality of drive waveform data stored in the drive waveform storage unit 72. The drive waveform retention unit 73 has storage areas A and B, acquires the drive waveform data from the drive waveform storage unit 72 in response to a change in the ink temperature, and retains the drive waveform data in the storage areas A and B.

[0058] For example, the drive waveform retention unit 73 retains the drive waveform data before switching in one of the storage areas A and B, and retains the drive waveform data after switching in another storage area. The drive waveform data retained in each of the storage areas A and B is updated when the ink temperature changes.

[0059] The output unit 74 can output drive waveform generated based on the drive waveform data retained by the drive waveform retention unit 73 in each of the storage

areas A and B, to the ink discharge unit 30. The output unit 74 can output the drive waveforms before switching and the drive waveforms after switching to the ink discharge units 30a, 30b, 30c, and 30d, concurrently.

[0060] The switching unit 75 has a function of switching the drive waveform based on the temperature information of the ink. Specifically, the switching unit 75 switches the drive waveform according to the temperature of the ink indicated by the information input from the acquisition unit 71, such that either the drive waveform before switching or the drive waveform after switching output by the output unit 74 is output through the amplification unit 76 to each of the ink discharge units 30a, 30b, 30c, and 30d. Switching may be performed by using a switching circuit or may be performed by software.

[0061] Further, the switching unit 75 switches the drive waveform at a timing when positions at which the inks discharged by the ink discharge units 30a, 30b, 30c, and 30d arrive on the target coating material 2 are separated from each other in the conveying direction 20. As a result, inks discharged by the ink discharge units 30a, 30b, 30c, and 30d are applied on the target coating material 2 at the positions separated in the conveying direction 20.

[0062] In other words, the position at which the ink discharge unit 30a applies ink onto the target coating material 2 when the drive waveform to cause the ink discharge unit 30a to discharge ink is changed, and the position at which the ink discharge unit 30b applies ink onto the target coating material 2 when the drive waveform to cause the ink discharge unit 30b to discharge ink is changed are separated from each other in the conveying direction 20.

[0063] In this case, the ink discharge unit 30a corresponds to an example of the first liquid discharge unit, and the ink discharge unit 30b corresponds to an example of the second liquid discharge unit. The present invention is not limited to the above-described configuration, and the first liquid discharge unit may be any of the ink discharge units 30a, 30b, 30c, and 30d, and the second liquid discharge unit may be any of the ink discharge units 30a, 30b, 30c, and 30d that is different from the first liquid discharge unit.

[0064] The amplification unit 76 amplifies the drive waveform input from the switching unit 75 and outputs the amplified waveform to the ink discharge units 30a, 30b, 30c, and 30d.

[0065] To the piezoelectric element 32 provided in the ink discharge unit 30, a drive waveform output by the amplification unit 76 is input. The piezoelectric element 32 expands or contracts in response to the drive waveform, to apply positive or negative pressure to the ink in the liquid chamber. Depending on the pressure applied by the piezoelectric element 32, the ink discharge unit 30 can discharge ink.

<Example of process by control unit 7>

[0066] Next, the process by the control unit 7 will be

described with reference to FIG. 4. FIG. 4 is a flowchart illustrating an example of process by the control unit 7. In the process illustrated in FIG. 4, the timing when the control unit 7 receives the user's operation to start the film formation through the operation unit of the film formation device 100 is triggered.

[0067] First, in step S41, the acquisition unit 71 acquires information indicating the temperature of the ink to be discharged by the ink discharge unit 30 based on a resistance value input from the thermistor 31.

[0068] Subsequently, in step S42, the switching unit 75 sets the temperature of the ink indicated by the information acquired by the acquisition unit 71 as a comparison value.

[0069] Next, in step S43, the drive waveform retention unit 73 acquires two drive waveform data from among a plurality of drive waveform data stored in the drive waveform storage unit 72, and retains the two drive waveform data in the storage areas A and B. For example, the drive waveform retention unit 73 retains the drive waveform data before switching in the storage area A when the waveform data corresponds to the temperature of the ink that is the comparison value and the temperature of the ink corresponding to the waveform data increases, and retains the drive waveform data after switching in the storage area B. The drive waveform data after switching corresponds to a temperature that is the nearest to the temperature corresponding to the drive waveform before switching on either the low temperature side or the high temperature side.

[0070] Subsequently, in step S44, the output unit 74 outputs, to the ink discharge unit 30, a drive waveform generated based on the drive waveform data that the drive waveform retention unit 73 retains in the storage areas A and B.

[0071] Next, in step S45, the acquisition unit 71 acquires information indicating the temperature of the ink discharged by the ink discharge unit 30, based on the resistance value input from the thermistor 31.

[0072] Subsequently, in step S46, the switching unit 75 determines whether a change in the temperature of the ink is greater than or equal to a predetermined threshold. The change in the temperature of the ink is a difference between the temperature of the ink indicated by the information acquired by the acquisition unit 71 and the temperature set as the comparison value. After the determination, the switching unit 75 updates the comparison value to the temperature indicated by the temperature information of the ink acquired by the acquisition unit 71.

[0073] In step S46, when the change in the temperature is determined to be greater than or equal to the threshold (YES in step S46), the process proceeds to step S47. When the change in the temperature is determined to be less than the threshold (NO in steps S46), the process proceeds to step S49.

[0074] Subsequently, in step S47, the switching unit 75 switches the drive waveform such that the drive wave-

form after the switching output by the output unit 74 is output to the ink discharge unit 30 through the amplification unit 76.

[0075] Subsequently, in step S48, the drive waveform retention unit 73 updates the drive waveform data that are retained.

[0076] For example, the drive waveform retention unit 73 retains in the storage area A the drive waveform data after switching that is retained in the storage area B. When the temperature increases (when a value obtained by subtracting the temperature before the change from the temperature after the change is a positive value), the drive waveform retention unit 73 acquires drive waveform data from the drive waveform storage unit 72 that conforms to a temperature higher than the temperature to which the drive waveform data after switching conforms, and retains the drive waveform data in the storage area B. Meanwhile, when the temperature decreases (when a value obtained by subtracting the temperature before the change from the temperature after the change is a negative value), the drive waveform retention unit 73 acquires drive waveform data from the drive waveform storage unit 72 that conforms to a temperature lower than the temperature to which the drive waveform data after switching conforms, and retains the drive waveform data in the storage area B.

[0077] Subsequently, in step S49, the control unit 7 determines whether the process is terminated.

[0078] In step S49, when the process is determined to be terminated (YES in step S49), the control unit 7 terminates the process, and when the process is determined not to be terminated (NO in step S49), the control unit 7 performs the process from step S44 again.

[0079] As described above, the control unit 7 can perform the process of switching the drive waveform based on information on the temperature of the ink discharged by the ink discharge unit 30.

<Example of change in temperature of ink>

[0080] Next, a change in the temperature of the ink discharged by the ink discharge unit 30 will be described with reference to FIG. 5. FIG. 5 is a diagram illustrating an example of a temperature change of ink with respect to a film formation time.

[0081] When the film formation is performed continuously for a long time, the temperature of the ink changes due to an influence of the internal temperature of the film formation device 100 and heat generation caused by the driving of the ink jet head 9. The graph 51 in FIG. 5 illustrates the temperature change of the ink according to the film formation time.

[0082] The physical properties of the ink, such as viscosity, change according to the ink temperature, and thus the discharge characteristics change. For example, when the ink temperature increases, the viscosity of the ink decreases and the viscosity resistance decreases. Then, when the drive waveform for the low ink tempera-

ture is used, a discharge speed becomes greater than the desired speed. As a result, a position at which the discharged ink arrives on the target coating material 2 is displaced from the desired position. In addition, a volume of a droplet of the discharged ink is larger than that of the desired one, and a size of the dot formed by the discharged droplets of the ink on the target coating material 2 becomes larger, or the thickness becomes thicker. As a result, an irregularity occurs in the ink applied to the target coating material 2, and the quality of the formed film may deteriorate.

[0083] For example, in a mode in which an image is formed on a target coating material, such as a paper, at a predetermined interval by the liquid discharge device, the influence of the abnormal area may be avoided by switching the drive waveform using an invalid area, such as between formed images.

[0084] However, in the mode of continuously forming a uniform film on the target coating material 2, as in the film formation device 100 according to the embodiment, since an invalid area to be used for switching the drive waveform is not present, the influence of the abnormal area is particularly noticeable.

[0085] Therefore, in the embodiment of the present application, the drive waveform can be switched according to the ink temperature. A horizontal bar illustrated in the graph 51 represents a time range in which the same drive waveform is used. The drive waveforms of the number corresponding to the number of the horizontal bars adjusted according to the ink temperature are stored in the drive waveform storage unit 72, and the drive waveform is switched according to the ink temperature.

[0086] For example, each of the plurality of drive waveforms stored in the drive waveform storage unit 72 is adjusted so that the higher the temperature of the ink, the smaller the discharge force. By switching the drive waveform according to the temperature of the ink, the discharge speed of the ink and the volume of the droplet are substantially constant regardless of the temperature of the ink.

[0087] For example, when the drive waveform corresponding to the horizontal bar 53 is switched to the drive waveform corresponding to the horizontal bar 52, the drive waveform is switched approximately at the same timing as indicated by the timing 52a and the timing 53b, so that the discharge characteristic is transiently changed in accordance with the switching. As a result, abnormal areas may occur, such as a stripe region caused by a change in the discharge speed of the ink, or a density irregularity caused by a change in the volume of the ink droplet. When the abnormal areas caused by the inks discharged by the ink discharge units 30a, 30b, 30c, and 30d are concentrated at positions close to each other in the conveying direction 20, the abnormal area becomes more prominent.

[0088] On the other hand, in the embodiment of the present application, when the drive waveform is switched, the ink discharge units 30a, 30b, 30c, and 30d

apply ink to positions which are spaced apart from each other in the conveying direction 20 on the target coating material 2. Thus, the positions of each abnormal area are dispersed in the conveying direction 20, and the abnormal area by the plurality of ink discharge units becomes inconspicuous compared to the case where the abnormal areas are concentrated in a specific area in the conveying direction 20.

10 <Example of drive waveform>

[0089] Next, the drive waveform will be described with reference to FIG. 6. FIG. 6 is a diagram illustrating an example of the drive waveform. FIG. 6(a) illustrates the drive waveform before switching, and FIG. 6(b) illustrates the drive waveform after switching. The horizontal axis and the vertical axis of FIG. 6 indicate time and an electric potential, respectively.

[0090] As illustrated in FIG. 6(a), the drive waveform 33 before switching is an example of a first drive waveform including pulse waveforms P1a, P2a, and P3a. The pulse waveforms P1a and P2a are negative pressure waveforms that cause the ink jet head to discharge ink. Two droplets are discharged by the application of the pulse waveforms P1a and P2a and merged into a medium droplet during flight. The pulse waveform P3a is a positive pressure waveform and has a function of reducing vibration remaining in a liquid level after discharge.

[0091] A pulse interval T_a represents a time interval between the pulse waveform P1a and the pulse waveform P2a. The pulse width Δt_a represents a pulse width of the pulse waveform P2a. A falling timing t_{1a} represents a falling timing included in the pulse waveform P2a, and a rising timing t_{2a} represents a rising timing included in the pulse waveform P3a.

[0092] As illustrated in FIG. 6(b), the drive waveform 34 after switching is an example of a second drive waveform including pulse waveforms P1b, P2b, and P3b. The pulse waveforms P1b and P2b are negative pressure waveforms that cause the ink jet head to discharge ink. Two droplets are discharged by the application of the pulse waveforms P1b and P2b and merged into a medium droplet during flight. The pulse waveform P3b is a positive pressure waveform and has a function of reducing vibration remaining in a liquid level after discharge.

[0093] The pulse interval T_b represents a time interval between the pulse waveform P1b and the pulse waveform P2b. The pulse width Δt_b represents a pulse width of the pulse waveform P2b. A falling timing t_{1b} represents a falling timing included in the pulse waveform P2b, and a rising timing t_{2b} represents a rising timing included in the pulse waveform P3b.

[0094] The potential difference V_1 represents a potential difference in a negative peak potential between the pulse waveform P1a and the pulse waveform P1b. The potential difference V_2 represents a potential difference in a negative peak potential between the pulse waveform P2a and the pulse waveform P2b.

[0095] The negative peak potential of the pulse waveform is different between the drive waveform 33 and the drive waveform 34, such that the potential differences V1 and V2 are generated. The drive waveform 34 has a smaller negative peak potential and a smaller discharge force than the drive waveform 33 by the amount of the potential differences V1 and V2. When the ink changes from a low temperature to a high temperature, the drive waveform 33 is switched to the drive waveform 34 and the discharge force is reduced so that the change in the discharge speed of the ink, the droplet volume of the ink, or the like before and after the switching of the drive waveform is reduced.

[0096] FIG. 6 illustrates an example in which the voltage potentials of the drive waveforms are different from each other, but the present invention is not limited to the above-described example. The switching unit 75 may switch the drive waveform 33 to the drive waveform 34 in which at least one of the electric potential, the falling timing, the pulse width, and the rising timing, included in the pulse waveform, and a time interval between a plurality of pulse waveforms, is different from the drive waveform 33. The item that is different between the drive waveforms can be selected depending on the characteristics of the ink accordingly.

<Example of change in ink application state with switching of drive waveform>

[0097] FIG. 7 is a diagram illustrating an example of a change in the ink application state with the switching of the drive waveform. FIG. 7(a) illustrates a comparative example, and FIG. 7(b) illustrates the embodiment of the present application. FIG. 7 illustrates a dot array formed by applying ink discharged by ink discharge units 30a, 30b, 30c, and 30d onto the coated material 2. In the dot array, dots of ink discharged from nozzles of the ink discharge unit are arranged in a direction perpendicular to the conveying direction 20.

[0098] In FIG. 7, each array of dots is repeatedly applied in the conveying direction 20. A dot array of the same type of hatching represents a dot array by the same ink discharge unit.

[0099] In the comparative example, the present embodiment is not applied.

[0100] In FIG. 7(a), a dot array 35aX is formed of ink discharged by the ink discharge unit 30a. A dot array 35bX is formed of ink discharged by the ink discharge unit 30b. A dot array 35cX is formed of ink discharged by the ink discharge unit 30c. A dot array 35dX is formed of ink discharged by the ink discharge unit 30d.

[0101] A dot array 35aX' is formed of ink discharged by the ink discharge unit 30a when the drive waveform is switched. A dot array 35bX' is formed of ink discharged by the ink discharge unit 30b when the drive waveform is switched. A dot array 35cX' is formed of ink discharged by the ink discharge unit 30c when the drive waveform is switched. A dot array 35dX' is formed of ink discharged

by the ink discharge unit 30d when the drive waveform is switched.

[0102] In the dot arrays 35aX', 35bX', 35cX' and 35dX', the discharge characteristics of the ink are transiently changed by switching of the drive waveforms, and the volumes of droplets of the discharged ink are reduced. Thus, the sizes of dots are reduced.

[0103] In the comparative example, the dot arrays 35aX', 35bX', 35cX' and 35dX' are concentrated in a specific area in the conveying direction 20, as illustrated by a region 701. As a result, differences from the other regions are more prominent.

[0104] Meanwhile, in FIG. 7(b), a dot array 35a is formed of ink discharged by the ink discharge unit 30a. A dot array 35b is formed of ink discharged by the ink discharge unit 30b. A dot array 35c is formed of ink discharged by the ink discharge unit 30c. A dot array 35d is formed of ink discharged by the ink discharge unit 30d.

[0105] A dot array 35a' is formed of ink discharged by the ink discharge unit 30a when the drive waveform is switched. A dot array 35b' is formed of ink discharged by the ink discharge unit 30b when the drive waveform is switched. A dot array 35c' is formed of ink discharged by the ink discharge unit 30c when the drive waveform is switched. A dot array 35d' is formed of ink discharged by the ink discharge unit 30d when the drive waveform is switched.

[0106] In the dot arrays 35a', 35b', 35c' and 35d', the discharge characteristics of the ink are transiently changed by switching of the drive waveforms, and the volumes of droplets of the discharged ink is reduced. Thus, the sizes of dots are reduced.

[0107] In the embodiment of the present application, the dot arrays 35a', 35b', 35c' and 35d' are spaced apart in the conveying direction 20. That is, dot arrays formed of inks discharged by the ink discharge units 30a, 30b, 30c, and 30d, respectively, when the drive waveforms are switched, are not adjacent to each other in the conveying direction 20. Thus, the differences from the other regions are reduced, and the abnormal area becomes inconspicuous compared with the dot arrays 35aX', 35bX', 35cX', and 35dX'.

[0108] In addition, since dots formed of the same type of ink are present in the vicinity of the abnormal area, the differences from the other areas are further reduced according to coalescing or leveling (averaging) by the same type of ink.

[0109] In FIG. 7, the dots formed of ink having small droplet volumes are exemplified as the abnormal area, but the abnormal area of the embodiment of the present invention is not limited thereto. For example, when the discharge speeds of the inks are different, the positions of the dots move in the conveying direction 20, and a stripe-like region extending in a substantially perpendicular direction to the conveying direction 20 is formed. Also, for the stripe-like region, the abnormal area becomes inconspicuous, in the same manner as above.

<Effect of film formation device 100>

[0110] As described above, in the present embodiment, the film formation device 100 (the liquid discharge device) includes a plurality of ink discharge units 30 (the liquid discharge units) capable of discharging ink (liquid), an output unit 74 capable of outputting a drive waveform to each of the plurality of ink discharge units 30, an acquisition unit 71 for acquiring information representing the temperature (characteristic) of the ink, and a switching unit 75 for switching the drive waveform based on the temperature of the ink.

[0111] The plurality of ink discharge units 30 include an ink discharge unit 30a and an ink discharge unit 30b disposed at a position separated from the ink discharge unit 30a in the conveying direction. When the temperature of the ink satisfies a predetermined condition, a position at which the ink is applied by the ink discharge unit 30a and a position at which the ink is applied by the ink discharge unit 30b on a target coating material 2 (target discharging medium) are separated from each other in the conveying direction 20.

[0112] The switching unit 75 switches the drive waveform output to the ink discharge unit 30a and the drive waveform output to the ink discharge unit 30b when the ink temperature satisfies the predetermined conditions. The predetermined condition is satisfied, for example, when the temperature of the liquid (ink) changes by a predetermined threshold or more.

[0113] Accordingly, the ink discharged in a state where the discharge characteristics of the ink discharge units 30a and 30b are transiently changed when the drive waveform is switched, is dispersed separately in the conveying direction 20. As a result, since an abnormal area that is formed becomes inconspicuous, degradation of the quality of the film (discharged region) can be suppressed.

[0114] In the embodiment of the present application, each of the plurality of ink discharge units 30 includes four (a plurality of) ink jet heads (liquid discharge heads) disposed in a direction intersecting the conveying direction 20. Accordingly, a film can be formed in a wider area in the width direction of the target coating material 2.

[0115] In the embodiment of the present application, the drive waveform 33 includes pulse waveforms P1a and P2a, and the switching unit 75 switches the drive waveform 33 (first drive waveform) to a drive waveform 34 (second drive waveform) in which at least one of an electric potential, a falling timing, a pulse width, and a rising timing, included in the pulse waveforms P1a and P2a, and a time interval between a plurality of pulse waveforms, is different from the drive waveform 33. Accordingly, the ink discharge unit 30 can discharge ink appropriately in accordance with the characteristics of the ink, such as the temperature.

<Other preferred embodiment

[0116] In the above described embodiment, the ink discharge units 30a, 30b, 30c, and 30d that discharge the same type of ink are exemplified, but the present invention is not limited to the above-described configuration. When at least two ink discharge units 30 discharge the same type of ink, the same effect as described above can be obtained.

[0117] Further, performing the switching of the drive waveform for each of the ink discharge units 30a, 30b, 30c, and 30d has been illustrated, but the present invention is not limited thereto. When the drive waveform is switched for each of the ink jet heads 9 included in each of the ink discharge units 30a, 30b, 30c, and 30d, the same effect as described above can be obtained.

[0118] The timing of switching the drive waveform may be different for each ink discharge unit 30 or each ink jet head 9. However, all the ink jet heads 9 of all the ink discharge units 30 may be switched at approximately the same timing. All the ink jet heads 9 of all the ink discharge units 30 are located at different positions. Therefore, if the drive waveforms are switched at approximately the same timing, positions at which all the ink jet heads 9 of all the ink discharge units 30 apply ink are separated from each other in the conveying direction 20. As a result, the same effect as described above is obtained.

[0119] In the above-described embodiment, the drive waveform is switched in response to the change in the temperature of the ink. However, the same effect can be obtained when the drive waveform is switched in response to a change in other characteristics of the ink in accordance with humidity, atmospheric pressure, or the like.

[0120] The film formation device 100 illustrated in the above-described embodiment is applicable to various applications. For example, the target discharging medium may be a member included in a battery, such as a storage battery, and a film may be formed on the member included in the battery.

[0121] Members included in batteries are manufactured by laminating various films, such as electrode layers, insulation layers, or active material layers. For the members, films having uniform thicknesses and free from internal defects are required to be uniformly formed. Since the film formation device 100 can form a film, in which an abnormal area becomes inconspicuous and degradation of quality due to the abnormal area is suppressed, the film formation device 100 can be preferably used for forming films on the members included in the batteries. The film formation device 100 is an example of a liquid discharge device for a battery member.

[0122] Although the embodiments have been described as above, the embodiments are presented by way of example and the invention is not limited by the embodiments. The embodiments may be implemented in various other forms, and various combinations, omissions, substitutions, modifications, or the like may be

made without departing from the scope of claims.

[0123] In addition, all the numbers, such as ordinal numbers, quantities, and the like, used in the description of the embodiments are exemplified for the purpose of illustrating the technical content of the present invention, and the present invention is not limited to the exemplified numbers. The connection relationships between the components are exemplified for the purpose of illustrating the technical content of the present invention, and the connection relationships that implement the functions of the present invention are not limited thereto.

[0124] The embodiments of the present invention also include a liquid discharge method. For example, a liquid discharge method by a liquid discharge device that discharges and applies liquid to a target discharging medium conveyed in a predetermined conveying direction to form a discharged region, including a step of discharging the liquid based on a drive waveform by a plurality of liquid discharge units; a step of outputting the drive waveform to each of the plurality of liquid discharge units; a step of acquiring information representing a characteristic of the liquid; and a step of switching the drive waveform based on the characteristic, the plurality of liquid discharge units including a first liquid discharge unit and a second liquid discharge unit that is disposed at a position separated from the first liquid discharge unit in the conveying direction, and when the characteristic satisfies a predetermined condition, a position at which the liquid is applied by the first liquid discharge unit and a position at which the liquid is applied by the second liquid discharge unit on the target discharging medium being separated from each other in the conveying direction, is provided. According to the liquid discharge method, can obtain the same effect as the above-described liquid discharge device can be obtained.

[0125] In addition, each of the functions of the embodiments described above can be implemented by a single processing circuit or a plurality of processing circuits. The "processing circuit" in the specification of the present application includes a processor programmed to perform each function by software, such as a processor implemented in electronic circuits; or a device designed to perform each function as described above, such as an Application Specific Integrated Circuit (ASIC), a digital signal processor (DSP), a field programmable gate array (FPGA), or a conventional circuit module.

[0126] This application is based on Japanese Patent Application No. 2021-021104, filed February 12, 2021, the content of which is incorporated herein by reference.

Reference signs list

[0127]

1 unwinding unit
11 unwinding roll
2 target coating material
20 conveying direction

3 application unit
30,30a,30b,30c,30d ink discharge unit (an example of a liquid discharge unit)
31 thermistor (an example of a detector)
32 piezoelectric element
33,34 drive waveform
35a,35b,35c,35d dot array
35a',35b',35c',35d' dot array after switching drive waveform
4 curing unit
5 drying unit
6 winding unit
61 winding roll
7 control unit
71 acquisition unit
72 drive waveform storage unit
73 drive waveform retention unit
74 output unit
75 switching unit
76 amplification unit
9 ink jet head (an example of a liquid discharge head)
10 nozzle
100 film formation device (liquid discharge device, liquid discharge device for battery member)
P1a,P2a,P3a pulse waveform
P1b,P2b,P3b pulse waveform
V1,V2 potential difference

Related art document

Patent Document

[0128] Patent Document 1: Japanese Unexamined Patent Application Publication No. 2011-201050

Claims

1. A liquid discharge device (100) for discharging and applying liquid to a target discharging medium (2) conveyed in a predetermined conveying direction (20) to form a discharged region, the liquid discharge device (100) comprising:

a plurality of liquid discharge units (30, 30a, 30b, 30c, 30d) configured to discharge the liquid based on a drive waveform (33, 34);
an output unit (74) configured to output the drive waveform (33, 34) to each of the plurality of liquid discharge units (30, 30a, 30b, 30c, 30d);
an acquisition unit (71) configured to acquire information representing a characteristic of the liquid; and
a switching unit (75) configured to switch the drive waveform (33, 34) based on the characteristic,
wherein the plurality of liquid discharge units (30, 30a, 30b, 30c, 30d) includes a first liquid dis-

- charge unit (30a), and a second liquid discharge unit (30b) that is disposed at a position separated from the first liquid discharge unit (30a) in the conveying direction (20), and
 wherein when the characteristic satisfies a pre-determined condition, a position at which the liquid is applied by the first liquid discharge unit (30a) and a position at which the liquid is applied by the second liquid discharge unit (30b) on the target discharging medium (2) are separated from each other in the conveying direction (20).
2. The liquid discharge device (100) according to claim 1,
 wherein the switching unit (75) switches the drive waveform (33, 34) output to the first liquid discharge unit (30a) and the drive waveform (33, 34) output to the second liquid discharge unit (30b) when the characteristic satisfies the predetermined condition.
3. The liquid discharge device (100) according to claim 1 or 2,
 wherein the characteristic is a temperature of the liquid discharged by the liquid discharge units (30, 30a, 30b, 30c, 30d), and
 wherein the predetermined condition is satisfied when the temperature of the liquid changes by a predetermined threshold or more.
4. The liquid discharge device (100) according to any one of claims 1 to 3,
 wherein each of the plurality of liquid discharge units (30, 30a, 30b, 30c, 30d) includes a plurality of liquid discharge heads (9) disposed in a direction intersecting the conveying direction (20).
5. The liquid discharge device (100) according to any one of claims 1 to 4,
 wherein each of the plurality of liquid discharge units (30, 30a, 30b, 30c, 30d) includes a detector (31) for detecting a temperature of the liquid, and
 wherein the characteristic includes the temperature detected by the detector (31).
6. The liquid discharge device (100) according to any one of claims 1 to 5,
 wherein the first liquid discharge unit (30a) and the second liquid discharge unit (30b) discharge the same type of liquid.
7. The liquid discharge device (100) according to any one of claims 1 to 6,
 wherein each of the drive waveforms (33, 34) includes a pulse waveform (P1a, P2a, P3a, P1b, P2b, P3b), and
- wherein the switching unit (75) switches a first drive waveform (33) to a second drive waveform (34) in which at least one of an electric potential, a falling timing, a pulse width, and a rising timing, included in the pulse waveform, and a time interval between a plurality of pulse waveforms, is different from that of the first drive waveform (33).
8. A liquid discharge device for a battery member, the liquid discharge device comprising:
 the liquid discharge device (100) according to any one of claims 1 to 7,
 wherein the target discharging medium (2) is a member included in a battery.
9. A liquid discharge method by a liquid discharge device (100) that discharges and applies liquid to a target discharging medium (2) conveyed in a predetermined conveying direction (20) to form a discharged region, the method comprising:
 a step of discharging the liquid based on a drive waveform (33, 34) by a plurality of liquid discharge units (30, 30a, 30b, 30c, 30d);
 a step of outputting the drive waveform (33, 34) to each of the plurality of liquid discharge units (30, 30a, 30b, 30c, 30d);
 a step of acquiring information representing a characteristic of the liquid; and
 a step of switching the drive waveform (33, 34) based on the characteristic,
 wherein the plurality of liquid discharge units (30, 30a, 30b, 30c, 30d) includes a first liquid discharge unit (30a) and a second liquid discharge unit (30b) that is disposed at a position separated from the first liquid discharge unit (30a) in the conveying direction (20), and
 wherein when the characteristic satisfies a pre-determined condition, a position at which the liquid is applied by the first liquid discharge unit (30a) and a position at which the liquid is applied by the second liquid discharge unit (30b) on the target discharging medium (2) are separated from each other in the conveying direction (20).

FIG.1

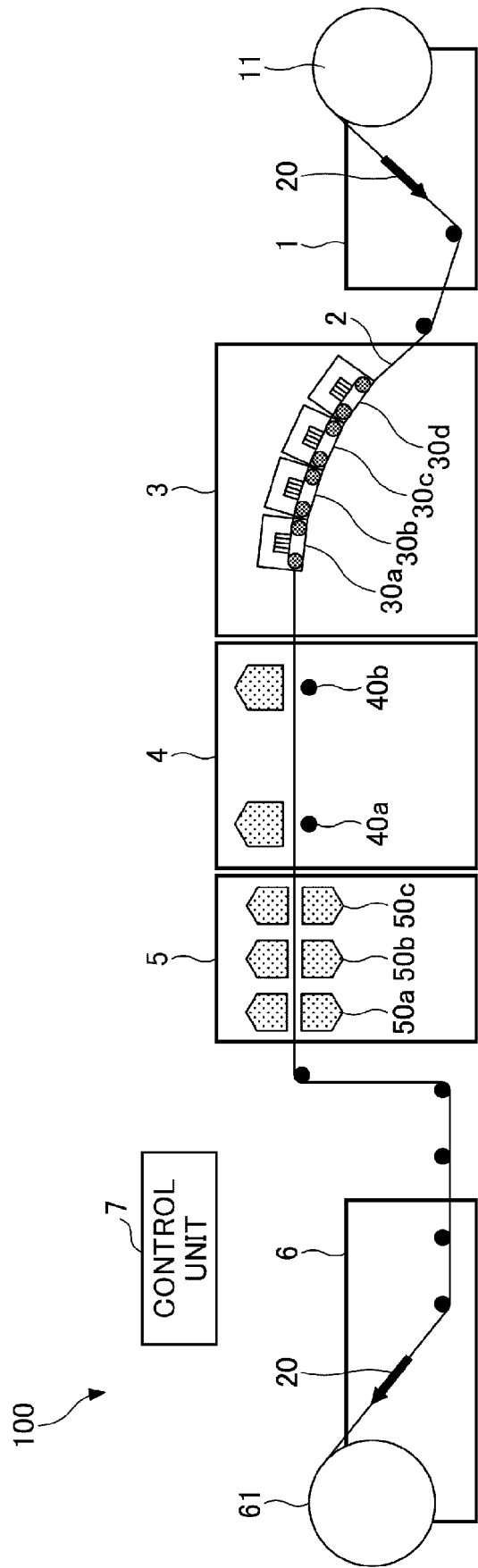


FIG.2

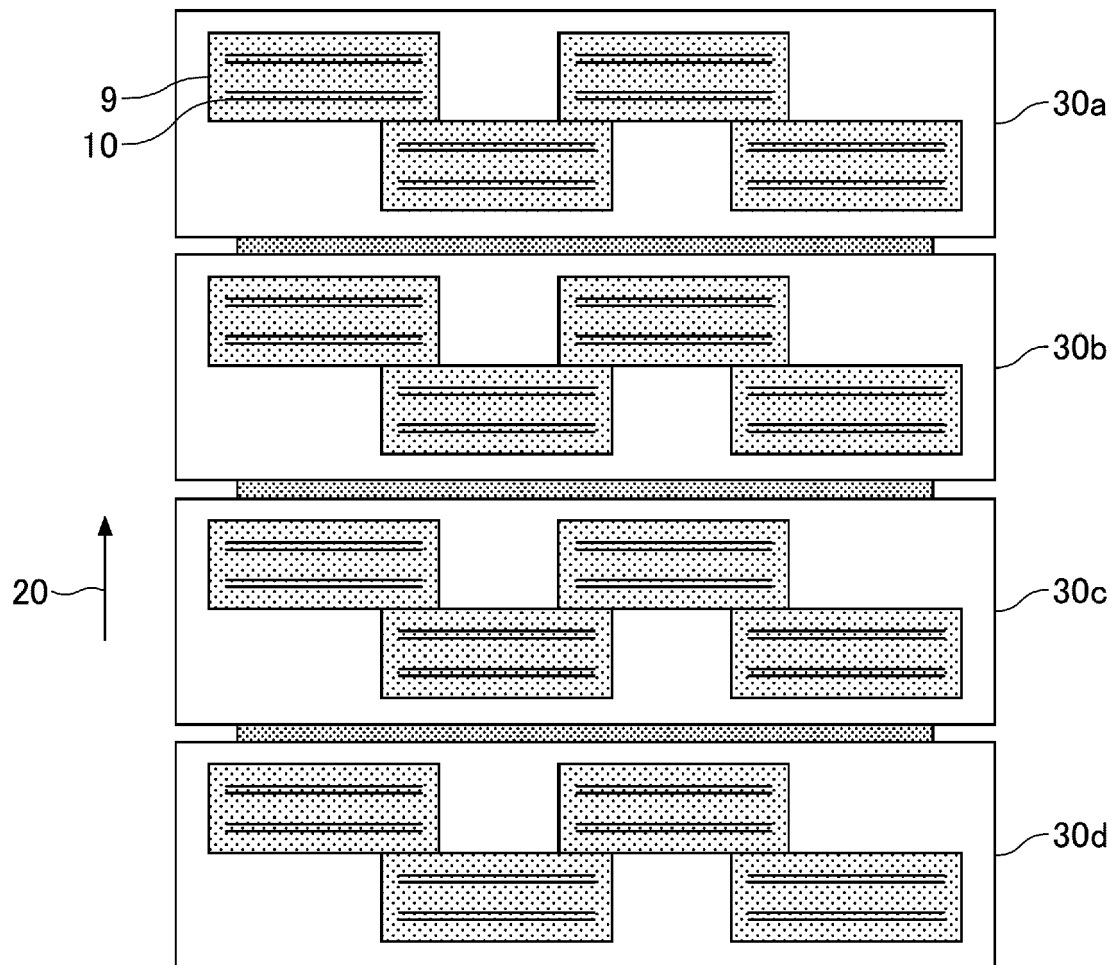


FIG.3

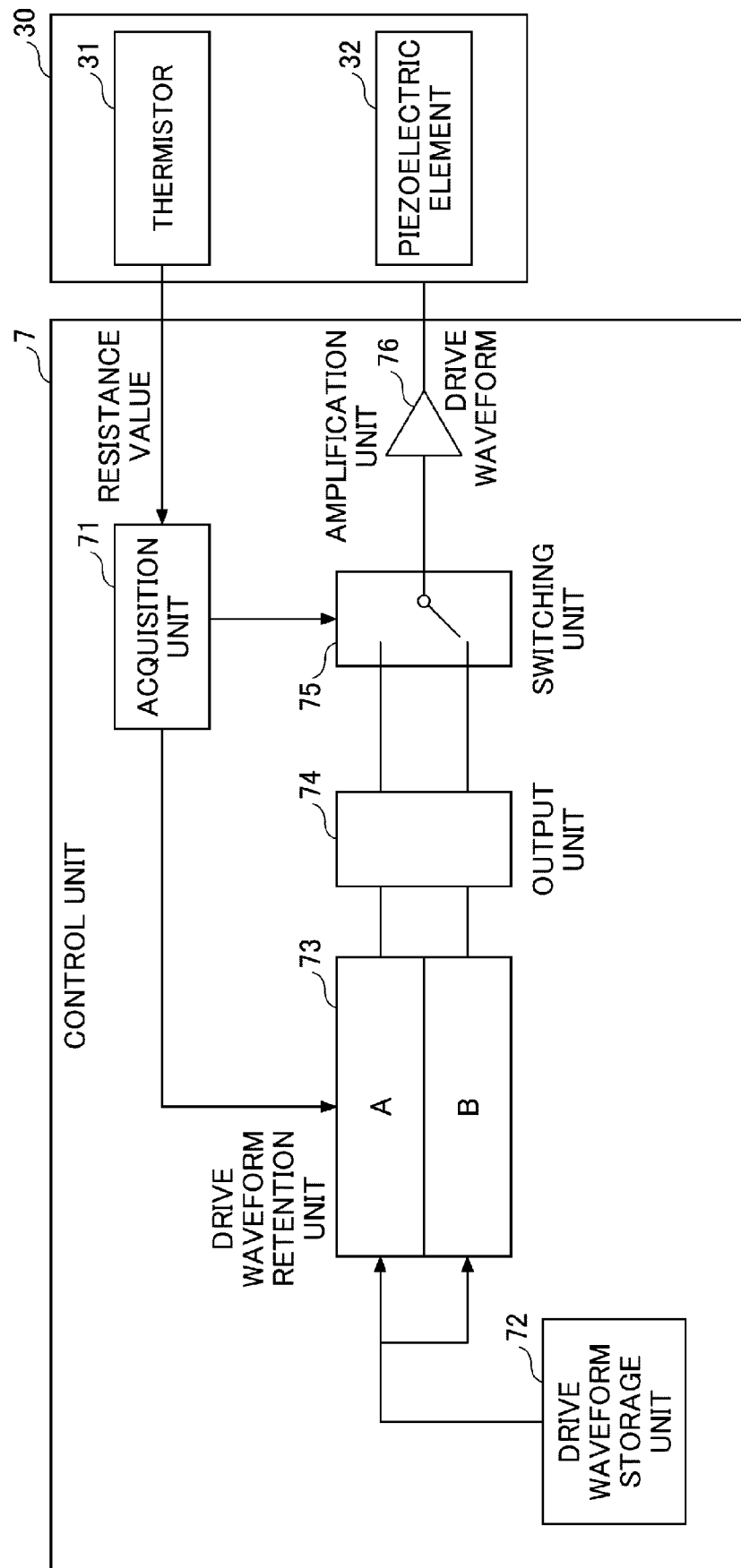


FIG.4

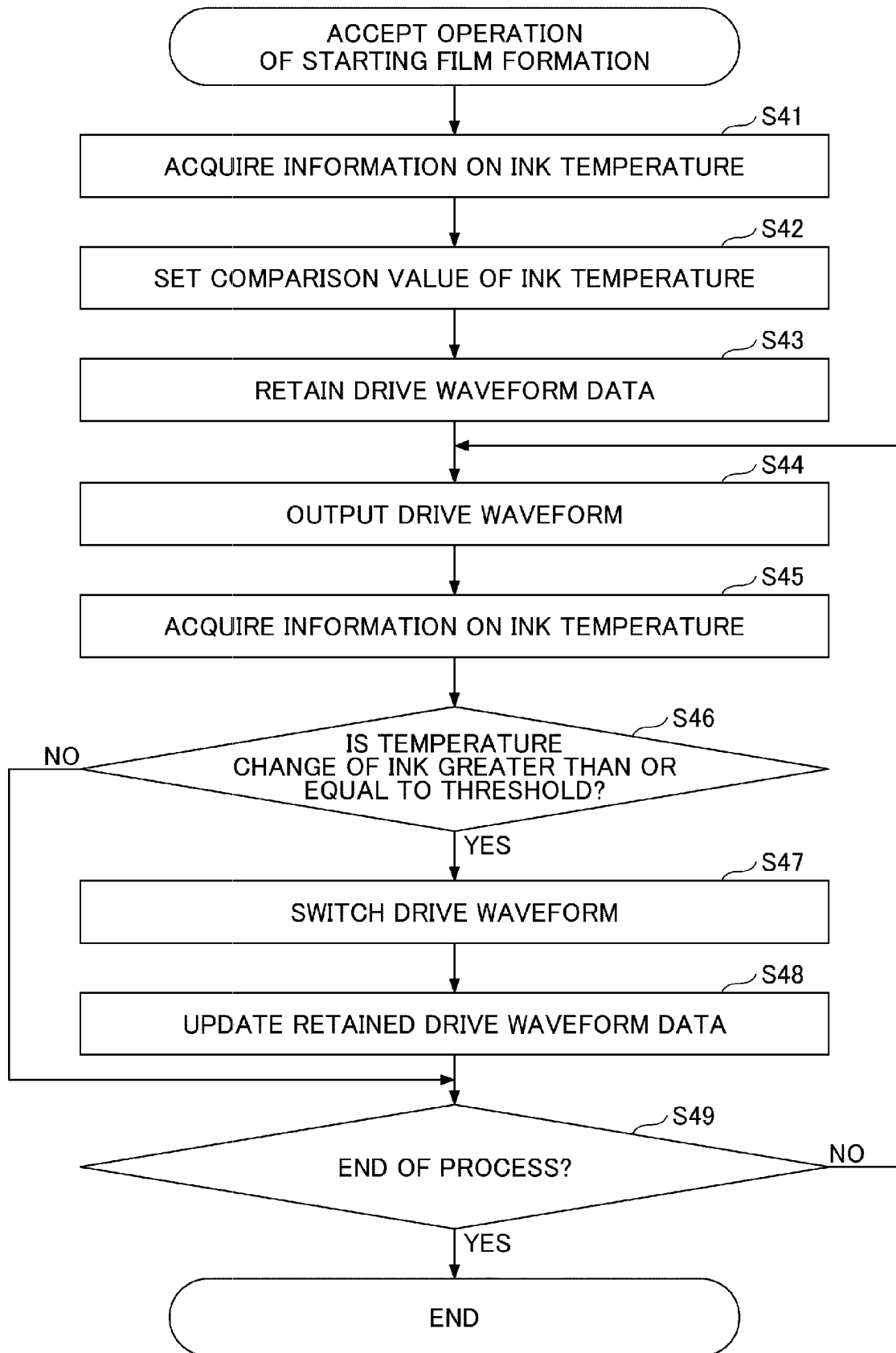


FIG.5

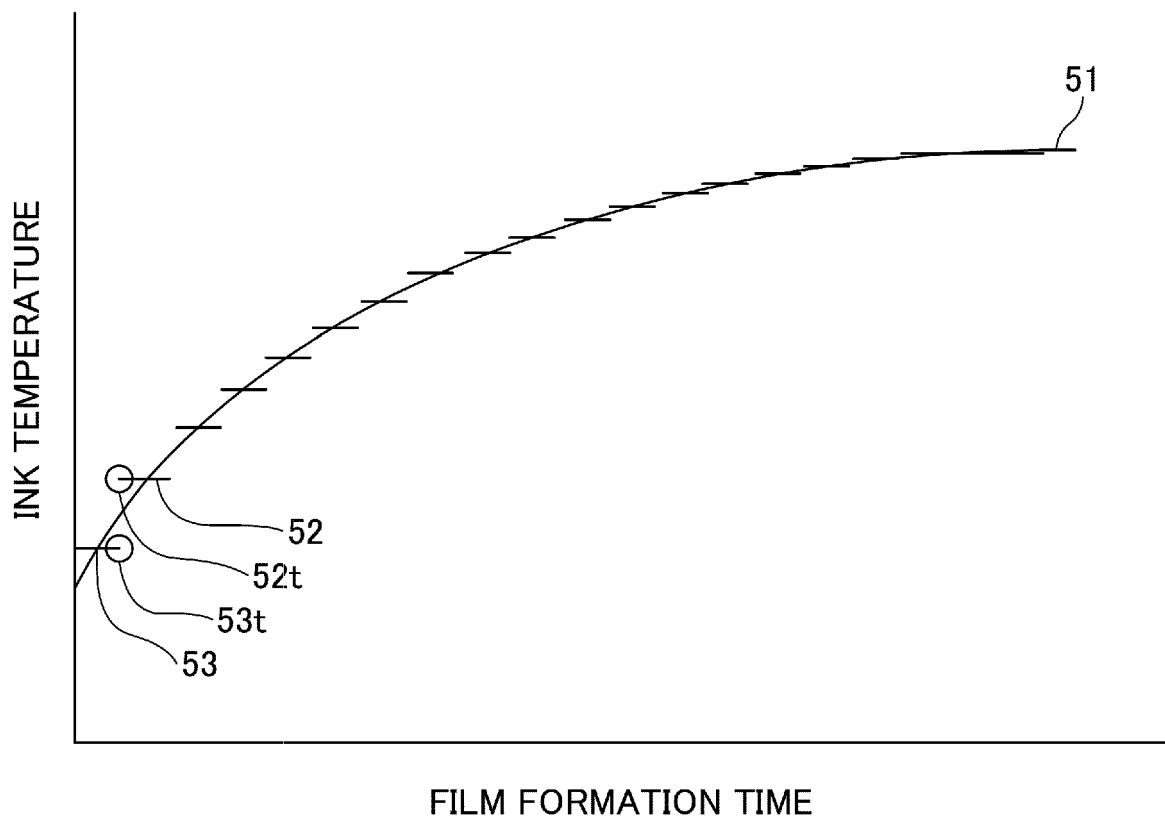
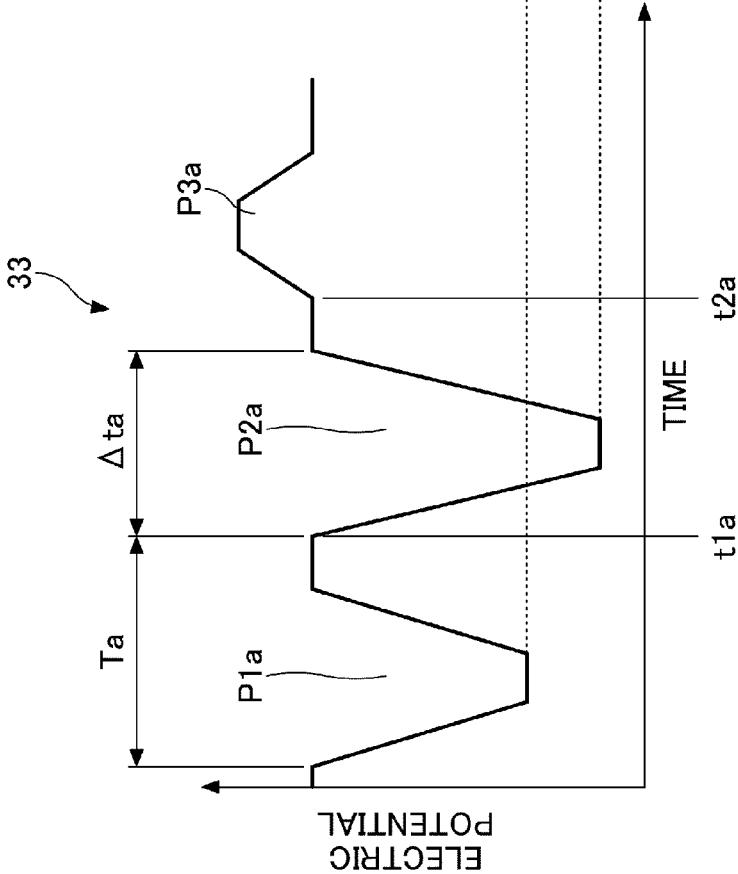


FIG.6

(a)



(b)

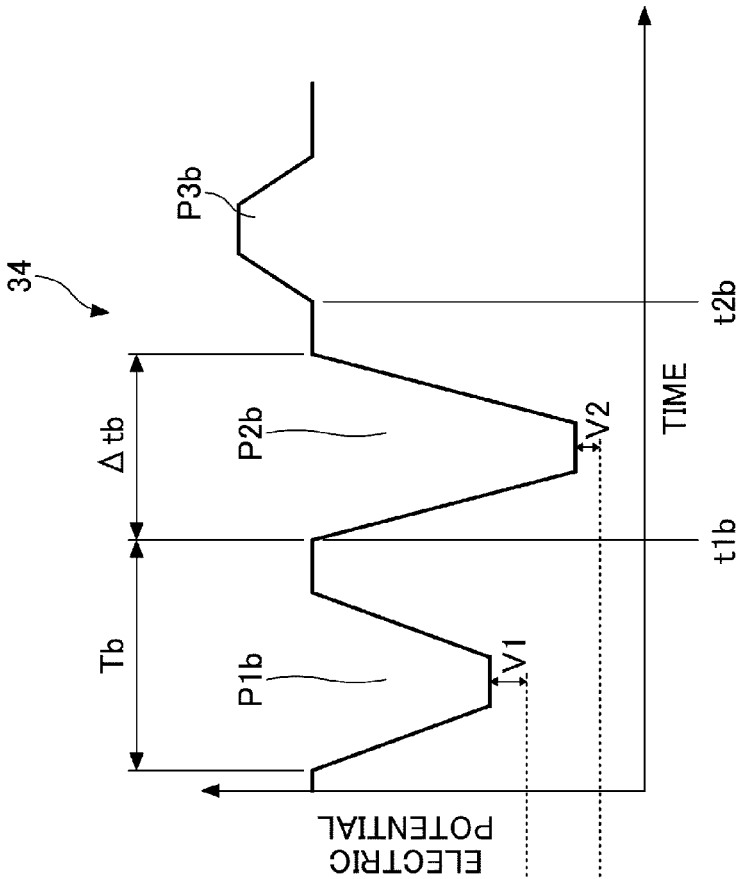
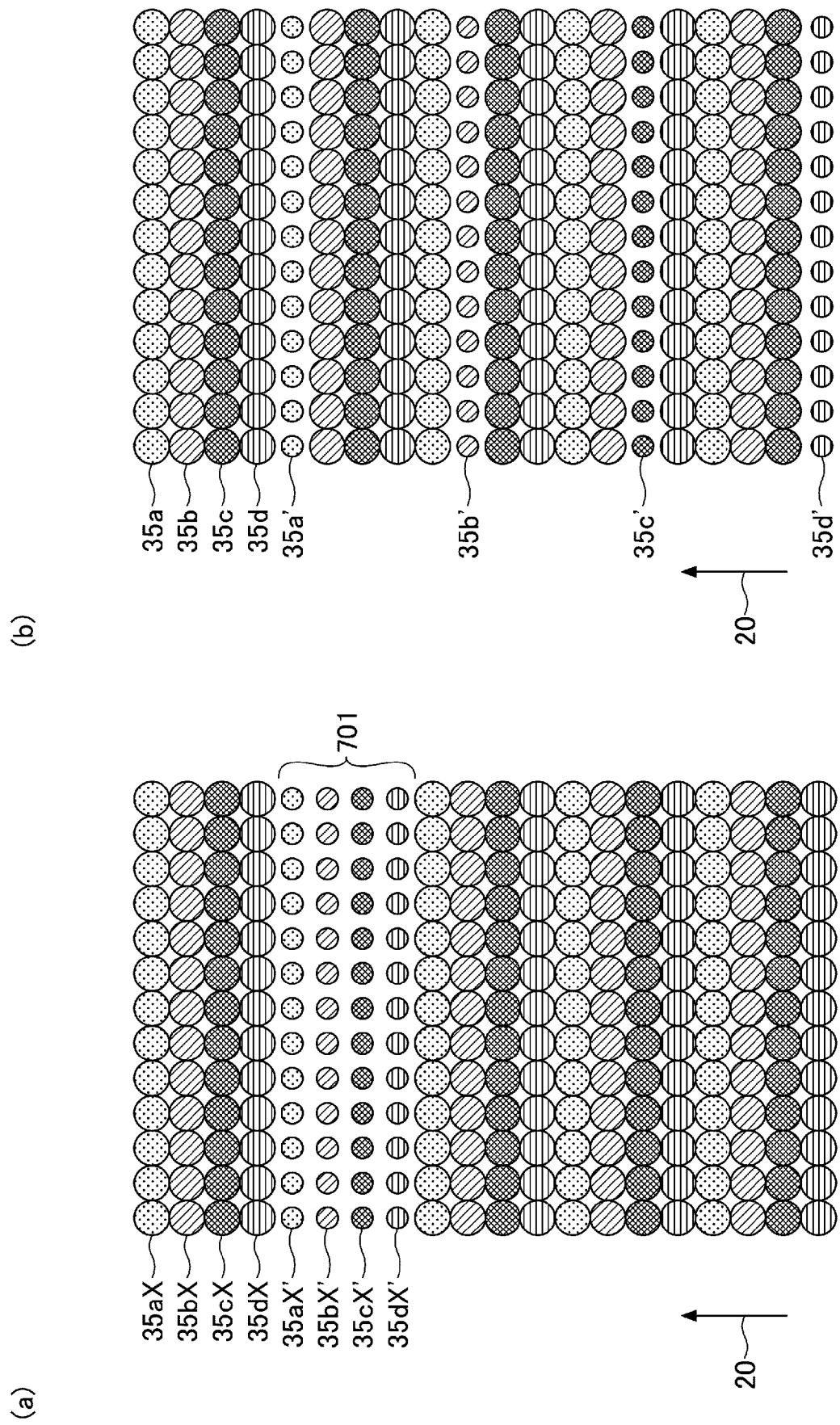


FIG.7





EUROPEAN SEARCH REPORT

Application Number

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Place of search	Date of completion of the search	Examiner
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